Project Symphony

Our energy future

Project Symphony

Lessons Learnt Report (Milestone 03: Testing)

Version 2.0

In partnership with:

western power synergy AEMO GOVERNMENT OF WESTERN AUSTRALIA Energy Policy WA

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Acknowledgements and Disclaimers

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The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

The views expressed herein are specific to the conditions set within the Symphony Pilot and are made within the context of the Wholesale Electricity Market in Western Australia.

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1. Background

Project Symphony is a pilot project where customer distributed energy resources (DER) like rooftop solar, battery energy storage and other major appliances, like air conditioning, will be orchestrated as a virtual power plant (VPP) to participate in a future energy market and unlock greater economic and environmental benefits for customers and the wider community.

A collaboration between Western Power, Synergy, AEMO and Energy Policy WA, with funding from the Australian Renewable Energy Agency (ARENA), the Project will understand how the opportunities and challenges of increasing DER can be managed to ensure a reliable, secure, and affordable electricity system. To achieve this purpose, the Project will design, procure, develop, implement, and test software based 'platforms' capable of registering, aggregating and orchestrating customer DER to provide 'must have' on-market and off-market scenarios.

While technology plays an important role in realising the safe and reliable integration of increasing DER, customer participation in sufficient numbers via a positive customer experience will be critical to the success of the Project. In addition to research of the customer experience, the Project includes installing and securing a meaningful aggregation of customer DER assets via direct engagement and multiple third-party aggregators.

To be completed by September 2023, the Project has secured over 900 DER assets from approximately 470 customers predominantly on a single electricity distribution feeder in the pilot area of Southern River, south-east of Perth.

The following four 'must-have' scenarios will be designed developed and tested during the Project:

a. **Scenario 1: Energy Services – Bi-directional Energy - Balancing Market:**

    a. The balancing market is a mandatory 'gross pool' market for dispatch and 'net pool' for settlement that determines the most economically efficient dispatch of generation to meet system electricity demand at a given time.

    b. All registered facilities, including DER aggregated generation facilities must be available to participate and must comply with the resulting dispatch instructions from the market operator (AEMO).

    c. The aggregator is able to offer (sell) or bid (buy) energy into the balancing market whilst incorporating or adhering to a 'dynamic operating envelope' (DOE), provided by the distribution system operator, which is designed to maximise or increase the amount of renewable hosting capacity on the network by publishing the total available power transfer capacity (load and generation) at a given time.

b. **Scenario 2: Network Support Services (as part of Alternative Options):**

    a. A contracted service provided by a generator, retailer, or DER aggregator to the network operator/DSO (Western Power) to help manage or solve localised network constraints.

b. A network support service could alleviate distribution level peak electricity demand or reverse power flow and/or local voltage issues identified by the DSO at a cost that is less than traditional augmentation such as larger transformers, more 'poles and wires' or otherwise expanding capacity.

c. **Scenario 3: 'Constrain to Zero':**

a. To demonstrate the ability of the AEMO Platform to instruct the Aggregator platform to constrain energy output from DER to zero export (net) or zero output (gross). The intention is that this could be offered as a market or retailer service.

d. **Scenario 4: Essential System Service (ESS) - Contingency Raise:**

a. Market provided response to a locally detected frequency deviation to help restore frequency to an acceptable level in the case of a 'contingency event' such as the sudden loss of a large generator or load.

b. An example of raise is the discharge of rapid generation such as starting a fast response generator on the network to bring frequency back to an acceptable level.

2. Purpose and Approach

The purpose of this report is to provide a high-level overview of the lessons learnt during the *testing* phase (Milestone 3) of Project Symphony.

A workshop-based approach with participation by key members of each Participant organisation, including Energy Policy WA was used, and focussed on the following principles of engagement:

- Be open and transparent.
- Language should be neutral/unemotional and matter of fact – we are bystanders observing.
- Focus on behaviours, processes, and outcomes rather than people.
- Lessons aim to be insightful and valuable to others in a similar position.

Overall, what supportive advice would you give to a similar project team about to embark on exactly the same type of project? What would we do differently next time?

3. WA Context

The West Australian context for the pilot is important, noting that unlike the NEM, the SWIS is an isolated network that must balance all demand and generation loads internally without reliance on interconnectors. The independent Australian Energy Market Operator (AEMO), a participant in Symphony, has the role of ensuring this balance is maintained at all times as it manages the security of the SWIS and the WEM.

Energy Policy WA (EPWA) is the government agency responsible for the delivery of energy policy advice to the WA Minister for Energy and is also responsible for supporting the delivery of the government's Energy Transformation Strategy, including a key Participant to Project Symphony providing active guidance and oversight.

The WA Government owns three corporations with active roles in the WA electricity supply chain. Two of these corporations are involved in Project Symphony:

- Western Power, as lead participant, which is solely responsible for building, maintaining and operating the electricity transmission and distribution network within the South West Interconnected System (SWIS); and

- Synergy, which sells and generates power within the SWIS. Synergy is the sole retailer for most customers consuming less than 50MWh/year in the SWIS. Retail and export tariffs are regulated and set by the State Government for these customers.

The rapid growth in distributed energy resources (DER), such as rooftop solar, while delivering significant financial and environmental benefits for individuals owning DER, is leading to a range of emerging issues for network operators such as Western Power and challenging the traditional electricity generation and retail business models.

The WA community is installing rooftop solar at unprecedented rates. With one in three households in the SWIS already having a rooftop solar PV system, and over 3,000 households adding a new system each month, customers with DER are already enjoying the benefits of lower electricity bills while contributing to de-carbonising the power system.

However, the high penetration of DER can pose a significant risk to power system stability, for example at times of low system demand.

In response, the WA Government released the DER Roadmap of which Project Symphony is a key DER Roadmap Action.

Action	Element	Owner	Description	Priority
22	DER Orchestration	Synergy, EPWA Western Power	By July 2020, commence a comprehensive VPP technology pilot to demonstrate the end to end technical capability of DER in the SWIS…and transition to market participation testing.	High
23	DER Orchestration	Synergy AEMO	Complete a comprehensive VPP market participation pilot that tests the incorporation of aggregated DER into energy markets, including market dispatch and settlement arrangements from the market operator to individual customer.	High

Rooftop solar installation rates have already far exceeded forecasts with over 600MW of new capacity added since the DER Roadmap was published. Other technical issues have also come to light and the risks associated with low load and high levels of DER have further been refined (AEMO, 2021c). While EPWA and AEMO will work with Western Power and Synergy to develop and implement interim solutions to these challenges, including 'last resort' measures to reduce or constrain rooftop solar generation such as Emergency Solar Management (ESM), the Project is still regarded as delivering the best long-term outcomes for customers and the power system via active DER participation through market-based mechanisms. Project Symphony will lay the groundwork for enabling WA consumers to opt-in to aggregated virtual power plants and provide services to the network and WEM, including turning down (or using up) excess output, or managing demand in return for compensation. One of the Project's working hypotheses is that DER can provide cheaper, lower carbon outcomes through network and market services (e.g. load under control, generation

under control, frequency, voltage) in a way that shares the most value with customers through their participation, than the alternative of significant network investment and transmission level responses.

4. Lessons Learnt

4.1. Summary

Following the delivery of both the scoping and planning phase (Milestone 1) as well as the build and integrate phase (Milestone 2) of the project, Project Symphony is now in the testing phase (Milestone 3) of the Participants' technology solutions.

The 'stability period' testing phase of the pilot was delayed by 5 months with customer acquisition, DER asset commissioning, as well as issues with the scenario design and a rescoping of platform functionality due to third party aggregator requirements all contributing factors. Despite the delay, Project Symphony reached a very important milestone at the end of March 2023 as the technology platforms of each of the Project Participants (Western Power, Synergy and AEMO) entered a '90-day stability period'.

During the stability period Project Symphony will be measuring the availability and reliability of the end-to-end technology platforms while intensively testing ways in which customer DER assets like rooftop solar, battery energy storage and major appliances (like air conditioners) can participate in new markets and services. This will enable the Pilot participants, including Energy Policy WA, to identify what is required to enable the scaled application of DER participation beyond Project Symphony.

With customer acquisition now finalised, there has been a natural shift in focus towards technology lessons along with policy and regulation lessons.

Project Symphony's 'Work Package 5 Platform As built report' was also recently completed as part of Milestone 3. Part of the process of developing that report was a 'lessons learned' specifically around the technology build from the perspective of the DSO, DMO and Aggregator. The resulting lessons are quite detailed and provide a 'deep dive' into the lessons of the 'as-built' process. For completeness of 'Lessons Learned #3' we have also included them as appendices in this report.

Project Symphony is an innovative project that is ambitiously aggregating several types of different manufacturer brands including both new and existing customer owned DER assets being rooftop solar, battery energy storage systems, hot water systems and air-conditioners. The VPP will also orchestrate a large (500kw) behind the meter battery and a network connected (1.2MW) battery. The complexity inherent in Project Symphony is also reflected in the lessons learnt 3, particularly around the integration of assets into the aggregator platform.

Delays to the completion of customer recruitment impacted the timeframes within the pilot. While the program has recruited all 900 DER assets, the delay in the finalisation of recruitment impacted the cadence of 'go-live' for each of the scenarios given a minimum number of assets being required to ensure robust testing, prior to entering the 'stability period'.

The initially strict eligibility criteria for customer acquisition has been outlined as a contributing factor to the delayed customer acquisition. By initially limiting recruitment to customers who had exporting

PV systems, the pilot reduced the size of the potential customer base in a meaningful way. A flow on impact was seen in the 'traditional' methods of customer acquisition used by the Aggregator relying on electronic mail as the main channel. Also, rather than limiting the recruitment pool to preferred asset functionality up-front, more consideration could have been given to developing and implementing appropriate customer incentives to increase the size of the recruitment pool, particularly for PV and air-conditioner assets.

Delays in asset recruitment naturally impacted asset commissioning. This was further exacerbated by insufficient technical capability and understanding of asset specifications, data capabilities, communication protocols and standards.. Greater visibility and understanding of asset 'orchestration' requirements and utilising resources with previous experience and capability in orchestrating the type of assets being recruited by the program are key lessons.

Significant delays in the planning, designing and procuring of a demand response solution for air-conditioners together with the 'stability period' not occurring in summer (peak electricity demand), Project Symphony will not be able to fully achieve the Network support Service (NSS) objectives.

Within Milestone 3, the Aggregator (Synergy) signed contracts with energy services companies Evergen and Rheem to supply third-party distributed energy resources (DER) as part of Project Symphony. The contracts have enabled Synergy to integrate Evergen and Rheem customer DER into Project Symphony, adding up to 190 assets to the 715 assets already signed to the pilot. The key lesson around third-party aggregation to date is that it has demonstrated its benefit to asset recruitment. To maximise this benefit, earlier engagement is recommended to allow time for overcoming technology integration issues associated with the additional complexity.

The project is now also observing the initial lessons learnt associated with 'policy and regulation'. Aggregated DER's performance standards are now being tested which will provide the pilot with an understanding of the suitability of existing market rules to accommodate aggregated DER. The current experience of third-party aggregation has shown Project Symphony that regulatory reform is likely required around robust customer protections for contracts passing from the third-party aggregators to the parent aggregator. There are also lessons emerging around the requirement for consistent interoperability standards and regulatory instruments like the current metering code not catering for third party aggregation, so allowing time for legal work arounds while awaiting holistic reform is recommended.

Project Symphony is currently demonstrating its flexibility by accommodating different asset requirements, specifications, and technology solutions however, it is understood that while testing different constructs can be valuable, it will not necessarily result in greater or faster VPP facilitation without rule or policy change/s. To ensure these regulatory lessons are captured by Project Symphony, a specific gap analysis session was completed to identify any barriers to DER participation in both on and off market services in the future. The results of that session within this report.

Finally, the lessons learnt #3 report clearly demonstrates the continued need for collaborative and innovative ways of working across four independent participant organisations. They also highlight the requirement for the project to be flexible and open to refinement and iteration as a project like this is being delivered.

