D5.4 KS2 Lessons Learnt Report No. 4

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CERTIFICATION

As a person duly authorised by the Recipient and not involved in the day to day administration of the Project, I hereby certify that the information contained in this document is true and correct.

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1. Executive summary

This report focuses on lessons learned as a result of ARP017, through which 5B is improving its proprietary solar photovoltaic (**PV**) technology, the 5B Maverick™ (**5B Maverick**), via increased automation in both assembly and deployment.

The four key lessons for Milestone 5 of this project are:

1. The importance of pilots and rapid prototypes in proving concepts via production runs;
2. The challenges associated with navigating design standards for novel products and solutions for doing so;
3. The importance of investing in ongoing research and development (**R&D**) and the critical role that ARENA has played in enabling that for this project, as well as collaboration with industry leaders to obtain leading material technologies for long-term gains; and
4. The advantages of simplifying field operations to be local and deliverable.

2. Key lessons

2.1. Lesson Learnt 1: Proving concepts via production runs is critical

Product "design for assembly" is a critical requirement for the 5B Maverick. It is absolutely fundamental to select sub-assembly and component designs for their ability to be put together safely, productively, and consistently. This applies in both manual and fully automated assembly paradigms, and in all constructs in between.

We have learnt that (pilot) production runs are a crucial tool for testing a design in respect of its ability to meet "design for assembly" requirements. Many nuanced aspects of the interface between human and/or machine/robot operators and the physical product cannot be understood in typical design environments (eg. CAD). It may be tempting to consider a component or sub-assembly "ready" when a design is complete and prototype built. The reality is that it is only "ready" when it is qualified in an integrated production run.

Rather than accelerating towards deciding on specifics for equipment, we have learnt to let the process be proved via a production run first. It is important to give new processes time to settle, and learn from all of the potential and real mistakes before specifying advanced manufacturing equipment. This process can *feel* slow, but the work is more accurate, cost effective, and ultimately achieves the intended result faster than if a company wastes time and money revisiting equipment designs and decisions without first understanding the process as it plays out in a production run.

Category	Technical
Objective	Improve design efficiency and accuracy, through piloting, rapid prototyping and detailed process analysis.
Detail	• We should implement rapid prototyping at the concept stage to quickly evaluate outcomes, expedite informed decision-making, and accelerate final design iterations. • The devil is in the details. For instance, while developing an automated process to remove cardboard packaging from PV modules, we observed that de-palletisation involves unique challenges. These challenges include first-of-its-kind tasks,

	such as removing cardboard corners, which add complexity and extend the process time. As a result, achieving our planned throughput time of 14 seconds per module has proven more difficult due to these specific intricacies. This highlights the importance of thoroughly understanding and addressing detailed aspects of the process to meet our efficiency goals. This is why rapid prototyping and pilot production runs are essential to accelerate our final design iterations.
Implications for future projects	• **Enhanced Focus on Detailed Analysis**: Future projects will need to incorporate a thorough examination of intricate details early in the development process to identify and address potential challenges. Many details will only be learnt in the pilot production environment. • **Prioritisation of Prototyping through Production**: Rapid production prototyping will become a critical step in the design phase to quickly evaluate outcomes and make informed decisions, reducing the risk of unforeseen complexities. • **Realistic Timeframes**: Project timelines will need to account for potential delays due to the intricacies involved in unique tasks, ensuring more realistic and achievable goals. • **Improved Efficiency Goals**: By understanding the importance of detailed process analysis, future projects can better plan for and achieve efficiency targets, reducing time and cost overruns. • **Iterative Design Approach**: An iterative approach will be emphasised, allowing for continuous improvements and adjustments based on rapid prototyping feedback, leading to more refined final designs. • **Investment in Innovative Solutions**: There will be a greater emphasis on investing in innovative solutions to address unique challenges, ensuring that new processes are both effective and efficient.

2.2. Lesson Learnt 2: Navigating design standards for novel products

Designing and commercialising a new product or technology requires extensive testing, iteration, and consultations with external consultants. Often this process includes navigating design standards that were designed for other purposes i.e. not for 5B's unique requirements. Each time 5B has encountered this issue, we look at the relevant standard and find that the existing text does not give us a clear pathway forward. The interpretation of the standard will hinge on the consultant of the day, and each rabbit hole requires the company to find the expert of experts on the narrow area of focus. It is therefore difficult to make design decisions to go one way or another based on the standards.