4.2. Lessons Learnt - Customer Engagement & Experience

No.	Subject / Topic	Barrier OR Benefit	Outcome and / or Lesson
1	Customer – Data sharing	**Benefit:** When data requirements were shared it increased participant understanding of the objectives and drivers of the other participants. **Barrier:** The original customer contract and project participant privacy obligations did not adequately facilitate the level of data sharing required across project participants to meet the pilot's objectives.	**Lesson:** Data Sharing Agreements should be completed early and seen as a key dependency for DER programs as they result in an improved understanding of the end-to-end data processes required by each of the participants in enabling DER participation.
2	Customer – Engagement Third Party Aggregators	**Benefit:** Third Party Aggregators (TPAs) have provided additional insights, including new/additional ways of engaging and acquiring customers for VPP participation. **Benefit:** A parent/TPA model increases customer and asset participation. **Benefit:** TPAs are responsible for the customer asset management. **Benefit:** TPAs can bring engaged customers and installed assets quickly expanding the potential size and scale of the VPP facility. **Barrier:** The lack of regulatory framework around emerging business models has added risk to the parent aggregator as third-party aggregators are responsible for the	**Outcome:** Third Party Aggregators (TPAs) have access to the wholesale market via Synergy. **Outcome:** Third Party Aggregators (TPAs) product offerings allow the pilot to test a wider set of assets. **Outcome:** TPAs have customer engagement methods that Synergy doesn't currently/traditionally use, such as face to face sales and fee for service offerings. **Lesson:** Engage with TPAs early in the program to understand the industry best practice for VPP asset recruitment, to increase the customer and asset participation in the program. **Lesson:** Asset management can be outsourced. **Lesson:** 'Energy as a service' offerings to customers to avoid upfront capital cost could scale faster. Note, payback period on battery can be prohibitive for customers without incentive/s. **Lesson:** Individual customers have differing needs and as such, a catalogue of products and services need to be offered to enable a high

* previously identified as a barrier but additional

		customer assets, they provide to the parent VPP. **Barrier:** The lack of regulatory framework around emerging business models has added risk to the parent aggregator as third-party aggregators are responsible for the customer assets, they provide to the parent VPP. **Barrier:** TPAs assets may not be in the right location for network support services in advance of DER saturation.	level of participation. **Lesson:** Reform is required for customer protections in TPA contracts that are passing to a parent aggregator.
3	Customer – PV recruitment	**Barrier:** The initial recruitment strategy was narrow with recruitment only focused on customers whose PV was regularly exporting to the network. **Barrier:** Recruitment methodology options were limited to traditional direct recruitment channels like electronic direct messaging and phone calls.	**Outcome:** Strict eligibility criteria meant that only customers invited to participate could express their interest in participating in the pilot, further limiting the target market. **Outcome:** Project Symphony has taken longer than anticipated to recruit the requisite number of customers.**:**
4	Customer Experience – site visits	**Barrier:** Multiple customer site visits are required to register and commission customer DER assets.	**Outcome:** Customer experience of the program and recruitment was negatively impacted. Installers had limited project information to explain to customers the complexity of what the project is trying to achieve and why they have had to visit their homes multiple times. **Lesson:** Future VPP product recruitment strategies should limit the number of site visits required by having all relevant technical expertise, and

			requirements to support the recruitment of multiple DER assets at a time. Lesson: Provide 'engagement' training for new installers when they join the project and provide them with key messages for customers to minimise impact of site visits and to increase understanding of the program's objectives.

4.3. Lessons Learnt - Technology

No.	Subject / Topic	Barrier OR Benefit	Outcome and / or Lesson
1	Technology integration Technical requirements	**Barrier:** The end-to-end technical capacity and understanding of VPP including the specific requirements in implementing the 'hybrid model' was insufficient to scope and implement the platforms efficiently and effectively.	**Outcome:** It took significant time to complete the technical design, build and test activities which also resulted in re-work due to the inconsistency in detailed understanding of the 'hybrid model'. **Outcome:** The program has been routinely delayed as technical challenges have required extensive negotiation and build-up of understanding across the project participants to refine scope whilst developing. **Outcome:** Program delays due to insufficient technical understanding of asset specifications, data capabilities, communication protocols and standards has affected DER asset commissioning timelines. **Lesson:** Commence detailed design work early and incorporate a period of prototyping in the program which includes the end users of the platforms as opposed to the technical test teams only.
2	Technology integration Technical requirements	**Barrier:** There was limited technical information and data available to the Aggregator on Air Conditioners (A/C) and	**Outcome:** Program delays due to insufficient technical understanding of asset specifications, data capabilities,

		Hot Water Systems (HWS) to limit platform integration risks.	communication protocols and standards has affected commissioning timelines. **Outcome:** Customer satisfaction with the process was impacted adversely due to multiple uncoordinated site visits to collect information. **Lesson:** Greater planning to understand asset orchestration requirements is required. Detailed data including firmware level and nameplate data for invertors, A/C and HWS are required to plan and facilitate end to end implementation of orchestration. **Lesson:** Develop a comprehensive DER information / data collection plan to minimise the number of customer site visits. **Lesson:** Consider future updates to the DER Register to incorporate any controllable assets such as A/C.
3	Technology integration DER orchestration – maturity and complexity	**Barrier:** Different DER asset types and models require different technology to control them and respond to commands, making interoperability complex. **Barrier:** Since the publication of AS4755, DRM functionality inclusion has been optional, and interpretation of the standard is not consistently applied especially in brownfield settings.	**Outcome:** AS4755 is being inconsistently understood and applied by different OEMs. **Outcome:** Some A/C manufacturers include interface modules whereas others do not. **Outcome:** DRM cards need to be retrofitted into some models of A/C resulting in delays as well as increase installation cost per customer. **Outcome:** Commissioning delays experienced due to the multiple combinations of customer assets being recruited. **Lesson:** Early engagement with OEMs and product retailers around equipment capability can de-risk implementation in the field. **Lesson:** Asset information including operability and nameplate data is required upfront to ensure asset compatibility with platforms is sufficient to improve asset commissioning. **Lesson:** Consistent, mandatory standards (such as AS4755) be

			adopted in support of DER integration and participation. **Lesson:** For brownfield sites, consider sample audits based on the more popular DER manufacturers and models to better understand the variability prior a broader implementation.
4	Technology integration DER orchestration – maturity and complexity	**Barrier:** The technology that enables DER orchestration is relatively immature and not widely available. Vendor development is occurring alongside test & learn activities. **Barrier:** Some OEMS have interoperability challenges. **Barrier:** Demand Response Mode (DRM) technology for A/C is not widely understood and capability not readily available especially in the local WA market.	**Outcome:** Compatibility issues arise between certain OEMs resulting in site revisits and inability to seamlessly integrate. **Outcome:** Some interface device signaling errors cause involuntary A/C activation and negative customer feedback. **Outcome:** Some inverter models required firmware updates to establish compatibility. **Outcome:** Currently the program has a shortfall on available A/C commissioned into the aggregator platform to demonstrate the Network Support Service use case can be reliably met including A/C. **Lesson:** Consistent, mandatory standard/s be considered for adoption in support of DER integration and participation. **Lesson:** Establish stricter criteria for orchestrating assets, focusing on OEMs with proven platform compatibility and preferably with independent certification on DER control capability. **Lesson:** Comprehensive pre-deployment testing should be undertaken. For Pilot projects, consider the establishment of a test lab/facility where the most common DER types would be thoroughly tested. **Lesson:** Where possible ensure any DER program has previous capability (skills and experience) in orchestrating the type of assets being recruited.

5	Technology integration Installation	**Barrier:** Faulty power and distribution transformer monitor installations	**Outcome:** Incorrect data collection during pilot. **Lesson:** Implement clear and detailed Installation and Commissioning Procedures to ensure correct installation and setup.
6	Technology integration Testing	**Benefit:** Decoupling BMO and NSS due to schedule delays, allowed Test & Learn to start testing ahead of the deployment of all scenarios.	**Outcome:** This exposed a misalignment in interpretation of requirements between Aggregator and DMO ahead of full scenario deployment. **Lesson:** Consider a staged approach to implementation if you are building a platform for multiple scenarios.
7	Technology integration Testing	**Barrier:** Overlapping developmental (X-SIT) and stability period (Test & Learn) streams of testing caused conflicting priorities for existing resource pool. **Barrier:** Lack of visibility of potential delays in delivery streams (impacting schedule) resulted in insufficient time to adjust the resourcing profile. **Barrier:** Initial verification test period was compressed due to environment setup and splitting of the testing streams. **Barrier:** Environment configuration registers were not aligned or well maintained.	**Outcome:** Overlapping of testing and interdependencies added complexity and effort required for test execution, defect remediation and release management. **Outcome:** Competing priorities for test and development team resources due to finite resource pool resulted in further delays in the project and test timelines. **Outcome:** Initial verification test scope focused on ensuring end-to-end environment setup was complete, resulting in compressed execution schedules and ‘bare minimum’ / ‘happy path’ scoping of testing to be completed. **Outcome:** Multiple testing streams created competing priorities in relation to development delivery, release management, test execution and defect remediation. **Lesson:** Ensure that detailed project management plans are captured in a centralized collaboration tool by each organization, which provide full visibility of delivery capability to identify gaps or bottlenecks early **Lesson:** Conduct impact assessments changes to timelines to ensure adequate resources are in

			place to deliver multiple streams. **Lesson:** Split delivery and testing into parallel streams to allow for scenario 'go-live' flexibility and identification and remediation of initial issues.
8	Technology integration Architectural principles	**Barrier:** A lack of agreed overarching architectural principles including definition of developmental and testing environments in advance of pilot implementation.	**Outcome:** The program's ability to be nimble and flexible has been limited when implementing fixes and new versions of software. **Outcome:** Participant platform environments are built to different principles and standards which can lead to a material impact on the test and learn schedule and to the program's scalability and service levels. **Lesson:** The principles and requirements for environments and service levels should be defined and agreed to up front to minimise the impact on the project.
9	Technology Capability	**Barrier:** Misaligned understanding of detailed requirements and participant expectations on business capability and context of program boundary under test.	**Outcome:** Some participants built technical platform functionality and associated business capability based on misaligned understanding of detailed requirements and expectations. **Outcome:** This resulted in the delay to the Test and Learn phase of the program due to the re-design, re-development and re-testing of two of the four scenarios under Symphony. **Lesson:** Commence rapid prototyping early in the program which includes the end users of the platforms as opposed to the technical test teams only.
10	Technology Integration Testing Lower granularity of success criteria (entry and exit) required to avoid issues found in T & L	**Barrier:** The rigour and completeness of testing scenarios was less than required to support more detailed testing during the test-and-learn process.	**Outcome:** In a complex environment that includes multiple participants, evolving technology and solutions, and changing market constructs, the rigor of testing criteria (entry and exit) needed to aid in shaping and assessing delivery risk/misalignment should be known early in the project. **Outcome:** Testing activities were impacted, resulting in project delays.

			Outcome: A focus on functional capability, such as system integrations, did not assess operational capability of DER using the delivered and tested functions. **Lesson:** A shared understanding of what is intended, functionally and operationally (pass/fail), during a test and the ability to understand if it happened or not is critical to testing.
11	Technology Integration Testing Visibility of Vendor's System Integration Testing (SIT) Outcomes	**Barrier:** Vendors' SIT approach and outcomes were not made visible to the project team in the early part of the project.	**Outcome:** As a result, the completeness of internal testing before release was unclear which had adverse impacts. **Outcome:** In response, a robust three phase process was established: 4.4. The DMO developed a list of test requirements ○ The vendor would take this information and develop a detailed vendor SIT plan. ○ The vendor executed a walkthrough of the testing (live or a recording) according to the test plan **Outcome:** Testing and data analysis impacts as the messaging schema changed and impacted the ability to ingest data into the reporting platform. **Outcome:** Cascading impacts on participant development/delivery activities due to the requirement to have the same versions. **Lesson:** Ensure that, even in a trial or Pilot context, an appropriate degree of change control disciplines and communications are established and maintained from the outset of the project.
12	Technology Value stacking	**Barrier:** Initial Aggregator implementation was not able to value stack multiple services.	**Outcome:** Complexity in reviewing and analysing aggregated facility performance, and market design inconsistencies due to highly dynamic registration of facilities that switch between the provision of different services intraday. **Lesson:** Initial aggregator capability implemented for Symphony is not

			scalable to WEM participation due to significant uncertainty for registered participants and settlement complexity. **Lesson:** Aggregator platform enhancements and capability needs to be designed for market registration requirements as a target state (As per Project Objectives).

4.5. Lessons Learnt – Governance

No.	Subject / Topic	Barrier OR Benefit	Outcome and / or Lesson
1	Governance – working groups	**Benefit:** Working groups for key technical areas were established early to provide structure and focus. **Barrier:** Multiple working groups often attended by the same key resources had an opportunity cost.	**Outcome:** Overall, while the establishment of working groups to progress the design and build of key technical requirements was a benefit, the volume of meetings can be a significant time commitment for key resources so need to be efficient (independent facilitation where possible, documented decision making and escalation process) to deliver value. **Lesson:** Working groups need to be flexible and able to evolve into more refined groups as the focus areas and priorities of a program change. **Lesson:** Participation needs to be managed and reviewed regularly by team leads and/or Product Owners. **Lesson:** Each working group should hold regular 'retrospectives' to review lessons learnt and implement identified improvements.
2	Governance – escalation pathways	**Barrier:** Project Participants struggled with understanding and following the available escalation paths to resolve issues efficiently **Barrier:** Availability of key personnel to make timely project critical decisions impacted by full calendar of working group and	**Outcome:** At times, the program struggled to achieve timely decision making on key technical aspects of the program which impacted cross-participant communications and collaboration, which resulted in schedule delays. **Outcome:** Escalation paths defined were not followed when most needed, during periods of critical decision making under pressure.

		internal organisation meetings.	**Outcome:** While a 'Tiger Team' was established and helped to bring a number of issues to a close, it was set up as a reactive, rather than proactive measure. **Lesson:** A cross participant 'Tiger Team' should be established at the commencement of the 'Build' phase of the program to specifically address program issues and manage overall delivery. **Lesson:** The escalation path for all issues across all working groups should be standardized / documented and adhered to in a consistent way.
3	Governance – delivery methodology	**Barrier:** A lack of a consolidated cross-Participant view of all of the project activities and their interdependencies in order to effectively manage the program.	**Outcome:** Each Participant managed their project plans independently without the use of a consolidated view such as a Gannt Chart. As the program was implemented this increasingly became a hinderance due to the dependencies and predecessors within each plan. **Outcome:** Areas of misalignment persist e.g. Hypothesis (AEMO) = Investigation Topics (WP) = Themes (Synergy) **Outcome:** Unable to deliver all functionality in one 'big-bang' delivery as per the original schedule resulting in significant delays (5 months) to start of 'stability period'. **Outcome:** Independent (not cross-organisational) management tools, resulted in poor visibility of bottlenecks, prioritisation, dependencies in the delivery pipeline and didn't have built in escalation workflows. **Lesson:** If possible, a single delivery methodology should be agreed and adopted by the Program. **Lesson:** A consolidated, single program view overseen by Product owners and the PMO (such as a single Program Gannt chart) for milestones along with allocated resources,

			related interdependencies etc. should be agreed and established during Scoping and Planning. **Lesson:** Rather than plan for a 'big-bang' release of all functionality for all 'must-have' scenarios during a single month, consider a more staggered approach to delivery considering: business value and seasonality (time of year needs for different types of DER participation) to drive releases of each scenario. This also allows for introducing enhancements, fixes for previous releases. **Lesson:** Collaborative, cross-organisation *delivery* tools should be established and utilized during Scoping and Planning, with hosting agnostic to the organisations participating, rather than using independent internal tools and processes.
4	Governance Strategic Prioritisation and Alignment	**Benefit:** Establishing Project Symphony as a Pilot (as opposed to a trial) to identify the barriers to increased DER participation in the SWIS **Barrier:** Lack of early alignment and agreement among senior leadership of different Project Participant organisations as to the strategic importance/relevance of Project Symphony. **Barrier:** Unclear/poor visibility of internal organisations' strategic and project priorities in relation to Project Symphony and DER participation in general. **Barrier:** No shared, longer-term strategic view for DER participation pathway / transition to	**Outcome:** Misalignment on strategic importance and project priorities has resulted in cross-organisation delivery conflicts including at times the high tolerance for delays and achieving of project objectives in general. **Outcome:** Each organisation has worked in silos when defining capability requirements for scale beyond Project Symphony resulting in some technical, and DER product development capability being short term or 'single use'. **Outcome:** Project Symphony needed to be developed as a strategic priority for all organisations and resourced accordingly throughout the Pilot. **Outcome:** Executive support and alignment across the organisations regarding Project Symphony has been intermittent and contributed to inefficiencies and delay. **Outcome:** "Having an aligned perspective on the vision, belief and shared strategic prioritisation would

		scale among participant organisations.	have positively impacted overall capacity, capability and commitment". **Lesson:** For Pilot deployments, the use of effective and persistent program wide communication to reinforce the strategic importance, objectives and required outcomes is recommended. **Lesson:** Executive level membership of oversight/steering committees is highly recommended. **Lesson:** Joint, Executive or Sponsor level workshop/s to define Pilot objectives and requirements should be conducted during Planning and Scoping.
5	Governance Change (Release) Management	**Benefit:** A standardised cross-organisation release management approach was delivered to reduce risk, while providing visibility and traceability of change.	**Outcome:** Amendments and streamlining of the release management process has resulted in all organisations adopting the process and reducing technical issues because of 'unplanned/unexpected' changes to shared testing environments. **Outcome:** Having a release management process ensures predictable delivery of code into the TRIAL environment with quicker root cause analysis and rollback or fix on fail. **Lesson:** Change and release management processes should be defined upfront to mitigate any gaps in understanding of processes. **Lesson:** Collaborative cross-organisation DevOps tools should be considered, with hosting agnostic to the organizations participating and should be mandated for all organization to manage project delivery, rather than using internal tools and processes. **Lesson:** For scaling of the project past the pilot stage, dedicated release management personnel and capabilities should be considered.

6	Governance – Resourcing	**Benefit:** Resourcing – capability, availability, capacity and retention has been challenging. For example, Aggregator has had seven different project managers since start of the Pilot.	**Outcome:** Budget has been adversely impacted. **Outcome:** Lack of continuity and buy-in among key resources has hampered progress and contributed to >5 month delay to planned start of 'stability **Lesson:** Similar projects should plan retention and knowledge transfer strategies for key resources.
7	Governance – Participating	**Benefit:** Co-location where possible and resource sharing (e.g. AEMO key resource to Synergy) has provided greater knowledge sharing, empathy and insight. **Barrier:** Each participant organisation needed to understand and appreciate each other's business role, objectives and 'pain points' much earlier in the Pilot. **Barrier:** Lack of co-location due to COVID restricted the opportunity for more 'organic' cross-pollination of organisational culture, operations, objectives and challenges	**Outcome:** At times, incorrect assumptions as to each other's drivers, objectives and challenges impacted/reduced a shared understanding of what each organisation needed or wanted from each other or needed from the Pilot. This impacted the delivery of some technical capability and the ability to achieve certain Pilot objectives. **Lesson:** Day in the life' days should be hosted by each organisation to provide a strategic and operational overview and highlight challenges experienced by each organisation.

4.6. Lessons Learnt – Policy and Regulation

No.	Subject / Topic	Barrier OR Benefit	Outcome and / or Lesson
1	Policy and Regulation - participation	**Barrier:** The original customer contract along with the Electricity Industry (Metering) Code 2012, and project participant privacy obligations did not adequately facilitate the level of data sharing required. *	**Outcome:** The verifiable consent definition in the metering code inhibits digital customer recruitment. When dealing with third party aggregators, additional layers of consent for information has been encountered. **Outcome:** The metering code does not currently cover Third Party Aggregators.

			Lesson: Understand what the regulatory implications of a process are early to allow time for legal workarounds and recommendations.
2	Policy and Regulation – Visibility (network)	**Benefit:** Project Symphony used AMI and transformer monitoring to obtain visibility in Project Symphony	**Outcome:** WP to develop plan for network visibility (see DER Roadmap Action 14) to facilitate orchestration of DER. This will be a forward-looking strategy and plan for investment. **Outcome:** Learnings from Project Symphony including identifying the minimum level of visibility needed for DSO when monitoring power flow or calculating the DOE including: • Understanding the requirements to facilitate market settlement • Quantify market benefits to compare against costs **Outcome:** Aggregator NSS services have been validated just as well through AMI as with distribution transformer monitoring even when AMI saturation is not 100% **Lesson:** AMI including a subset of AMI is enough to validate services provided by an aggregator and provides the DSO with data that could be used for additional compliance monitoring activities (for example to infer non-compliance with some equipment standards). **Lesson:** Timely, remote reading of interval meter data is imperative. **Lesson:** There needs to be a unified framework for the procurement of market services (see lack of alignment between AOS/NSS/NCESS drivers, processes and outcomes) and a clear transition pathway from existing processes to future arrangements. **Lesson:** Symphony has predominantly residential customer participation and additional testing is needed for larger customers (i.e. Commercial & Industrial).
3	Policy and Regulation –	**Benefit:** Project Symphony has tested	**Outcome:** Symphony to inform better understanding of the visibility

	Visibility (system operation)	both on-market and off market services **Barrier:** Market services like ESS contingency raise require a higher degree of measurement then that of market services like CtZ.	requirements that will be placed on Small Aggregations registering in the WEM. **Outcome:** Additional equipment (telemetry) may be required at each participating connection point/NMI to settle a VPP facility for some services while sampling from some sites may be suitable for others. **Outcome:** Under the existing WEM rules the DSO and DMO will not have full visibility on how assets are performing. **Outcome:** There is a threshold at which the DSO and DMO require visibility (at each NMI or at what facility size in MW) questions remain around the point at which off-market portfolio optimisation needs to be considered as a service itself in terms of net energy variations from baseline forecasts. That is, when does an 'optimised' customer behaviour become the new normal from a forecasting perspective. **Lesson:** There needs to be a unified framework for the procurement of market services (see lack of alignment between AOS/NSS/NCESS drivers, processes and outcomes) and a clear transition pathway from existing processes to future arrangements **Lesson:** The existing regulations do not adequately capture or detail small aggregation' as a facility class. **Lesson:** Symphony will not provide clarity on the facility size/threshold question.
4	Policy and Regulation – Dynamic Operating Envelopes	**Benefit:** Project Symphony has tested publication of DoE's at the NMI in 5-minute intervals **Barrier:** A cost benefit has not been conducted against applying the DoE at the asset or transformer. **Barrier:** Low penetration of aggregation on the	**Outcome:** Subject to Project Symphony final outcomes: • Operating Envelopes calculated for each NMI • Operating Envelopes published for each 5-min interval **Outcome:** Calculating DoE's at the NIMI has been feasible however, further consideration is required of the costs and benefits of starting at a high