This lack of alignment between the standard and the product can often lead to significant time spent understanding, testing, iterating, validating, and ultimately convincing consultants or decision-makers of the need to change, adapt, or re-interpret standards so that they are fit-for-purpose for the novel product.

Category	Technical
Objective	Align the design standards for telehandlers with the 5B Matador Carriage attachment
Detail	• Design standards with regards to Rough Terrain Variable Reach Trucks (telehandlers) are vague when it comes to the design of attachments, especially so when operating outside the suite of standard types. As such, interpretation of these standards by clients and third party review processes varies greatly. Design approval by the telehandler manufacturer, or an authorised representative of, is the only sure fire way of being compliant. • 5B has engaged a specialist equipment designer through a telehandler original equipment manufacturer (**OEM**) to engineer and fabricate an OEM-approved Carriage (approved with ***one*** particular telehandler OEM) combined with the 5B Load Restraint System. This will be a fully compliant solution with an off-the-shelf telehandler,

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	including Radio Frequency Identification (**RFID**) integration. This same carriage can be physically adapted to integrate with multiple telehandler makes and models. • While it is possible to build an OEM-approved, fully compliant Carriage with the 5B Load Restraint System (and 5B is pursuing that option), that type of solution is limited to only one telehandler OEM's ***model***, or a limited range of models as every manufacturer and/size of telehandler have a different hitch design. A standard slip-on solution remains the most flexible and cost effective solution given that one design can service all forklifts and telehandlers. • 5B has consulted with the Telehandler Association of Australia. The Association has reported that this uncertainty on the use of slip-on attachments has already been identified, and it is working towards updating the standards, albeit, it is still very early days.
Implications for future projects	• **Flexibility**: 5B's slip-on solution is a universal fit, able to fit all telehandlers and forklifts in a 7-12T range. This flexibility provides more options for sourcing suitable machines for a project, and also allows for increased flexibility during deployment. Specifically, a backup deployment machine does not need to be like-for-like with regards to manufacture and model type; it could be a different machine type altogether, able to complete other tasks on the project. • **Cost**: The 5B Load Restraint System by itself is approximately a third of the cost to build when compared to an OEM-approved, fully integrated solution combined with a standard carriage. When you consider the flexibility described above, the cost savings are even greater. For example, consider that the main deployment machine and backup machine were not able to be the same manufacturer. The Combined Carriage and Load Restraint System system would need to at least have different back

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carriages to suit the different systems. At worst, two separate carriages completely.

- **Other integrated solutions**: The 5B Load Restraint System is potentially not the only solution that 5B might want to slip on to a standard fork carriage. If this type of solution can be approved for use, it opens up a whole world of possibilities for installation of ground anchors and ground interface block placement, among other things, all with the use of one machine.

2.3. Lesson Learnt 3: Investing in ongoing R&D for long-term gains

Investing in long-term R&D development for the 5B Maverick has resulted in 5B staying ahead or at least at the forefront of the solar PV industry via its Next Generation Maverick development. This continued R&D work on the Maverick has been future-focused, leading 5B to stay abreast of the latest industry developments, mostly being made in China, with 5B's experts in solar being among a handful of people in Australia who are in-the-know about the forthcoming material changes.

5B has retained knowledge about industry developments as a result of collaboration, communication, and a sustained focus on understanding what lies ahead for the industry and how these changes can be applied to the Maverick. None of this would have been possible without dedicated resourcing for long-term R&D, enabled by the co-funding provided by this ARENA grant.

Category	Technical
Objective	Prototype Maverick Generation 6 (Next Gen Maverick)
Detail	• 5B's R&D development has led it to be well-positioned in terms of forecasting potential PV industry changes in material sets for modules and mounting structures. For example, there are broad industry movements (driven out of China) to change module frames to reduce the carbon footprint and costs. By understanding such alternate material sets and their supply chains we can be ahead of the broader PV industry and incorporate product improvements otherwise not possible when one is passive to the directionality of the upstream module design and supply chain (i.e. just along for the ride). • By forcing ourselves to think fundamentally about certain aspects of Generation 6 automated array assembly and by reaching upstream into the module supply chains – we have been able to unlock additional advantages outside of simple labour savings. Such upsides span areas of field reliability, yield, structural performance, DC-BOS and safety. These improvements are potentially on the leading edge of global