		Symphony feeder reduces the effectiveness of DoE's being set at 5-minute intervals.	resolution. **Lesson:** 5-minute settlement will become the norm in 2025 when high penetration of aggregated DER exists, but 30-minute intervals are likely sufficient and more economic up until that time. **Lesson:** A transitional approach to be considered as DER technical capability improves, standards become clearer, and customer participation increases. This approach allows the DSO and aggregator time to plan, develop and scale platforms without delaying implementation of less complex participation services.
5	Policy and Regulation – Dynamic Operating Envelopes	**Benefit:** In Project Symphony the DSO has defined the DoE and the Aggregator has applied it to the device. **Barrier:** Whilst the process is working well within the scope of Project Symphony, an explicit monitoring and compliance framework around application of a DoE do not exist and need to be fully considered.	**Outcome:** While the DSO has monitored performance against the DOE, no compliance process has been applied. **Outcome:** Current policy position for DOE Compliance approach: • For export limits, FRMP responsible for applying the DOE at the NMI • For import limits, Aggregator responsible for applying DOE • Where no Aggregator present, DOE not applied • DSO responsible for monitoring and enforcing compliance with the DOE by the aggregator as the ETAC holder. • DSO not responsible for policing compliance with the DOE at the device. **Outcome:** DMO has no direct role in DOE application. **Lesson:** Symphony found no reason to change this approach. • Compliance by the DSO with requirements for calculation and publication of a DoE will need to be formalised within a regulatory instrument similar to other network performance measures such that it can be used to demonstrate cost effective

			management of network constraints and facilitating market access by DER. **Lesson:** A monitoring and compliance framework around application of DOEs at the device by the Aggregator/FRMP needs to be considered further and is not within scope for Symphony to inform.
6	Policy and Regulation – Aggregation	**Benefit:** For Project Symphony the B2B transfer of data has been though existing billing processes. **Benefit:** Standing data for 5-minute ToU settlement has also been provided. **Barrier:** The aggregator as the retailer can only obtain historical data where AMI exists. **Barrier:** Potentially insufficient granular data.	**Outcome:** How the exchange of historical meter and other energy data will be facilitated to enable aggregators to access the data. **Outcome:** Customers can provide their own historical data to an aggregator if they have it. **Lesson:** Where the aggregator is the retailer, existing transfer of billing data may be sufficient in operating a VPP. Where there is limited access to historical interval data, proactive targeted recruitment of customers into a VPP becomes more difficult. **Lesson:** Aggregators require access to a DER register that clearly provides information on the make and capacity of installed DER to understand what is connected and what could potentially be aggregated is important for legacy fleet. **Lesson:** There could be an expansion in the assets that are currently managed through the DER register, for example air-conditioning and EV charging equipment.
7	Policy and Regulation – Aggregation	**Benefit:** Project Symphony is testing the technical capability of an Aggregator to value stack and the ability for a VPP to provide multiple services concurrently	**Outcome:** Approach to be taken to prevent 'double dipping' (where aggregation provides payment for similar existing services) **Outcome:** Symphony will test if aggregators can receive compensation twice for providing the same service. e.g. exporting energy to deliver an NSS and BMO or ESS. **Lesson:** Value stacking of services should be possible without creating an environment where an aggregator is compensated twice for providing the

			same service. **Lesson:** Further clarification of WEM rules around the small aggregation facility class for VPP's is needed to enable them to value stack effectively.
8	Policy and Regulation – Registration & Aggregation	**Benefit:** Project Symphony has tested VPP capability to register a dispatchable facility in the WEM environment.	**Outcome:** How VPP facilities will be certified has yet to be determined as the facility visibility issue will need to be resolved. **Lesson:** Network switching can impact the make-up of a facility **Lesson:** There needs to be a flexible or dynamic nature to how VPP facilities are registered in the network.
9	Policy and Regulation – Essential System Services	**Benefit:** Symphony has tested aggregator spot trading or re-bidding based on current availability to test DER providing FCESS. **Benefit:** Project Symphony has installed over 100 HSDR to measure FCESS service delivery. **Barrier:** A HSDR on each BTM battery is not expected to be cost effective or physically practical at scale. Alternatives will need to be considered.	**Outcome:** Symphony, along with other VPP market trials, to inform whether the requirement of DER aggregations to meet a Dispatch Target will be amended to allow such facilities who cannot control their output, such as hybrids and DER providing FCESS. **Outcome:** The capability of the facility will drive which services it can participate in. **Outcome:** The outcome of Project Symphony will be to provide recommendations based on capability demonstrated. This may mean a new facility class or criteria specific to DER aggregations that may enable them to participate in a service. **Lesson:** There may be future answers for optimization options **Lesson:** Parent aggregator needs forecasting ability and mechanism for fast submission to AEMO.
10	Policy and Regulation – Standardised Protocols	**Benefit:** Project Symphony is testing a VPP under proprietary communication standards. **Barrier:** Cost and complexity associated with aggregating assets with different standards.	**Outcome:** Standards and protocols that govern communication between the Aggregator and devices in a VPP. **Outcome:** There are large inconsistencies with the standards being used between devices.

		Barrier: Consider complexity of API level standards.	**Outcome:** Scalability has been impacted by not having uniform standards. **Lesson:** A more predictable interoperability standard is preferable. **Lesson:** Commercial risk over time is increased without a universal standard. **Lesson:** Establish a clear pathway to implementing a standard for communications to provide a clear signal to manufacturers.
11	Policy and Regulation – Standardised Protocols	**Benefit:** Project Symphony considered multiple failure scenarios, including: • WP systems fail and operating envelope fails – a standard DoE will be applied • If the aggregator platform fails, then a default DoE is deployed at the gateway device so it can continue to orchestrate behind the meter. • Loss of communications • Cyber threat risks **Barrier:** The lack of standardised communication protocols or responses increased the difficulty of planning for failure scenarios.	**Outcome:** Clarify what standards and rules should be placed on VPPs and equipment to mitigate against loss of communications. **Outcome:** If the gateway device fails, the inverter doesn't have a fail-safe. Fall back is compliance with AS777 protocols. **Lesson:** All inverter devices should have a uniform fail-safe mode where the DoE is stored within the inverter itself. **Lesson:** Implement improvements in minimum equipment standards to include behavior around loss of communication. **Lesson:** Symphony believes that this needs to be captured as part of device compliance during the connection process.
12	Policy and Regulation – Tariffs and contracts	**Benefit:** Project Symphony provided learning on customer contracts for VPPs. A bespoke contract was created to enable opt-in to the pilot. **Benefit:** The Symphony aggregator has also contracted with 3PA which has provided learning.	**Outcome:** There would be benefits if bilateral contracts were part of the standard form contract. **Outcome:** Changes required to the retailer and network operator licensing framework to protect customers from risks with entering contracts with aggregators. **Outcome:** Use of the existing consumer tariff meant that negative bill impacts for customers were likely

		Barrier: The contract is opt-in only so had limited application for scale. **Barrier:** 3PA currently must contract through a parent aggregator. **Barrier:** Explore intrinsically arising value of aggregation for customers and that values division between customer and aggregator, including peak reduction. **Barrier:** While customers were offered incentives to participate, specific aggregation tariffs were not tested as part of the project to reduce complexity.	greater than under an aggregation product due to increased energy imports to charge batteries and reduced exports due to PV curtailment during the testing process. **Outcome:** Customer responses to aggregation products were not able to be tested as they were out of scope. **Lesson:** The customer standard form contract does not include recognition of bi-directional services. Updating to recognise these services as default could ease recruitment and reduce contractual complexity for VPPs. **Lesson:** Recommend changes to the heads of power agreement for standard customer contracts recognise and enable bi-directional purchase of energy services. **Lesson:** 3PA customer protections need to be understood in more detail to ensure the right setting and standards are in place when participating with parent aggregator. There is likely benefit in establishing minimum requirements for 3PAs as part of the Alternative Electricity Services framework. **Lesson:** There is benefit in standardising customer protection across parent aggregators and 3PAs. **Lesson:** Protections should be implemented to provide protection for 3PAs when engaging with Synergy as the sole market facing entity for non-contestable customers. **Lesson:** Further testing is required around customer aggregation products to improve understanding once technical capability can be cleanly implemented.
13	Policy and Regulation – WEM & NSS Dispatch	**Benefit:** Project Symphony tested dispatch of NSS via the DMO. **Benefit:** Facility registration in Symphony	**Outcome:** Symphony will inform how NSS can be provided by a subset of connection points within a registered also providing WEM services. **Lesson:** Further information from test and learn is required to provide

		enabled a single facility to provide multiple services. **Barrier:** Inability to recruit required AC numbers or capacity on a transformer to effectively measure NSS over a long term and during peak network stress periods. **Barrier:** The 90-day period for test and learn and delays in commencing the test and learn period limited the ability to test NSS over a long term and during peak network stress periods.	learning. **Lesson:** Additional testing on NSS recommended during real network peak conditions as an extension of, or post Symphony.
14	Policy and Regulation – WEM & NSS Dispatch	**Benefit:** In Symphony unplanned outages have been managed by providing a default DoE. **Benefit:** In Symphony outages have occurred due to planned switching of the network. **Barrier:** Potential to define comms channels, real-time and/or what level of timeliness is needed **Barrier:** Not tested in peak demand seasonality	**Outcome:** Symphony to inform the way distribution network outages and network switching issues will be managed. **Outcome:** DSO to provide network switching information affecting Electrical Location of connection points that are part of a Small Aggregation providing WEM services. **Lesson:** The DSO needs to communicate switching in a manner that allows the aggregator to maintain control of the facility. **Lesson:** DSO to provide network switching information affecting Electrical Location of connection points that are part of a Small Aggregation providing WEM services to the aggregator. **Lesson:** DSO needs to have the capability to update DOEs in a timely manner to reflect forced outages in the distribution network.

* previously identified as a barrier but additional outcomes and/or lessons have been identified

4.7. Lessons Learnt – Other

No.	Subject / Topic	Barrier OR Benefit	Outcome and / or Lesson
1.	Other Document Control and Management	**Barrier:** Maintenance of folders and permissions between the participants / PMO over a multi-year program of works is difficult.	**Outcome:** Each participant established their own folders within their own environments for quick and easy access however, this negates the ability for participants to access required information. **Lesson:** Find and implement a records management system that easily facilitates cross organizational access.

5. Appendices

5.1. DSO Lessons Learnt from Work Package

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6.6 DSO Platform Build Lessons

The following sections highlight early project lessons identified during the DSO Platform delivery phase of the project. They have been grouped under four sections:

- **Build to facilitate Test and Learn:** Issues and/or areas that impacted the enablement of Test and Learn for the DSO Platform.
- **Ability to Scale:** Issues and/or areas to be addressed to support future scalability of a DSO Platform.
- **Process Improvement:** Identified areas where DSO capabilities require review and improvement to support a future DSO; and,
- **Maturity and Supportability:** Issues and/or areas to consider that impact future support and management of the DSO Platform as-built solution.

6.6.1 Build to facilitate Test and Learn

Issues and/or areas that impacted the enablement of Test and Learn for the DSO Platform.

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	Symphony Network Model	**Benefit** During the earlier stages of the Test and Learn (T&L) phase of the Pilot, it became apparent that the DOE resulting from spare hosting capacity was higher than the total capacity of the DER assets. This prevented the Aggregator from successfully demonstrating that DER could remain within the DOEs while providing market services. The Symphony network model, enabled the project team to artificially make changes to the network ratings, such as lowering the distribution transformer (DSTR) and cable impedance ratings, without impacting Western Power's business as usual network model. **Benefit:** The DSO platform developed it's own network model that allowed it to enter certain DER assets, for example Symphony BESS, manually without impacting the BAU procesess.	**Outcome:** Alterations to the Pilot network model's import side of the network ratings generated the expected DOE constraints and allowed testing of DOE compliance for export. However, these changes led to unforeseen DOE compliance problems as a rules-based DOE QR Checker failed because the Import Ratings were too low, causing DOEs to not be published until the rule was disabled. **Lesson:** Keeping the Symphony network model isolated from the Western Power BAU Network Model will allow the project to reach its Test and Learn objectives. It is recommended to consider Test Objectives during the platform requirements phase of the project to allow flexibility in the future. **Lesson:** To avoid breached DOE compliance on the export side in the future, the network model could be altered to feature two different ratings (one for

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			import and one for export) to avoid potential future consequences.
2	Alignment to Enterprise supported technology and support models	**Benefit:** The DSO's approach in developing the solution modules enabled the DSO Platform to focus on the Design principles "Learning over Obstacles", as well as "Minimum Viable Product" to obtain the learning outcomes faster. **Barrier:** The Pilot DSO Platform was designed and built operationally independent from core Western Power BAU business systems and processes. As a result, Western Power BAU Support Process did not support several technologies included in the 'as-built' DSO Platform.	**Outcome:** The DSO Platform established its own Support and Maintenance team to manage technical assistance requests, troubleshooting issues, and new feature requests/enhancements according to its Service Level Agreements. **Lesson** It is important to ensure that business systems and process are operationally independent to not impact enterprise technologies during the Pilot, as well as ensure that the governance regarding corporate and technology strategy, assumptions, business requirements and design principles deliver the desired outcomes. This requires careful consideration on how the modules can be deployed quickly to acquire the learnings, whilst allowing for future growth and support from Maintenance and Support teams as time progresses past the Pilot.
3	Dependency management	**Barrier:** Parallel technology build and commercial framework development had been done in order to ensure that the technology build was completed in time for the summer testing period.	**Outcome:** Difference in the technical solution that was built vs the commercial framework agreed by the DSO and Aggregator for validation of NSS compliance. **Lesson:** Complete key commercial framework items prior to the commencement of technology design and consider a co-design approach between technology and commercial teams going forward.
4	Analysis and Reporting Tools	**Barrier:** Project Symphony's data output included intricate and varied datasets which could not be supported by existing Enterprise Data Analytics Platform tools alone for Test and Learn Hypotheses test cases.	**Outcome:** A corporate server Python environment and the associated data scientist libraries were needed for the analysis of large time series datasets. **Lesson:** When first starting a project involving large data sets, it will be important to

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			consider the capabilities of data analytics toolsets in terms of their size and granularity to support the necessary statistical analysis. It is essential to evaluate these tools early on in the process.

Table 10: Build to facilitate Test and Learn Lessons

6.6.2 Ability to Scale

The Pilot DSO Platform was designed and built with an objective to deliver Learning Outcomes and as such, components of the design and build may not scale.

Issues and/or areas to be addressed to support future scalability of a DSO Platform.

Table 3: Ability to Scale Lessons

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	Functional Aspect to Scaling the DOE Calculator Module	**Barrier:** The development of the Pilot was centred around a single urban 22kV distribution feeder from the Southern River Zone Substation named "SNR 540". Characteristics of this network included: • High penetration of grid-connected solar photovoltaic power systems, • Large percentage of modern dwellings, • Serviced by majority underground power infrastructure, • Low number of commercial service connections or HV meters, • High level of advance metering infrastructure (AMI); and, Subsequently, modules developed and tested for the DOE Platform during the Pilot may not be easily transferable to different physical network topology due to the dependence on AMI meters and other characteristics specific to SNR540, which vary between networks. **Benefit:** Focusing on SNR540 feeder enabled the project to speed up the process of acquiring knowledge.	**Outcome** The acquired knowledge provided a pathway forward to inform the potential for broader deployment of VPP and DER orchestration across the SWIS. **Lesson:** When developing a module to calculate DOE's, it is important to ensure that it is transferrable to different networks and can be used in a variety of contexts, for example, low AMI penetration, rural properties, and above ground HV and LV networks. The key learning is that when testing a DSO platform, consideration should be given to the specific characteristics of the network it is being tested on and its potential implications for transferability. **Lesson:** Before scaling, it will be important to evaluate different network topologies and characteristics.

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2	Load Forecasting	**Barrier:** The solution delivered relied on the DOE Calculator Module load forecaster (at NMI level) for: • DOE calculations: Load forecast was crucial for determining the available network capacity, which was used for DOE calculations, • Network Support Service (NSS) dispatch; Load forecast was used for determining whether an NSS dispatch was required – the capacity (MW), quantity (MWh) and timing (start and end times) However, the quality of the forecast at lower network segments such as NMI or Distribution Transformer Level was not accurate enough especially during sudden weather changes and very hot days, particularly for the Network Support Services dispatch.	**Outcome:** Inaccurate forecasting of NSS calls can lead to increased financial costs and operational inefficiencies, which could negatively impact the business and network. To mitigate this risk, a manual work around solution was implemented that relied on rules based on temperature forecast. This solution required DSO Platform users to check the weather forecast for temperatures above 35 degrees Celsius and a minimum of 20 degrees Celsius. **Lesson:** Accurate forecasting of load or demand is essential to make informed decisions and ensure operational efficiency going forward. Prior to scaling, define the level of accuracy required and test the forecast models for periods of sudden weather changes and very hot and cold days in the future.
3	DOE Calculation	**Barrier:** The Evolve Platform had calculated and allocated the publication of Dynamic Operating Envelope's (DOE) for the Pilot. Due to the need to transfer large amounts of data from the DSO Data Processing module to the Evolve Platform, and carrying out multiple power flows to assess and assign the entire DOE set (72 hours), including a high number of DER participating, a considerable amount of processing time had been required, resulting in the following scalability limitations: • As the acquisition of data can take up to two hours and current computing power needed to assess, calculate and assign the entire DOE set (72-hour forecast) for the network in the Pilot area requires up to 1 hour of processing time, this module did not allow for easy recalculation in	**Outcome:** An "exception" path had been created to enable the implementation of a short notice/ Default Operating Envelope (OE) in the event of outages, both planned and unplanned allowing, the Symphony engineer to publish the DOE in a timely manner. Evaluation is required to compare the DOE Calculator Module against the default/static seasonal Operating envelope to determine the best approach in

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		response to deviations from forecasts, network outages and unplanned switching • In addition, it had been unlikely that the other parts of the DOE calculation process were feasible for a larger solution. For example, 72-hour DOE forecast time period would mean that calculations would have needed to be done on separate versions of the Symphony Network Model to take into account scheduled and unplanned outages in other networks. **Benefit:** By having implemented the default DOE process, including custom static values, unplanned outages were quickly identified, allowing the Symphony engineer to publish the correct DOE and maintain network stability. **Benefit:** Additionally, the default DOE process that had been implemented enabled the Aggregator to recruit customers outside of the original Pilot Area in order to meet customer and DER asset targets whilst still receiving a DOE.	maintaining DOE accuracy and reducing network risk. **Lesson:** It is essential properly design and architect the solution to be able to scale up and enable DOE computations to be done simultaneously for each feeder. It is recommended to assess other possible ways to improve the speed of DOE computations without compromising accuracy and/or network security. For example, calculating and publishing DOEs at shorter periods more frequently with lower Data Exchange or partial re-calculations will result in better forecast input, and network model accuracy in the future.
4	Analysis and Report	**Barrier:** The challenge of managing the amount and complexity of data Project Symphony generated for each partner, along with the lack of adequate tools and resources to carry out Service Verification activities created a barrier to developing an information architecture suitable for a larger DSO Platform. The Western Power reporting tool lacked the ability to easily support advanced statistical techniques for large datasets. **Benefit:** The reuse of existing Western Power reporting tools and adequate monitoring of DOE and NSS compliance for the Pilot through the Reporting area had ensured that, should the DSO platform scale, transitioning the reports to enterprise teams to maintain and support will be easy.	**Outcome:** The DSO Platform users had been unable to obtain all the necessary strategic and operational performance insights from the data without using intermediary applications (other than the Western Power reporting tool), resulting in additional work and resources being required. **Lesson:** Significant resourcing will be needed in Data Warehouse design, Data Engineering and Data Analysis to maximise the business and operational

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			benefits from advanced data analysis. **Lesson:** When aiming to expand the solution, the architecture must take in account the need for Reporting, medium and long-term analysis, metrics, and key performance indicators that will be reported.

Table 11: Ability to Scale Lessons

6.6.3 Process Improvement

Identified areas where DSO capabilities require review and improvement to support a future DSO.

Table 4: Process Improvement Lessons

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	AMI Data Quality	**Barrier:** Utilising a headend system that was not created for telemetry data, the initial applications are more tolerant to communication interruptions and data losses. **Benefit:** The DSO Platform improved the 3-phase meter accuracy and reliability of data collected from service connections, which in turn improved load forecasting and service verification (DOE and NSS).	**Outcome:** The DSO platform is taking steps to investigate and resolve the component that is causing permanent PQ data loss. However, there is still a risk of not being able to verify DOE and NSS complaince and a potential decrease in the accuracy of load forecasting until the issue is resolved. **Lesson:** It is suggested that further investigation should be carried out to determine whether non-contestable customers should also move towards a 5-minute settlement in the future to help with the settlement process, as well as adhere to DOE and NSS compliance. This suggestion is in line with the plans in place in Western Australia about transitioning towards a 5-minutes settlement for contestable customers.
2	DOE Compliance	**Barrier:** The DOE Compliance Process had used AMI data to compare to DOEs for each interval and measure compliance. The processtook into account the number of NMIs that exceeded DOEs, the number of times DOEs were exceeded, how long	**Outcome:** DOE compliance was adequately measured using AMI data. Additional consideration was required to assess regulatory approval for policies or

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		DOEs were exceeded, and the percentage of DOEs breached. The resultswere reported from the perspective of the NMI and formatted to be shared with the Aggregator. Challengeshad been experienced in establishing systems to accurately monitor and report on compliance in a way that is resilient to incomplete measurement data and the potential measurement and time differences between the Aggregator measurement system (using an inverter connected power meter at the NMI) and DSO's measurement system (using the revenue meter at the NMI). **Benefits**: Early indications through test dispatches with a constrained network and binding DOE limits demonstrated that compliance performance was acceptable.	measures to apply when compliance was consistently not met. **Lesson**: Careful planning and consideration are necessary to ensure that a DOE compliance system is resilient to incomplete measurement data, differences in measurement systems, and the potential for measurement and time differences between the Aggregator and DSO systems when establishing and implementing it in the future.
3	DER Asset Standing Data Process	**Barrier**: The DER Standing data created for Project Symphony was a combination of data collected via the Western Power's DER Register and Project Symphony's participating DER data, provided by the Aggregator. This is because the existing Western Power DER Register was deemed not fit for the purposes of the Pilot, both in terms of data timeliness and completeness, due to the following reasons: • The time difference between DER's being added, uprgraded and or removed did not align with the DSO Platform requirements for dispatch schedules in the load forecast. • The requirements provided for the DER register only allowed for certain types of DER to be registered, not any type of controllable load.	**Outcome**: It was determined that in order to ensure reliability, timeliness, and completeness of data, a solution was implemented that enabled the Aggregator to send the details of the as-installed DER directly to the DSO Platform for NMIs that had been registered, rather than using the usual BAU DSO/Western Power process to inform the Symphony project. Additionally, the manual process to enter DER assets had to be to be defined in order for a larger DSO platform. **Lesson**: The Pilot Asset Standing Data process is deemed fit for the purpose of the Pilot,but further improvement is required to enhance the data collection processes to be sufficient for DER Orchestration at scale. Additionally, further analysis is required to determine the best approach to accurately record electric vehicle charger data, and assess how these types of DER, as well as other controllable DERs such as Air-Con, Hot Water Systems and

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			Swimming Pool Pumps, will affect the available network capacity. This work is expected to be undertaken through the AEMO initiated proposal[23] to amend the WEM Procedure: DER Register Information to incorporate new DER Types such as EVSE.
4	Outage Management	**Barrier:** Western Power existing processes for managing and communicating outages on the low voltage network were not responsive enough for effectively managing VPP operations, due to the following reasons: • Outage windows were often over-estimated in planning documents to provide field crews with flexibility, • Some planned outages did not go ahead as planned for various reasons, • much of the information related to planned outages was recorded in Western Power's systems in an unstructured format, including switching plans, • Western Power's GIS derived LV model was based on the "as-built" model, not the "as-operated" model, resulting in mis-alignment to the actual network state. **Benefit:** The DSO Platform had implemented the Outage Management Process for both planned and unplanned outages in order to preserve the steadiness of the network in the Pilot area. Almost in real time, outage information was utilised to warn the DSO Platform of major outages that could impact DOEs to ensure that the correct DOEs were published. Additionally, the DSO Platform had taken an innovative approach in combining "as-	**Outcome:** The process was not practical for DSO larger scale operations as it did not allow for the early identification and management of network changes that impacted Virtual Power Platform operations. **Lesson:** • The DOE calculation period needs to be shortened, for example, every three hours in order to better consider planned and unplanned outages in the future. Currently, there is a 72 hour forecast window which does not account for the numerous network changes that may occur in that time. • Investigating alternative solutions such as Network Model discovery through Neural Networks/Machine Learning or State Estimation could be done to improve accuracy of the network model, resulting in an optimised network and DOE performance. • Finally, combining the electrical network "as-switched" and "as-designed" data sources can provide a more comprehensive view of the system and the problems it will be facing. This can be especially useful when dealing with complex networks, as it will allow for a clearer picture

[23] https://www.aemo.com.au/consultations/current-and-closed-consultations/aepc_2022_02

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		switched" and "as-designed" data to get a better understanding of the network model and the load created by the NMIs connected to the PPilot area.	of the current state of the network and address any potential issues that may impact VPP orchestration.
5	Pilot Processes	**Barrier:** Several processes and associated modules had been implemented to enable data sharing for the purpose of enabling testing and learning by all project partners with the intent to meet key project objectives such as informing future scale. Thus, to inform scale some processes and integrations are not suitable to scale outside of the Pilot, these include: • **End-to-end NSS process;** The solution built did not support the tracking and change of NSS calls, and the current data model made it challenging to validate NSS provision when multiple requests were made at the same time intreval. • **Facility registration;** The solution built relied on Facility Registrations to identify customers that required DOEs. This process assumed that participants were registered to provide services in the market and as such, did not allow for flexible exports for non-market participants. The solution built may not have allowed for customers who invest in expanded PV and battery capacity as they would have been prevented from dispatching above their static inverter connection limit, except when included by their Aggregator in a facility, even though there may be have been spare network hosting capacity. • **Robustness;** Some parts of the solution would have required further hardening to sustain them beyond the Pilot. For example, currently the DSO platform is still in the "Pilot" enviroment, the DSTR monitoring virtual machine server was a single point of failure.	**Lesson:** • Review the requirements, information architecture and associated data models for their suitability at scale prior to scaling. Wherever possible, align with a National Approach such as the adoption of IEEE 2030.5 and CSIP-AUS • Consider a policy position on whether customers will need to be part of a registered market facilities to access DOEs and/or whether flexible exports can be made available without market participation. Following this, implement a separate mechanism, instead of Facility registrations, for the DSO and Aggregators to identify customers that will require DOEs. • Prepare the as-built modules for production environments, removing single points of failure, automating system integerations and implementing exception handling for integration between partners. This will ensure that the system is able to handle unexpected errors and maintain a reliable performance.