	PV product design. Details are therefore largely confidential at this stage, but we can give one example. One of our very large partners has seen what we are doing and asked if we would be interested in working with them on pushing to >1500Vdc string voltages. This has potential significant cost savings for large solar farms. Whilst this is a somewhat slow burn topic with the International Electrotechnical Commission (an international standards organisation that prepares and publishes standards for all electrical, electronic, and related technologies, including solar energy), the world's first (& only) 2000Vdc demo farm was installed in China in 2023, and it is an example of how we are playing our small part to push the broader industry forward (in this case by making >1500Vdc prefabricated Maverick arrays).

Implications for future projects	• 5B's advanced manufacturing in Australia is on the leading edge of materials sets, product design, automation and product value add to the customer.
	• ARENA grant funding enabled us to raise co-funding for our ongoing R&D to fund this work and drive significant R&D outcomes for a high-risk, high-reward development project.
	• Materials set changes leading to: cost improvements, reduced carbon footprint, improved product longevity, improved performance and proactively staying ahead of competitors by adopting early.
	• An integrated long-term, forward-looking design with goals to maximise value add to our assembly & deployment processes and customers. Some implications include:
	    ○ **Reduced labour:** Streamlined assembly process, reducing production time via readily achievable automation tasks. Scale up production to meet higher demand (multi GW) is not (or less) restricted by labour constraints.
	    ○ **Innovative Edge:** Setting new industry standards and

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attracting innovation-focused customers. Opening up value add and business model opportunities not otherwise readily possible.

- **Consistency:** Higher product consistency and quality through simplified assembly and automation.
- **Workforce Development:** Ongoing need for training programs to upskill employees for managing automated systems on both Maverick and Module sides.
- **Supply Chain:** Management of risks, costs and complexity of supply chains, as always remains a priority and focus.

2.4. Lesson Learnt 4: Simplifying field operations to be local and deliverable

Whenever field automation is discussed in technical circles, the first suggestion is to always utilise GPS for location services, as well as use systems that require special training to achieve highly accurate placement of features.

Throughout the development of the Delta deployment robot, field markout application, and driver guidance module, several things became clear:

- Despite claims, GPS is not to be relied upon for tight tolerance, repeatable placement of objects in the field. Better practice is to use localised coordinate systems and technology locked to features/markers.
- Even with best effort planning and surveying, conditions on the ground can be unexpected, so localised adjustments on the fly are necessary in order to maintain tight tolerances for marking out.
- Specially trained field operators in remote locations can be difficult to organise, so the tools should be simple to use and highly prescriptive in nature. This allows 5B to source local labour to assist without requiring large amounts of training.

Category	Technical
Objective	Maverick Deployment System Create tools to automate highly accurate placement in the field of features related to the 5B Maverick that makes the process faster, easier, more accurate, and lower cost than other methods. These tools are required to align with the next iterations of the Maverick product which has much tighter tolerances than previous versions, as well as provide further pathways for more automation.
Detail	• 5B has spent considerable time and effort researching, testing, and trialling existing field positioning/locative tools for suitability for its particular use case. • We found that no tools provided a full fit, so decided to develop a suite of tools to sit on top of an existing technology (Surveyor's Robotic Total Station (**RTS**), survey lasers and arrays) to provide what is required.

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	• Rather than require highly specialised technical operators for the job, these tools have been developed with regular field staff in mind, requiring very little training to use and understand. • Despite their apparent simplicity on the surface, these tools have rich calculation engines underneath providing live 3D calculation and adaptation to local terrain conditions on the fly to match the way that the Maverick array drapes over field undulations whilst still following the core of the pre-planned site layout.
Implications for future projects	• Field operations will be mostly able to be completed by 5B staff and/or partners directly without costly surveyors that are highly variable in quality. • Mark out and guidance operations will be significantly faster and tighter tolerance than previous more basic methods. • Mark out operations will not require extensive special technical training for ground staff usage. • The operations will be highly tailored to the Maverick and will continue to develop alongside the product itself. • The development of these tools have far reaching impact beyond human-based field operations, allowing robotic field automation to be layered over the same process in time both for Operations and Maintenance and future site ground movement monitoring.