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		manual system integrations were not responsive enough in their current state and the DMO platform ignored NSS requests with Service ID's that they were unaware of.	

Table 12: Process Improvement Lessons

6.6.4 Maturity and Supportability

Issues and/or areas to consider that impact future support and management of the DSO Platform as-built solution.

Table 5: Maturity and Supportability Lessons

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	New Technology	**Barrier:** The 'as-built' DSO Platform included several technologies that were relatively new to Western Power and might not have been supported beyond the Pilot in their current state. These technologies included physical network devices, data platforms, and data routing technology.	**Lesson:** It will be essential to develop an enterprise transition plan at the outset of the process when developing new technologies in order to evaluate the scalability, upkeep, and how to progress beyond the Pilot phase.
2	Data Exchange Service	**Barrier:** The Data Exchange Service used in the PPilot was a product provided as part of the DMO Platform Vendor. A client was installed on the DMO, DSO and Aggregator Platforms to facilitate the use of this solution. The solution required all parties to have installed the same/correct version (at the same time), with limited backwards compatibility with major releases. This created difficulty in maintaining the solution as different versions were released and indicated that the solution may not have been as reliable or secure as more mature data transfer systems.	**Outcome:** This Module did not meet the DSOs solution architecture principles for Containerised Application Architecture and Open Standards Integration. The requirement to upgrade simultaneously with partner organisations impeded the ability to upgrade independently. **Lesson:** • Early enaging, aligning and agreeing between project partners on critical technology touchpoints such as integration technology is recommended to ensure future sucess. • When working with providers of innovative technology solutions that are less mature, it is recommended to factor complexity, time and risk into planning. This effort should not

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			be underestimated; for example, factor in multiple upgrades during the lifecycle in project plans and consider decoupling timelines with other projects and shared environments. When scaling, consideration needs to be given to providing the following: • The practicality of coordinating multiple organisations for release management, as part of the ongoing service management processes, will be recommended for industry wide deployment. A more streamlined, standardised deployment model similar to other web-hosted applications will be suggested.. This could be a standard DevOps type solution to automate the distribution and deployment of updates and new versions. • The cost-benefit analysis of investing in capabilities to manage the product integrations that may persist after the Pilot will be assessed, • The risk associated with not having a direct relationship with the product's supplier will increase in the future. • The architecture principles of containerised application architecture and open standards integration will be essential when scaling a solution that uses the Data exchange services in the future.
3	Absence of industry standards	**Barrier:** The lack of established industry standards, for example CSIP-AUS,	**Outcome:** The outcome of this was that the lack of established industry standards made it

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		posed a significant obstacle in the creation of a DSO platform, such as the Data Exchange Service.	difficult to develop all modules bespoke to the standard. **Lesson:** Establishing industry standards is essential for successful development of DOE platforms and services. The lack of established industry communication standards and protocols increases the difficulty of creating modules, leading to potential issues in the development process. Additionally, before beginning any large-scale project, where possible, it is important to ensure that the maturity level of the modules involved are up to industry standards and are able to be easily adapted and evolved as needed.
4	DSO Core Capability - DOE	**Benefit:** The Evolve Platform had been selected for the Pilot due to its ability to deliver the DOE Calculator module within the timeframe allocated based on prior experience as part of the evolve DER Project.	**Outcome:** While the platform had performed well for the Pilot, further analysis was required to ensure the platform and its supplier can deliver and support a robust calculation mechanism at scale. **Lesson** Having prior relevant experience will enable the DSO to complete development of technology necessary to publish DOEs within the Project Symphony timeline. To meet the DSO functional requirements, there are a number of components such as Default DOEs, NSS functions, Integration with DMO and Aggregator that will be built outside of the Evolve Platform and consideration should be provided to rationalising these components before scaling to reduce the total cost of ownership.
5	Change control process for database objects	**Barrier:** The DSO Platform Symphony Data Base and Enterprise Data Analytics Platform had received large volumes of inputs from the DMO and	**Lesson:** Deploying modern database tools, principles and administration procedures early on in the project will reduce development time, increase

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		Aggregator which was very complex and required a significant amount of resource effort in database development time and change control.	robustness and improve the quality of database management.

Table 63: Maturity and Supportability Lessons

5.2. DMO Lessons Learnt from Work Package 5

Table 23: Supporting technology of the solution components

7.7 DMO Platform Build Lessons Learnt

This section describes a range of topics and the associated outcomes and/or lessons learnt that pertained to defining and building the DMO platform solution. Whilst the content in this section is perhaps more pertinent to the scope in the ARENA Project Symphony Platform Functional and Non-Functional Requirements report, a range of topics have arisen since the development of that report. Hence, they have been included for completeness.

7.7.1 Defining the Solution

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
1	Adoption of emerging technologies and standards	**Benefit**: The selection of the two DMO principal vendors introduced a range of new technology capabilities. **Barrier**: There was a lack of fit-for-purpose DMO systems in the marketplace.	**Outcome**: A workable solution was established that demonstrated the viability of emerging technologies and approaches. **Outcome**: The solution aligned with emerging DER technology developments worldwide specific to how DER is being supported in other

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			jurisdictions. The adoption of alternative solutions may have reduced the impetus to consider the technology supporting Project Symphony.
		Barrier: There is a lack of skills and understanding of the technology in the local market.	**Outcome:** The solution required a high level of customisation to ensure if was fit-for-purpose for the Pilot.
		Benefit: Consideration of new technologies and standards will inform and shape future directions. Particularly the data exchange solution which will demonstrate concepts such as Distributed Ledger Technology (DLT), Self-Sovereign Identity (SSI) and Decentralized identifiers (DID).	**Lesson:** The impact and risks of adopting new technologies need to be assessed and mitigated as part of the early project planning and execution. **Lesson:** Initial use and performance testing has demonstrated the data exchange solution has high potential to manage the increased scale of data and higher number of participants expected to be transacted to support DER orchestration.
2	Non-Functional Requirement specification	**Barrier:** Some of the metrics used to confirm the NFR was met were inherently difficult to define given the initial use of the solution as part of a Pilot. The nature of the Pilot meant that the level of investment in technical capability precluded fully meeting various NFR metrics. Likewise, the scale and scope of the NFR was constrained in line with the Pilot.	**Outcome:** Some of the NFRs, whilst valid, were difficult to directly measure and meet. **Outcome:** The underlying monitoring and logging capability to confirm the metrics were not established or the time/cost was prohibitive in implementing them. **Lesson:** A balance between metrics relevant for a Pilot versus a production requirement to be carefully assessed to ensure the correct and appropriate definition.

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			jurisdictions. The adoption of alternative solutions may have reduced the impetus to consider the technology supporting Project Symphony.
		Barrier: There is a lack of skills and understanding of the technology in the local market.	**Outcome:** The solution required a high level of customisation to ensure if was fit-for-purpose for the Pilot.
		Benefit: Consideration of new technologies and standards will inform and shape future directions. Particularly the data exchange solution which will demonstrate concepts such as Distributed Ledger Technology (DLT), Self-Sovereign Identity (SSI) and Decentralized identifiers (DID).	**Lesson:** The impact and risks of adopting new technologies need to be assessed and mitigated as part of the early project planning and execution. **Lesson:** Initial use and performance testing has demonstrated the data exchange solution has high potential to manage the increased scale of data and higher number of participants expected to be transacted to support DER orchestration.
2	Non-Functional Requirement specification	**Barrier:** Some of the metrics used to confirm the NFR was met were inherently difficult to define given the initial use of the solution as part of a Pilot. The nature of the Pilot meant that the level of investment in technical capability precluded fully meeting various NFR metrics. Likewise, the scale and scope of the NFR was constrained in line with the Pilot.	**Outcome:** Some of the NFRs, whilst valid, were difficult to directly measure and meet. **Outcome:** The underlying monitoring and logging capability to confirm the metrics were not established or the time/cost was prohibitive in implementing them. **Lesson:** A balance between metrics relevant for a Pilot versus a production requirement to be carefully assessed to ensure the correct and appropriate definition.

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			Lesson: Confirm the availability of capabilities to support the measurement of NFR targets when the NFR are framed to ensure they can be adequately measured.
3	Vendor relationships	**Barrier**: Although the two principal DMO vendors had relevant experience and track record, they had not previously been engaged to deliver a combined commercial or technical solution. Relationships needed to be established as a necessary prerequisite to undertaking the Pilot. **Barrier**: No integrated software delivery platform was available to support both vendors.	**Outcome**: The adoption of two separate vendors with no previous relationships added complexity and time to the delivery of the Pilot. **Lesson**: The impact and risks of adopting vendors with no previous history would need to be assessed and mitigated as part of any project planning and execution.
4	Alignment with Technology Standards	**Barrier**: The DMO technology standards and patterns imposed a set of requirements on the vendors, which was different to the standard technologies they typically used. **Benefit**: Alignment with technology standards provides benefits such as efficient support and operational activities. The adoption of standards also provided economies of scale, reduced security exposure, etc across the enabling platform(s). Alignment with standards would also facilitate the transition from a Pilot to a more production capable solution	**Outcome**: The requirement to adopt a different set of enabling platform technologies introduced additional risk, cost, and time to the delivery. Vendors had to adjust / augment their delivery/technical resources and practices to deliver solutions. **Lesson**: The impact of technology standards and patterns on vendors be established and factored into the project plan and approach as early as possible.

Table 24: Lessons Learnt: Defining the Solution

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7.7.2 Delivering the Solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering delivering the DMO's solution for Project Symphony.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
1	Multiple repositories across DMO & vendors	**Barrier:** DMO managed its design and technical artifacts within its own document management systems. Artifacts needed to be duplicated across all vendor & DMO document management systems	**Outcome:** The DMO had to manage multiple repositories and ensured duplicated documents were maintained. This caused additional effort for version control and artifact management. **Outcome:** Despite multiple repositories, a set of shared documents were developed and maintained to keep the solutions aligned (principally in integration) in lock-step with each other. **Lesson:** A single repository for technical documentation could be adopted and shared across DMO, partners and vendors.
2	Awareness of delivery delays	**Barrier:** A framework for communicating and tracking key dates and requirements was established to ensure there was a common understanding with vendors. However, notification of the inability of vendors to deliver capability was often late in the testing planning and mobilisation activities.	**Outcome:** Testing planning and coordination activities had to be modified, which resulted in project delays and additional costs. **Lesson:** Ensure that the awareness and communication of the delivery timeframes, requirements, and completeness (entry/exit) criteria are well defined and communicated.
3	Incremental delivery approach	**Benefit:** To support a rapid test and learn process and to provide rapid feedback to Project participants, an incremental delivery approach was adopted in which capability was progressively	**Outcome:** Some early design decisions and specifications had to be reversed as a more comprehensive solution was delivered after delivery limitations were identified. In some cases, the original intent of the DMO's

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
		delivered across the hybrid business "ecosystem". **Barrier:** Early design decisions and specifications had to be reversed as a more comprehensive solution was delivered. **Benefit:** Incremental delivery supported the ability to provide rapid feedback on the suitability of the overall solution, and to assist in the evolution of the overall solution and market. Functional enhancements and defects were identified earlier in the delivery process. These items could then be incorporated into subsequent solution iterations. **Benefit:** The test and learn process was able to commence early in the process to assist in the delivery and confirmation of capabilities delivered.	approach/solution had to rebuilt/refactored as the project progressed. (For example, the original intent was for the Aggregator to dispatch from the DI but was changed to dispatching off pre-dispatch).
4	Deployment in non -production environments	**Barrier:** To reduce costs and to maximise flexibility in code delivery and solution configuration, the DMO solution was delivered and operated from a test environment rather than production environment. The standard monitoring and logging technologies deployed in a production environment were not available to the project (imposing additional costs and support overheads).	**Outcome:** Monitoring capabilities were not in place to rapidly identify issues such as lack of data delivery which impacted test and learn activities. Manual monitoring and invention were required as a result of automated monitoring and alerting capabilities not being in place. **Lesson:** The rationale and implications of this deployment approach needed to be communicated to partners to ensure expectations and a shared understanding of the

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			benefits of cost and flexibility in code and solution vs. the processes and disciplines of a production environment is required.
5	Visibility of Vendor's System Integration Testing (SIT) Outcomes	**Barrier:** Vendors' SIT approach and outcomes were not made visible to the project team in the early part of the project. As a result, the completeness of internal testing before release was unclear which had adverse impacts. **Benefit:** In response to these challenges, a robust three phase process was established: • The DMO developed a list of test requirements • The vendor would take this information and develop a detailed vendor SIT plan. The vendor executed a walkthrough of the testing (live or a recording) according to the test plan	**Outcome:** Some gaps in the solution were exposed during cross SIT in the QA environment and other testing, resulting in delays and additional costs. **Lesson:** Robust vendor-related SIT processes are established early in a project, which also produces auditable evidence of the vendor's SIT outcomes.
6	Different projects shared the same environments	**Barrier:** Two projects, Project EDGE and Project Symphony, shared the same underlying infrastructure and solutions. This created delivery complexities due to each project's schedules. **Benefit:** The overall cost to the DMO was lower than otherwise would have been the case. **Benefit:** The sharing of the same platforms enabled developments to be shared across both projects (where there was common needs),	**Outcome:** The shared environment created a direct set of dependencies between the project influence and the project execution and timing of both. **Lesson:** Ensure the impacts and implications are fully explored at the commencement of the two projects that share common infrastructure to understand delivery dependencies and impacts.

Table 25: Lessons Learnt: Delivering the Solution

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7.7.3 Supporting the Solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering supporting the DMO's solution.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
1	Deployment automation	**Barrier:** The vendor solution did not easily support the use of a Continuous Improvement /Continuous Delivery (CI/CD) pipeline. Manual intervention was required to promote software changes to the test (and QA) environments.	**Outcome:** Operational overheads were higher when CI/CD pipelines could not be used – this also impacted the ability to support automated code inspections. **Lesson:** In line with modern practices, ensure that software can be deployed in via a CI/CD pipeline primarily to support a DevSecOps approach which that underpinned the delivery of the Pilot (and supports the cyber security obligations of the DMO).
2	Configuration consistency	**Barrier:** The configuration between the development and the test/QA environments were different for a period of time.	**Outcome:** Software migration issues and testing outcome misalignment between the different environments created additional support and testing issues until the root cause was identified. **Lesson:** Ensure appropriate documentation, configuration and change management across all technical environments. **Lesson:** Ensure all the correct environments are in place for managing the migration of code through to a "production" environment. For example going from QA to trial without a "pre-prod" env that mirrors "production" (i.e. the trial environment).

Table 26: Lessons Learnt: Supporting the Solution

In partnership with:

5.3. Aggregator Lessons Learnt from Work Package 5

8.4 Aggregator Platform Build Lessons

It is not within the scope of this document to address non-build project facets such as customer sentiment or the viability of commercial models. The following "Lessons Learnt" are specifically limited to the activities undertaken by Synergy to design and build an Aggregator platform for Project Symphony.

8.4.1 Project Management

Project Management lessons reflect on the way the project's build activities were scoped, scheduled, and controlled.

No.	Topic	Benefit / Barrier	Outcome / Lesson
	Scope Control	**Barrier:** The delayed scoping of Third-Party Aggregators into the platform design impacted the build and develpopment of the platform which resulted in a significant increase in requirements mid-project. **Barrier:** Engaging suitable and willing Third-Party Aggregators was difficult as many potential DER asset operators are asset providers with a focus on site-specific behind the meter optimisation,	**Outcome:** The Third-party Aggregators scope added significant complexity to existing processes and solutions, including: agreeing API contracts for automation; sharing TNI/NMI mapping and identifying recruitment geographies; exchanging asset information for DMO requirements; and obtaining "after

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	rather than managing larger aggregations of DER assets.	the event" reconcilation telemetry for DER asset performance. The contracts with platform providers had to be re-negotiated to define the scope, functions and timing and the need for Synergy to develop a bidding model for Third-Party Aggregators, to determine the best time to incorporate their DER assets into market transactions, added further process complexity. **Lesson:** Having a in-depth understanding of third party aggregator functional and non-function platform requirements is essentail as part of intial plaform scoping. The introduction of significant new functionality mid-build leads to both (a) significant rework of existing solution components, and (b) challenges with resource allocation and scheduling.
Methodology	**Barrier:** Use of different project management methodologies between the Project Partners: Agile and Waterfall.	**Outcome:** The key principles of both methodologies are not consistently applied between Project Partners, leading to some frustration in application, confusion and delays due to re-work. **Lesson:** Attempt to document, agree, communicate, and apply the project management methodology for the overall program upfront. Funding models which better reflect the uncertain nature of developing technology pilots could be considered.

Table 37: Project Management lessons

8.4.2 Aggregator Platform Development

Aggregator Platform Development lessons address the actual construction of an integrated platform for supporting Aggregator functions.

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No.	Topic	Benefit / Barrier	Outcome / Lesson
	COTS / SaaS Capabilities	**Benefit:** The utilisation of SaaS platforms decreased the time to deliver solutions, both from a operations perspective and a functional perspective.	**Outcome:** Operationally, there were no lead times for procurement and installation, along with a reduced scope for support activities. Functionally, the ability to leverage vendor experience, based on a larger (international) industry exposure, was beneficial in exploring potential solutions to requirements. **Lesson:** Using "best of breed" solutions provided a richer set of capabilities overall, than would have been possible with a single platform approach.
	COTS / SaaS Capabilities	**Barrier:** SaaS solutions - even best of breed aren't feature complete enough to support the new market participation ecosystem explored by Project Symphony. A particularly evident expression of this issues is access to orchestration and telemetry data in SaaS platforms. **Barrier:** SaaS platforms are set up for limited sharing of real-time data at scale. **Barrier:** SaaS platforms may need improved enterprise integration capabilities to support up-stream reporting and asset visibility, management and analysis. **Barrier:** SaaS platforms currently focus on industrial automation boundaries, as such Synergy needed to develop a significant element of bespoke platform behaviour to fill the functional gaps not provided by COTS solutions. **Barrier:** Much of the market specific behaviour (e.g., forecasts, bids and offers, DOE instructions) required bespoke development.	**Outcome:** Vendor solutions are largely designed as "stand-alone" solutions or as with the intent of being integrated in a suite of solutions with different market roles and responsibilities. SaaS solutions focus more on an extension of traditional industrial automation boundaries. While "best of breed" has capability benefits, it comes at the cost of requiring custom development to deliver end-to-end interoperability and to supplement market specific behavoiurs. There are limited standards in the market integrated space, and integration is a significant effort. **Lesson:** SaaS vendors plays a role in delivering DER into the market, but significant gaps remain for supporting market operations. **Lesson:** There is an opportunity for SaaS players to expand their capabilities. **Lesson:** Aggregators will need to plan and scope for the effort required to build market capabilities as part of the expansion of DER. **Lesson:** Aggregators will need to develop significant components of the solution stack while

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			waiting for vendors to recognise the opportunity and develop their solutions.

Table 38: Aggregator Platform Development lessons

8.4.3 DER Assets

DER asset lessons address the physical activities of installing assets and once provisioned, maintaining connectivity and control.

No.	Topic	Benefit / Barrier	Outcome / Lesson
	Integration	**Benefit:** Use of a local Gateway Controller provided additional services not available through an OEM cloud API control approach. **Barrier:** VPP control requires asset re-selection as the optimisation platform attempts to control assets that were either slow to respond or failed to respond effectively. When assets don't respond to event instructions in a timely manner, or at all, the platform is obligated to frequently update its strategy, leading to less than optimal operations.	**Outcome:** Lack of availability of qualified/competent installers resulted in repeat site visit to complete work, and delays in commissioning DER assets into SEMS. Lack of support for emerging standards for controlling DER assets made connecting vendors and models more onerous, as edge devices needed updates to interact with specific assets. Once assets were commissioned, a number of issues were noted, including: • Some published peformance specifications for DER assets did not match testing performance results. • Residential grade assets provide more variable level of performance than would be expected in industrial grade assets • DER assets can become disconnected, and depending on the cause of the loss of connectivity, require a truck roll to resolve. • Each DER asset can only be controlled for a single market service, at one time however the facility can be used for multiple services. • Quality of DER asset health (responsiveness, availability) is an issue for control of achieving optimal VPP performance. This is a factor that needs to be considered. **Lesson:** Improved conformance to relevant industry standards will reduce the

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			cost, effort and time to test and incorporation DER assets into VPPs. Optimisation requires attention at the aggregate and device level, and significant attention in tuning to deliver services reliably
	Local Asset API standards	**Barrier:** DER assets expose APIs for control monitoring, but the APIs are typically vendor/model specific.	**Outcome:** There is a lack of consistent and uniform implementation of proposed industry standards (e.g., IEEE2030.5, CSIP-AUS) for local asset APIs. A "plug and play" model for DER assets is not currently available, and consequently significant effort can be required to integrate each new vendor/model. **Lesson:** Improved conformance to relevant industry standards will reduce the cost, effort and time to test and incorporation DER assets into VPPs. State and federal government agencies have a role in helping to drive down the cost of implementation of DER by working collaboratively with vendors to agree and implement consistent API standards within their on-site assets. Refer to ARENA's Distributed Energy Integration Program[35]
	Communication Network Services	**Barrier:** DER assets typically lack a full suite of network and cyber-security services, assuming the customer's network will provide those controls (such as firewall-based traffic segmentation).	**Outcome:** Given that the DER assets are also joined to the customer's home network for other network services (such as DHCP) the Gateway Controller must also be joined to the customer's network to establish access to the IoT asset. **Lesson:** DER asset device manufacturers will need to improve their network services and cyber-security capabilities, to enable multiple network domain connectivity (e.g. via virtual network interfaces), and in the process offer better separation of DER asset network traffic between the

[35] https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/

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			Gateway Controller (for control) and the customer network (for OEM monitoring). Needs to align with national cyber security standards.
	Costs	**Barrier:** The per-site commissioning costs to establish physical connectivity with DER assets, and the on-going site-based license model offered by SaaS vendor platforms, are both significant.	**Outcome:** Widespread integration of DER assets into the network will be cost prohibitive if the site commissioning and on-going licensing costs are not materially reduced. **Lesson:** Work with DER asset manufacturers and SaaS vendors to encourage greater interoperability between DER assets and gateway controllers through uniform adoption of technical and API standards. Explore alternative licensing models with SaaS vendors for grid-scale management of DER assets, conditional upon greater standardisation.
	Industry API Coverage	**Barrier** Alignment with industry APIs for DER has proved problematic across two axis: Vendor support for existing standards – such as IEEE2030.5 & CSIP-AUS – is incomplete. Where API standards do exist, they are focused on individual asset control and monitoring.	**Outcome:** While usage of CSIP-AUS is a goal, the reality currently is that many of the DER assets encountered at sites required vendor and model specific adaptors or configuration. There are capability gaps in API standards for DER aggregation and optimisation at higher levels of aggregation (such as sites, VPPs and market facilities). In the absence of relevant standards, Synergy has had to work with individual vendors to define behaviours and agree interoperability contracts. Both the incomplete support for existing standards, and the lack of standards in some areas, contribute to increased development and operational costs. **Lesson** DER management and control would benefit from developing interoperability standards for orchestrating and optimising at higher levels of aggregation. Further work is

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			required in this area to align vendors and industry participants. Support amongst vendors for existing standards needs to be encouraged or mandated.

Table 30: DER asset lessons

8.4.4 Operational Experience

Operational Experience lessons address *preliminary* insights from the day-to-day monitoring and control of DER assets in both Test and Learn and Stability phases. These observations may need amendment or revision as greater operational experience is gained by all participants.

No.	Topic	Benefit / Barrier	Outcome / Lesson
	Scalability	Barrier The current command, control and telemetry reporting approach to DER assets may not scale.	Outcome: Early indicators of concern include: • Processing large DOE instruction payloads that bundle mutliple DOEs over multiple days cause system load and processing challenges in the selected Aggregator solution. • Central control requires detailed customer telemetry data to be provided to the Aggregator. Telemetry reporting data volumes grow proportionally as larger numbers of sites are brought into the system, causing increasing load and processing challenges. Confirmation of DER asset response is required for VPP control. Symphony's design of a central command control may not scale as more VPPs and DER assets are brought into operation, leading to delays in receiving and processing confirmations. Lesson Further investigation is required around how to keep data and optimisation control closer to locally distributed control nodes. While a centralised command and control model works in an

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			environment that consists of a small number of industrial scale generation assets, it may prove problematic as a model for controlling localised DER assets at scale.
	Forecasting	**Barrier:** Designing VPPs around local geographical regions tends to amplify impacts of local variability (e.g.,cloud cover affecting all PV at the same time), impacting on the ability to achieve accurate VPP forecasts over short timeframes.	**Outcome:** The VPP Operational demand and capacity has been observed to diverge from forecast. Key variables impacting VPP forecasting accuracy are the short term impacts of local weather conditions impacting solar PV and unanticipated short term customer load. To operate a VPP optimally, the forecasting needs to be accurate and revised regulary. An example to improve the accuracy of the forecast, the inclusion of the latest Aggregated telemerty should be factored into the calculation and reset every hour or 5 minutes. **Lesson:** Structuring VPPs to distribute DER assets over larger geographic regions or customer profiles would also help to lessen the impact of transitory local conditions.

Table 40: Operational Experience lessons

5.4. Common Outcome or Lessons Learnt from Work Package 5

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9 Common Outcome or Lessons Learnt

This section describes a set of topics and associated outcomes and/or lessons learnt that relate to the overall Project Symphony end-to-end solution.

9.1 Defining the solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that pertained to defining the overall solution.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
	Understanding of the end-to-end market	**Barrier:** As the test and learn process was undertaken, it was apparent that the interpretation of the end-to-end market operation as a coordination mechanism was not consistent across all the partners despite the work done in the development of the architecture, use cases, design and testing. **Benefit:** A range of mechanisms were established to facilitate alignment. For example, joint design sessions to scope the platform build through working groups enabled: alignment of understanding of new concepts, resolution of technical issues, collaboration in test planning	**Outcome:** The implementation of individual partner solutions resulted in misalignment. A lack of understanding of each other's data requirement needs did not factor in the extended enterprise / intra- organisational, operational and data requirements, resulting in delays to test and learn processes and additional project costs. Challenges were encountered as a result of the delivery / build learning curve. The approach to / exploration of each partner's hypotheses was not clearly understood, and this resulted in initial misalignment during the project, which was resolved over time. **Outcome:** A set of run sheets to provide a more detailed view of different business events was developed to increase holistic understanding of business events / transactions. **Lesson:** Ensure that an understanding of the overall market operating model, processes, and rules of the DER market across the partners. **Lesson:** As the nature of the DER market characteristics evolved, partner understanding, and awareness were kept in lock step with this evolution to ensure the capabilities being delivered remain aligned across the hybrid operating model. **Lesson:** The development of use cases shaping the solutions delivered by the

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			partners includes more detail on the underlying market context. They need to say 'why' as well as 'what'. **Lesson:** Face to face, co-located opportunities to work together be established from an early stage and facilitate (and sustain) close collaboration throughout the project.
	Understanding of how the solution would support the Pilot	**Barrier:** The early use case shaping processes could have included more discussion and feedback on the broader purpose of market and power system operation, and the changes outlined in the DER Roadmap, to avoid misalignment later in the delivery of the project. Various collaboration activities (such as the joint design sessions) had sought to provide a holistic view of the market from the perspective of all actors. This included amendments being Piloted which were consistent with holistic operation as defined in the hybrid operating model. These activities proved to be insufficient.	**Outcome:** The early use case shaping processes could have included more discussion and feedback of the broader market context to avoid misalignment later in the delivery of the project **Outcome:** Business process and information flow was not understood at the level of detail to ensure the successful execution of the test and learn process **Lesson:** Incorporate additional business rules that exist in the current market, or expected to exist in the reform market, to guide participant behaviour. The benefits of this approach need to be weighed against the impact of limiting the scope of T&L activities and the learning that could be attained from attempting innovative approaches
	The lack of an end-to-end solution design for all partner solution	**Barrier:** E2E system process and data flow was not understood at the level of detail to ensure the solutions delivered by all three partners could successfully execute the test and learn processes	**Outcome:** DMO, DSO and Aggregator vendors completed solution design independently. Integration and capability misalignment issues were only identified later, either in the development process, during cross-organisation testing of the combined functional and operational capability, or during T&L activities during the Pilot **Lesson:** Ongoing integrated system design flow to be developed to ensure that each partners platform can support end to end T&L scenarios and testing outcome.

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			Recommend that the Project Management Office have technical oversight of the end-to-end solution.
	Project resource turnover	**Barrier:** Considerable resource turnover experienced over the duration of the project	**Lesson:** Where team members leave the project their knowledge and understanding needs to be passed to their replacement. Hence knowledge management frameworks and practices need to be adopted for projects of this nature.
	Adoption and availability of emerging and new technologies	**Barrier:** For all the 'as built' platform solutions, there was a lack of fit-for-purpose solutions available in the marketplace, thus each platform solution required modification or new capability to be developed to meet the solution functional and non-functional requirements. Given the relative immaturity of some these technologies and vendors, the solutions delivered would not be supported beyond the Pilot in a production environment in their current state.	**Lesson:** It will be essential for each partner to develop a transition plan for adoption and implementation of new technologies and processes beyond the Pilot phase. This will ensure the future phased integration is planned, developed, implemented and supported appropriately to ensure adequate investment and collaboration with industry partners and vendors. This will help mitigate any adverse impacts to organisation operating systems and processes.

Table 41: Lessons learnt that pertain to defining the overall solution.

9.2 Delivering the solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering delivering the overall solution with all project partners.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
	Detailed end-to-end test entry/exit criteria	**Barrier:** The rigour and completeness of testing scenarios was less than required when more detailed testing was undertaken during the test-and-learn process	**Outcome:** Testing activities were impacted, resulting in project delays. **Outcome:** A focus on functional capability, such as system integrations, did not assess operational capability of DER using the delivered and tested functions. **Lesson:** In a complex environment that includes multiple actors, evolving

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			technology and solutions, and changing market constructs, the rigor of the testing criteria (entry and exit) needed to aid in shaping and assessing delivery risk/misalignment be known early in the project. A shared understanding of what is intended to happen, functionally and operationally, during a test and the ability to understand if it happened or not is critical to testing.
	Commercial bias	**Barrier**: More easily measured commercial outcomes shaped the focus of effort rather than the overall test and learn objectives (e.g., NSS related capabilities).	**Outcome**: Solution delivery did not cover all aspects of the test and learn process, or core delivery capability but had a bias in the design and delivery focus. **Lesson**: Ensure that overarching project outcomes drive the design and delivery focus of all actors **Lesson**: Better communication required within organisations to ensure that pilot projects maintain ongoing alignment with larger objectives and programs of work. **Lesson**: Entering the project facilities into commercial arrangements related to some project scenarios and not others distorted the design process and potentially project outcomes. Recommend taking an all or none approach to contracts can impact on project outcomes.
	Data consideration	**Barrier**: When data was exchanged in the ecosystem the underlying data was not correct / meaningful despite adhering to the syntactic requirements of the data integration payload (i.e., schema). **Barrier**: Essential data was missing for some period of the test and learn process due to gaps in capability, or appreciation for the need for such data by different partners in the hybrid business model.	**Outcome**: Testing and analysis of the overall solution was compromised resulting in project delays and additional costs. **Outcome**: The ability to identify data gaps or issues was delayed as the data had to have progressed through the whole solution before being visible in any reporting solutions. **Lesson**: Include data business rules and sample data in parallel with well-

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
		Barrier: The uploading of data into the analytics and reporting platforms was possible only after data had moved through the integration framework, been processed, and then provided for uploading into the DMO's EDP **Benefit**: The integration models provided a mechanism to understand the linage (and provenance) of the data used in the Pilot **Benefit**: The DMO EDP platform provided an effective mechanism to provide visibility of the data needed to validate the overall solution (from a DMO perspective).	defined business processes/run sheets to assist in ensuring improved integration and solution design outcomes **Lesson**: Ongoing reviews and agreement on the end-to-end view of the process and data requirements ensure that complete sets of data are provided (commensurate with the scope of the solution at that time)
	Requirement currency	**Barrier**: While the capability required by partners evolved over time and was documented, development of capabilities were sometimes based on incomplete or out-of-dated requirements.	**Outcome**: The end-to-end solution was misaligned and that only became evident during joint testing activities. The result was blockers in running test scenarios that needed re-planning and rework resulting in schedule delays. **Lesson**: Undertake cross participant desktop run-throughs of mutual processes and expectations for testing. **Lesson**: An iterative approach to incorporate learnings and associated capability into the platforms over the course of the Symphony Pilot to support the evolving definition of the DER market.
	Collaboration Systems and Tools	**Barrier**: Whilst there was a common project sharepoint that housed all project artefacts, data and information and was assessable to partners, each partner used separate collaboration tools and systems for sharing information and communicating both internally and with their vendors. Outside of meetings and email there was not an efficient method to	**Lesson**: Utilisation of centralised integrated project management, collaboration, software development lifecycle and test management tools, with robust governance capabilities to facilitate communication and development of the 3 platform solutions, would have enhanced delivery of the project, through greater visibility and traceability, reduced duplication and reduced manual documentation and reporting.

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
		communicate or provide visibility between partners. A common testing tool was used to manage testing during X-SIT and T&L, however setting it up and creating traceability was a duplication of effort already carried out in individual partner third party tools. Additionally, common software development tools were not utilised in the project across all partners.	
	Visibility of Vendor's System Integration Testing (SIT) Outcomes	**Barrier:** Vendors' SIT approach and outcomes were not consistently visible to the project teams, particularly in the early phase of development. As a result, the completeness of internal testing prior to release was unclear which had adverse impacts. **Benefit:** In response to these challenges, detailed SIT plans were developed with vendors.	**Outcome:** In delivery of the platform solution, each party encountered gaps that were exposed during cross organisation SIT's and in further testing, resulting in project delays and additional cost for remediation. With the introduction of robust internal test plans, gaps were significantly reduced. **Lesson:** Robust vendor-related SIT processes and plans should be established early in a project and shared with each party. This will provide auditable evidence and visibility of each vendor's SIT outcomes.

Table 42: Overall Lessons Learned in defining the solution

9.3 Supporting the solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering support of the overall solution with all project partners.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
	Change control and management issues	**Barrier:** Configuration and data payload changes were made by vendors without due notification of these changes to partners. Barrier:	**Outcome:** Testing and data analysis impacts as the messaging schema changed and impacted the ability to ingest data into the reporting platform. **Outcome:** Cascading impacts on partner development/delivery activities due to the requirement to have the same versions. **Lesson:** Ensure that, even in a trial/Pilot context, appropriate degree of change control disciplines and communications

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No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			are established and maintained from the outset of the project.
	Messaging extensibility	**Benefit:** The vendor platform enabled additional channels to be established with minimal effort and via configuration to support emerging Data Exchange requirements.	**Outcome:** Reduced cost to the project and rapid implementation of additional capability.

Table 43: Overall lessons learnt in supporting the solution

In partnership with: