final report

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Te Pari Feedlot Auto Handler

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Executive summary

The Australian feedlot industry has been exploring opportunities for automation in the feedlot induction process with a view to improving operating efficiency, cattle performance and feedlot profitability. Two previous reviews have assessed the opportunity and feasibility of automation in this field. This project is to determine the value proposition of the automation by comparing the performance of an automated animal handler with an existing manual handler.

Te Pari Products Ltd was engaged to develop an auto handler for the feedlot induction process with the design of the prototype being determined during the first phase of the project. Once approved by MLA, the prototype was constructed and installed in a New Zealand feedlot alongside an existing manually operated handler. The automated tasks included the head bail and chin lifter, squeeze, anti backing bars, the backline drench and the injection processes.

A main experiment over 546 head of cattle was conducted with the system performance recorded by video cameras and the weigh scale, using agreed metrics. Results were collated to evaluate the value proposition of the automation.

The overall time for the auto handler was 2% faster on average and 7.4% on median value than the manual handler. Cycle time between animals for the auto handler was 30% slower on average and 3% on median value. The combined labour and medicament cost per animal was 6.8% less for the auto handler, providing payback for the automation in the 3rd year.

The head bail and injection tasks required less skill, training and experience to perform. There was no contact between the operator and animal resulting in less risk of injury and less fatigue. Application of the medicaments had improved accuracy, providing a 13% saving in drench. In a typical feedlot, automation of the head bail and drench tasks and semi automation of the injection task would provide a labour saving of one operator.

It is envisaged that further development of the prototype will result in an improved cycle time and value proposition for the automation.

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1 Background

The Australian feedlot industry has a history of adopting leading-edge technologies that will improve operating efficiency, cattle performance and feedlot profitability. Interest in automation within the feedlot industry is increasing. In 2017, MLA commenced automation projects in feedlot induction automation. Two MLA reviews have been published including MLA Project B.FLT.0247 - Review of opportunities for feedlot induction automation; and MLA Project B.FLT.1004 - Feasibility of induction automation R&D. Aligned with the MISP (2020) strategic imperative of improving feedlot productivity and profitability, the feedlot industry wishes to continue to explore potential opportunities in this field.

This project engaged Te Pari Products Ltd to develop a Feedlot Auto-handler for the feedlot induction process. The design of the prototype was determined during the first phase of the project. Once approved by MLA, the prototype was constructed and installed in a New Zealand feedlot for pilot testing of operability and testing of its value proposition. A main experiment over 546 head of cattle was conducted with results collated to evaluate the value proposition of the automation.

Upon completion of the main experiment, the prototype is to be shipped to the Darling Downs, Queensland for future evaluation.

2 Project objectives

2.1 Develop an induction automation prototype.

2.2 Determine the value proposition (cost benefit analsis) of the prototype for feedlots.

2.3 Ship the prototype to Darling Downs, Queensland, for future evaluation by lot-feeders.

3 Methodology

3.1 Method for objective 1: Develop an induction automation prototype

Te Pari Products in consultation with subcontracted engineers and the MLA Feedlot project manager developed plans for the Te Pari Feedlot Auto Handler.

Key areas identified for automation included the headbail catch, squeeze, anti backing bars, injection and drenching tasks. Additional technology identified included the development of positional sensing to provide positional data on the animal in the auto handler. Detailed CAD files of the handler design were prepared and a prototype was constructed in the Te Pari factory.
The prototype was installed at a test farm and as a pilot test, 30 head of cattle were run thru the prototype with results recorded by video for analysis. The prototype operation was further refined. Refer to the Appendix for details of the auto handler design.

3.2 Method for objective 2: Determine the value proposition (cost-benefit analysis) of the prototype for feedlots

The method for determining the value proposition involved a main experiment that compared the performance of the auto handler prototype against an existing manual handler. The auto handler was installed adjacent to an existing manually operated handler and over a total of 5 induction days the performance of the auto handler was compared with the manual handler. A total of 546 cattle were inducted with 260 head being processed through the manual handler and 286 being processed through the auto handler. Mob size ranged from 50 – 70 cattle and mobs were alternated between the handlers, 1 to 2 mobs through one handler then the next mobs through the other handler and so on. The mobs comprised a mixture of Hereford, Friesian, Angus and Murray Grey bulls, some with short horns, ranging in weight from 420kg to 620kg, with an average weight of 475kg. For the trial, both handlers utilized 2 operators. One operator filed the race and the other opeator undertook the head bail, back lining and injection tasks.

The system performance was recorded by 4 video cameras and the weigh scale. Data from the videos was entered into a spreadsheet at the end of each day along with visual observations noted during each session. Time and motion data for the tasks was calculated from the spreadsheet (See Appendix 9.1 & 9.8). Time spent loading animals in the race was included in the cycle time but time spent on checking equipment was not counted. Overall time is calculated from entry, the time the animals front feet are on the weigh platform, to leave, the time the animals rear feet leave the weigh platform. The cycle time is calculated from the time one animals rear feet leave the weigh platform to when the next animals rear feet leave the platform.

This report details the results of the main experiment and the Te Pari auto handler features, methodology, results, statistical analysis, discussion and cost-benefit analysis.
Performance metrics include time taken for each task, the success of the task, the need for operator intervention, animal behaviour, operator and animal safety. Monetary values are in A$. Refer to the Appendix for yard layout and camera placement.

4 Results

4.1 Objective 1: Develop an induction automation prototype

The auto handler design comprises a waiting zone and a treatment zone with automatic doors controlling the flow of animals thru the zones. The doors are triggered by sensors and positional sensing data provided by the weigh scale. The animals are automatically caught in the treatment zone by the head bail. Drenching and injecting units automatically dose the animals based on weight, then data is recorded on the weigh scale tablet. The auto handler design documents in the Appendix provide more detail on the operation of the handler.

4.2 Objective 2: Determine the value proposition (cost-benefit analysis) of the prototype for feedlots

The main experiment was conducted comparing the performance of the auto handler with the manual handler. Appendix

Table 1. Comparison of performance

	Manual Handler (s)					Auto Handler (s)				
	Avg	Mdn	Min	Max	SD	Avg	Mdn	Min	Max	SD
OA time	29.7	27	15	99	9.2	29.1	25	10	114	15.3
Cycle time	36	32	18	182	16.4	46.8	33	13	322	41.8
Time to head bail	8.6	8	3	25	3.5	12.1	8	5	85	10.9
Time to drench	4.7	3	1	18	3.5	2	2	2	2	
Time to inject	7.1	6	3	66	5.5	6	5	3	63	5.1

	Manual Handler	Auto Handler
Success of task		
Head bail	99.6%	95.1%
Injection	99.6%	74.8%
Drench	98.5%	93.4%
Operator intervention		
When animal enters treatment zone	3.8%	4.8%
When animal leaves treatment zone	4.6%	0.7%
Animal behaviour		
In the head bail	0.4% unsettled	5.9% unsettled
When leaving the head bail	0% unsettled	0% unsettled
Safety		
Operator safety incident	0	0
Animal safety incident	0	0
Medicament		
Amount of injectable used	0.36%	-2.8%
Amount of drench used	13.48%	-0.27%

Table 1 shows a summary of the comparison of the overall time spent in the treatment zone, the cycle time between animals leaving the handler and the automated tasks of head bailing, drenching and injection. The overall time for the auto handler was 2% faster on average and 7.4% on median value. The cycle time for the auto handler was 30% slower on average and 3% on median value. There was little difference in the number of operator interventions required and animal behaviour was also similar with 5.5% more animals being unsettled in the auto handler head bail. There were no safety issues for the operators or animals with either of the handlers. The auto handler used 13% less drench and 3% less injectable.

Table 2. Cost per animal

	Manual Handler ($)	Auto Handler ($)
Per animal		
Labour cost	0.4128	0.4257
Injection cost	5.1344	4.9727
Drench cost	4.2701	3.7530
Total cost per animal	9.8173	9.1514

Refer to the Appendix for labour and medicament costs.
The combined labour and medicament cost per animal was 6.8% less for the auto handler, based on an average weight of 400kg.

Table 3. Payback period

	Manual Handler ($)	Auto Handler ($)	Difference ($)	Cumulative Difference ($)
Year 1				
Total cost of 50,000 animals	490,865	457,570	33,295	
Cost of equipment	36,000	90,000	(54,000)	
First year total	526,865	547,570	(20,705)	(20,705)
Year 2				
Total cost of 50,000 animals	490,865	457,570	33,295	
Depreciation of equipment	3,600	9,000	(5,400)	
Second year total	494,465	466,570	27,895	7,190

Table 3 shows the payback period based on inducting 50,000 head per annum with an average weight of 400kg (B.FLT.2017 final report). The first year lists the capital investment and subsequent years include depreciation of the equipment based on a 10 year period.

The payback period for the automation is in the 2nd year.

Additional information provided in the appendix:
Table 6. Sequence of tasks
Chart 1. Percentage of median time taken for tasks in the manual handler
Chart 2. Percentage of median time taken for tasks in the auto handler
Table 7. Comparison of medicament use
Table 8. Medicament cost
Table 9. Equipment cost
Table 10. Labour cost
Table 11. Description of metrics
Data files:
Trial manual data

Trial auto data
Medicament use

4.3 Objective 3: Ship the prototype to Darling Downs, Queensland, for future evaluation by lot-feeders

The prototype is yet to be shipped to Australia.

5 Discussion

Automation can improve the labour efficiency, work environment and safety of the induction process. Although the raw data does not show a significant difference in performance between the manual handler and the automated handler, there are a number of benefits that make key tasks easier, faster and safer to undertake.

The automated head bail and chin lifter operation removes the skill and fatigue associated with the manual unit. Operation of the manual unit requires the operator to assess the speed of the approaching animal and to time the closing of the head bail to catch the animal. This requires training, experience and concentration. The auto unit does this by using positional sensing and a sensor eye and does not require an operator. The time for the animal to be head bailed was similar between both units although the auto time included the chin lifter operation that typically added another 2 seconds to the time. The minimum time for the task is limited by the speed in which the animal can reach the head bail.

Automatic application of the drench was faster than the manual gun, with the dose size more accurate and the spray pattern more evenly dispersed along the back line. The auto drench was applied consistently in a 1 metre strip along the animals back with no splashing. Dose time was 2 seconds and treatment was done while the animal was being injected. The correct dose size for the animal was calculated by the weigh scale and recorded automatically in the animal file. Manual application of the drench saw fluid being sprayed over a smaller area, in some cases missing the animal. The manual gun required considerable hand force to operate with the risk of fatigue and RSI over time. The gun was typically adjusted for volume once in a session and set to the largest animal in the mob.

Manual injection of the animal is a high risk task that involves the operator reaching into the handler to carry out the task. The operator's arm is positioned between the animal and the steel frame of the handler, where any sudden movement of the animal risks injury to the operator. The operator is also exposed to needle stick injury, that accounts for 20% of operator injuries (B.FLT.2047 final report). Manual injection is a skilled task that requires training, experience and concentration.
The automated tenting and injection was operated from the side of the handler and required no operator contact with the animal. This minimized the risk of needle stick and other injuries to the operator. Operation was easily controlled by a tent button and an inject button and required very little training. The correct medicament volume for the animal was calculated by the weigh scale and

recorded automatically in the animal file. For both the manual and auto handlers, the operator needed to wait for the animal to settle before initiating the task.

In comparing the data, the manual handler operation was more consistent than the automated handler, reflected in the difference between the average and median values. The manual handler standard deviation was less than that of the automated handler.

The automated handler prototype had a number of mechanical and software issues during the trial, including operation of the waiting zone entry gate, early triggering of the anti backing bars, delays in hydraulic power and leaking in the injector on the last day. These contributed to the inconsistency in the data. Time spent checking the handler was not included in the data however stopping and starting the inducting process affected the flow of animals thru the handler. Further development of the prototype should see an improvement in data consistency and task rate success.

Of note is the additional wait time of the auto handler, seen in table 6 sequence of tasks. The auto handler had 6 seconds more wait time. Whether this is a mechanical, software or animal flow issue would need to be investigated before further trials but potentially the wait time could be reduced. Also of note is that the manual handler did not have a chin lifter. This would add 2 seconds to the manual times.

Table 2 shows the cost per animal and table 3 the payback period. Table 3 indicates that payback for the automation, based on the current prototype performance in the trial, would be in the 2nd year.

When considering the figures, there was a significant saving in the cost of drench, contributing to the payback period. It is recommended to dose cattle to the heaviest animal in the mob when manually drenching cattle (Wormwise 2019), accounting for the over dose in the manual handler. This would be typical for all medicaments, backline, oral and injection, where medicament volume is calculated relative to animal weight. The auto handler was slightly under dosing both medicaments which provided a cost advantage. Tables 4 and 5 have the medicament costs of the auto handler adjusted to reflect the correct dose sizes.

Table 4. Adjusted cost per animal

	Manual Handler ($)	Auto Handler ($)
Per animal		
Labour cost	0.4128	0.4257
Injection cost	5.1344	5.116
Drench cost	4.2701	3.7632
Total cost per animal	9.8173	9.3049

Table 5. Adjusted payback period

	Manual Handler ($)	Auto Handler ($)	Difference ($)	Cumulative Difference ($)
Year 1				
Total cost of 50,000 animals	490,865	465,245	25,620	
Cost of equipment	36,000	90,000	(54,000)	
First year total	526,865	547,570	(28,380)	(28,380)
Year 2				
Total cost of 50,000 animals	490,865	465,245	25,620	
Depreciation of equipment	3,600	9,000	(5,400)	
Second year total	494,465	466,570	20,220	(8160)
Year 3				
Total cost of 50,000 animals	490,865	465,245	25,620	
Depreciation of equipment	3,600	9,000	(5,400)	
Third year total	494,465	466,570	20,220	12,060

The payback period is now increased to the 3rd year.

Another consideration is that the manual handler times did not include the 2 seconds for activating the chin lifter and the auto handler had a 6 second wait that could be reduced, so there is opportunity to reduce the payback period of the automated technology.

For the trials only 2 operators were used, because this is how the farm usually inducted cattle. One operator filled the race and the other operator undertook the head bail, back lining and injection tasks. The operators worked very quickly as a team. From the B.FLT.0247 report, Australian feed lots use on average 4 operators at the handler when inducting cattle, with the side operator often being responsible for the injection and back lining tasks. Automating these tasks would be a saving of one operator ($10,642 pa). This has not been factored into the value proposition calculation.

6 Conclusion/Recommendations

The trial indicated that the value proposition of the automated prototype is positive.

The head bail and injection tasks required less skill, training and experience to undertake. The injection task had reduced contact between the operator and animal resulting in less risk of injury and less fatigue. There was improved accuracy in the application of the medicaments providing a 13% saving in drench. In a typical feedlot, automation of the head bail and drench tasks and semi automation of the injection task would provide a labour saving of one operator.

Further development of the prototype mechanical operation and software sequencing will result in an improved cycle time and a reduced payback period. The auto injector is yet to be fully proven and could be developed further into multi injectors capable of both SC and IM injection.

It is recommended that the prototype be further developed, shipped to Australia and evaluated in a feedlot over several months.

7 Key Messages

- The prototype automated feedlot handler has a positive value proposition.
- Payback for the automation is achievable over 3 years.
- Expected payback could be improved as the prototype is developed.
- The key tasks of head bailing, injecting and drenching can be automated.
- This represents a reduction in labour of one operator.
- Auto head bailing is an equivalent speed to manual head bailing but requires no operator.
- Auto drenching provides a significant saving in drench and requires no operator.
- Auto drench application is precise with no over spray.
- Auto injection requires no operator contact with the animal and is safer.
- Needle stick accounts for 20% of operator injuries (B.FLT.2047 final report).

- Medicament volume is automatically calculated by weight for each animal and recorded in the animal file.
- Automated tasks require less operator training, experience, concentration and physical exertion.
- Key tasks are easier, faster and safer to undertake
- Automation improves the work environment.

8 Bibliography

McCarthy C, Brett P, Tscharke M (2017) B.FLT.2017 final report – Review of opportunities for feedlot induction automation. MLA.

Wormwise (2019) National worm management strategy. Wormwise hand book July 2019.

9 Appendix

9.1 Table 6. Sequence of tasks
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9.1

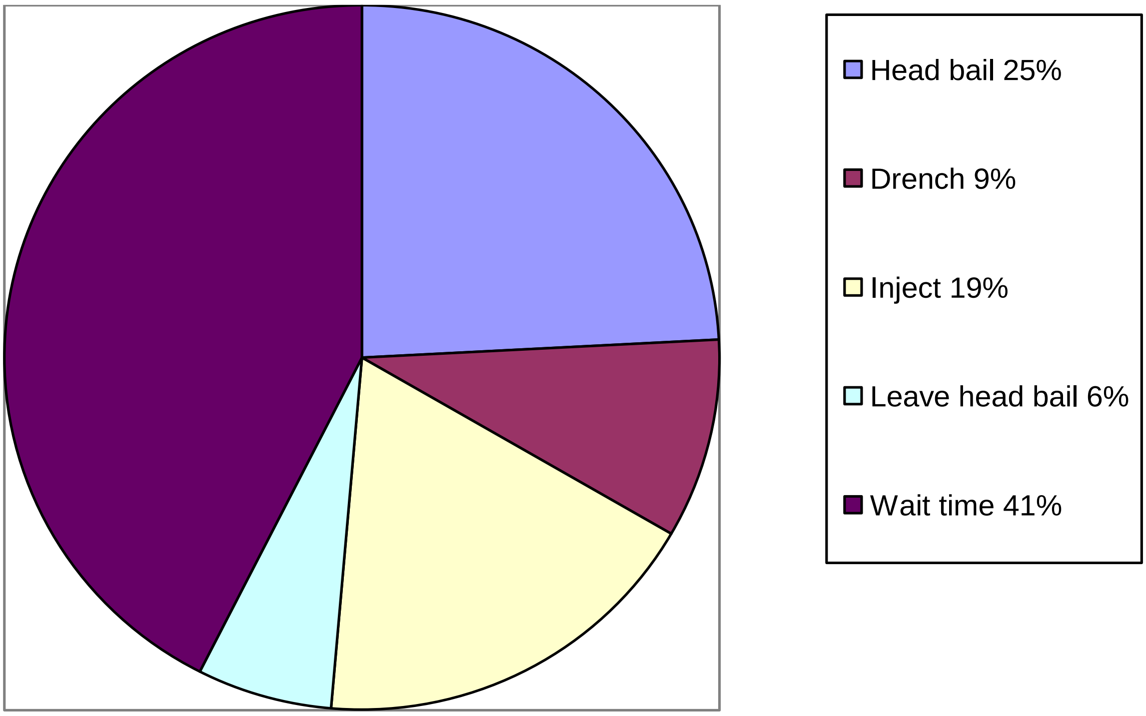
Table 6. Sequence of tasks

The table shows when each task occurs within the cycle time, the duration of each task and the wait time between tasks. Odd numbers rounded up.

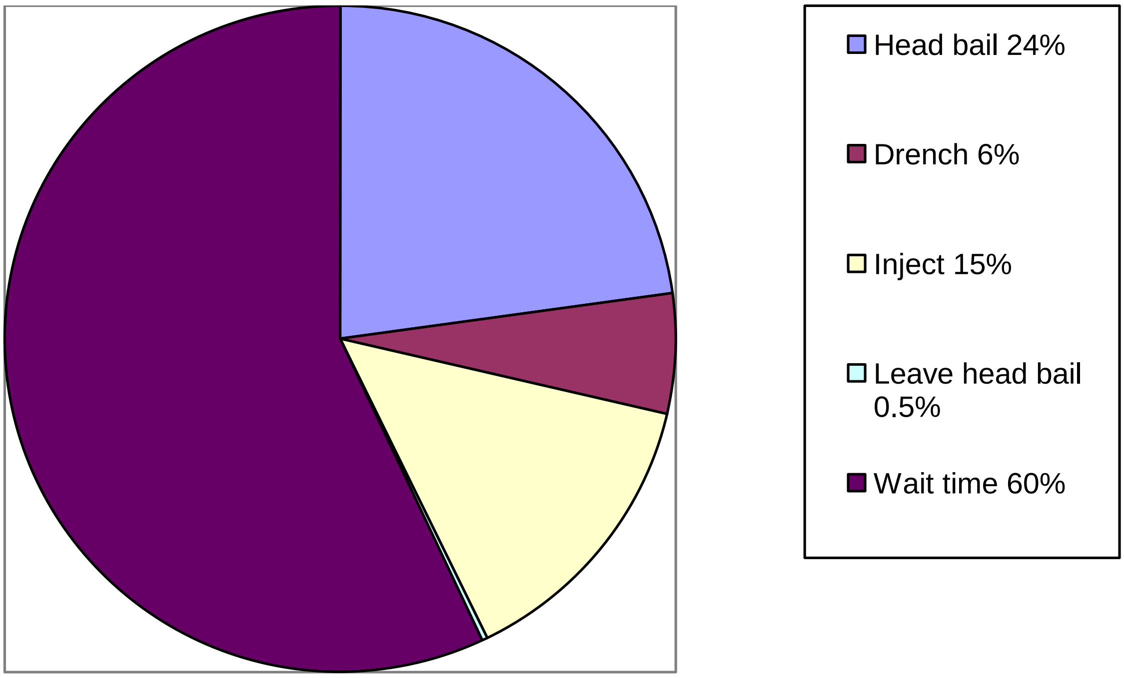
Manual Handler																		
Median Times (s)		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
Cycle time	32																	
AO time	27																	
Head bail	8																	
Drench	3																	
Inject	6																	
Leave head bail	2																	
Wait time	14																	

Auto Handler																		
Median Times (s)		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
Cycle time	33																	
AO time	25																	
Head bail	8																	
Drench	2																	
Inject	5																	
Leave head bail	0																	
Wait time	20																	

9.2 **Chart 1. Percentage of median time taken for tasks in manual handler**



9.3 **Chart 2. Percentage of median time taken for tasks in auto handler**



9.4 Table 7. Comparison of medicament use

Drench	Manual	Auto
Total weight of animals (kg)	129335	127471
No of animals	260	267
Total volume of drench (ml)	14677	12712
Prescribed volume of drench (ml)	12935	12747
Difference (ml)	1742	-35
Difference (%)	13.47	-0.27
Volume used per kg (ml)	0.1134804	0.0997246
Volume used for 400kg animal (ml)	45.392	39.89
Cost of drench per kg ($)	0.009408	0.009408
Cost for 400kg animal ($)	4.2701	3.7530
Prescribed cost for 400kg animal ($)	3.7632	3.7632
Difference for a 400kg animal ($)	0.5075	-0.0102

Injectable	Manual	Auto
Total weight of animals (kg)	129335	100900
No of animals	260	214
Total volume of injectable (ml)	649.03	490.39
Prescribed volume of injectable (ml)	646.7	504.5
Difference (ml)	2.33	-14.11
Difference (%)	0.36	-2.8
Volume used per kg (ml)	0.0050182	0.0048601
Volume used for 400kg animal (ml)	2.00728	1.94404
Cost of injectable per kg ($)	0.01279	0.01279
Cost for 400kg animal ($)	5.1344	4.9727

Prescribed cost for 400kg animal ($)	5.116	5.116
Difference for a 400kg animal ($)	0.0184	-0.1433

9.5 Table 8. Medicament cost

Drench	Cost ($)	Dose rate	Cost 400kg	Cost per kg
Bayer Imax 10lt	650	5ml/100kg	1.3	0.00325
Novartis Acatak 5lt	715	6ml/100kg	3.432	0.00858
Cydectin 5lt	609	10ml/100kg	4.872	0.01218
Eclipse 5lt	1135	5ml/100kg	4.54	0.01135
Dectomax 5lt	584	10ml/100kg	4.672	0.01168
Average			3.7632	0.009408

Injectable	Cost ($)	Dose rate	Cost 400kg	Cost per kg
Bayer gold 500ml	175	2ml/100kg	2.8	0.007
Ivomec plus 500ml	324	2ml/100kg	5.184	0.01296
Cydectin 500ml	1131	1ml/100kg	9.048	0.02262
Multimin 500ml	429	1ml/100kg	3.432	0.00858
Average			5.116	0.01279

9.6 Table 9. Equipment cost

Item	Manual handler cost ($)	Auto handler cost ($)
Handler hydraulic	25,000	
Handler auto		75,000
EID panel	3,500	3,500
T1, weigh bars and tablet	7,500	7,500
Auto drench unit		1,500
Auto inject unit		2,500
Total	36,000	90,000

9.7 Table 10. Labour cost

Average hourly rate for farm workers

	Average	Median	Min	Max	Mode
Fairwork Australia Nov 2020	$21.94		$19.49	$24.39	
Indeed employment website 2021	$26.08				
Payscale website 2021	$22.74				
MLA report B.FLT.0247 2017	$22.13	$22.00	$18.91	$27.00	$22.00
Average	$23.22				
Average per s	$0.00645				

9.8 Table 11. Description of metrics

Abbreviation	Description
Down time	Time not counted in the cycle time
Issues	Visual observation of key events being animal behaviour, animal injury, worker intervention, worker injury, mechanical malfunction, task failure.
IHB	Operator intervention at the head bail
WZ	The time the animal pauses before entering the waiting zone, recorded if greater than 3 sec.
Int	If intervention is required by an operator.
TZ	The time the animal pauses before entering the treatment zone, recorded if greater than 3 sec.
Entry	The time the animals front feet are on the weigh platform in the treatment zone.
HB 1 2 N R	Head bail on the 1st or 2nd attempt, N no success, R released.
Chin up	The time the chin lifter is fully raised.
Chin up 1 2 N R	Whether the chin lifter is successfully raised in the 1st or 2nd attempt, N no success, R released
Behave O U D	The behaviour of the animal in the chin lifter, O ok, U unsettled or D animal down
Release	The time the head bail doors fully open.
Leave	The time the animals rear feet leave the weigh platform.
Behave O S I U	The behaviour of the animal leaving the treatment zone. O ok, S stays more than 5 seconds, I requires operator intervention, U unsettled.
Inject start	For the manual handler, the time from when the operator picks up the injector. For the auto handler, the time from when the tent action starts.
Inject stop	For the manual handler, the time when the operator puts down the injector. For the auto handler, the time when the injector arm finishes retracting.
Tent 1 2 N R	Whether the tent action is successful in the 1st or 2nd attempt, N no success, R released.
Inject Y N R F	Success of the injection application to the animal. Y yes under the skin, N no success, R released and F manually injected from front of the head bail.
D start	For the manual handler, the time from when the operator picks up the drench gun. For the auto handler, the time from when the drencher is activated.
D stop	For the manual handler, the time when the operator puts down the drench gun. For the auto handler, the time when the drencher finishes the dose.
Drench Y N R	Success of the drench application to the animal. Y yes or N no if part of the drench is not applied to the animals back, R released.
OA time	The overall time from entry to leave.
Hbail time	The time from entry time to chin up.
D time	Time taken to drench
Inject time	Time taken to inject
Leave time	The time from release to leave.
Cycle time	The time between animals taken from the leave
Wait time	The OA time less the time taken for the tasks

9.9 Yard layout

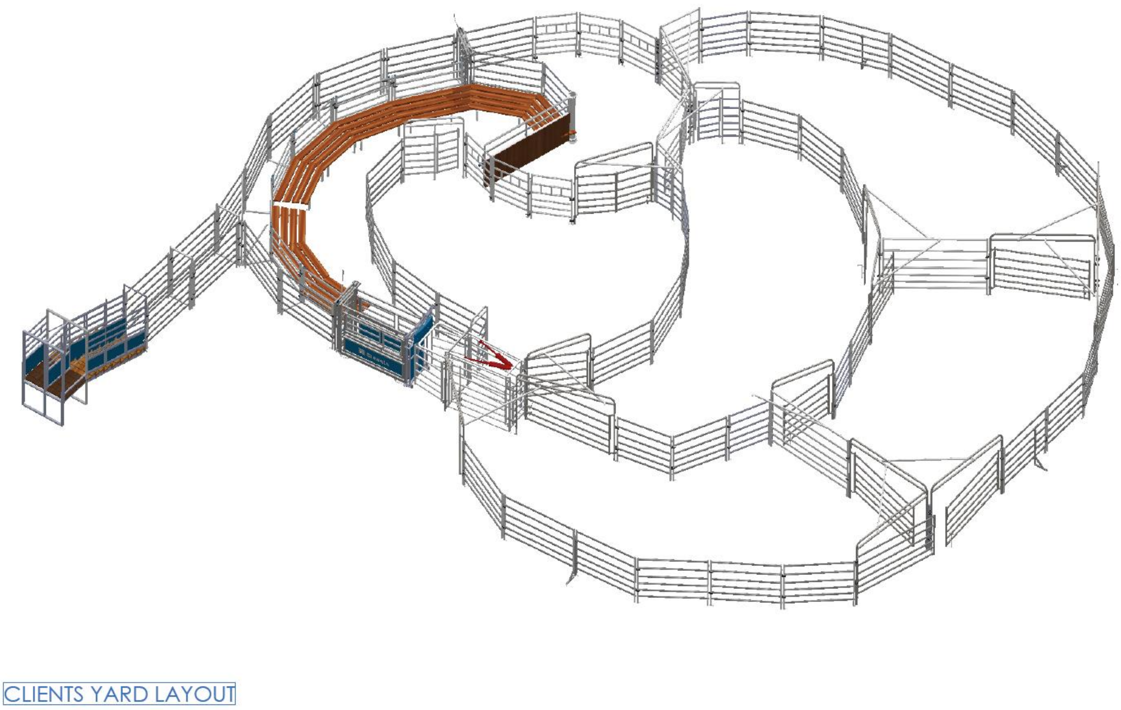


Figure 1. Existing yard

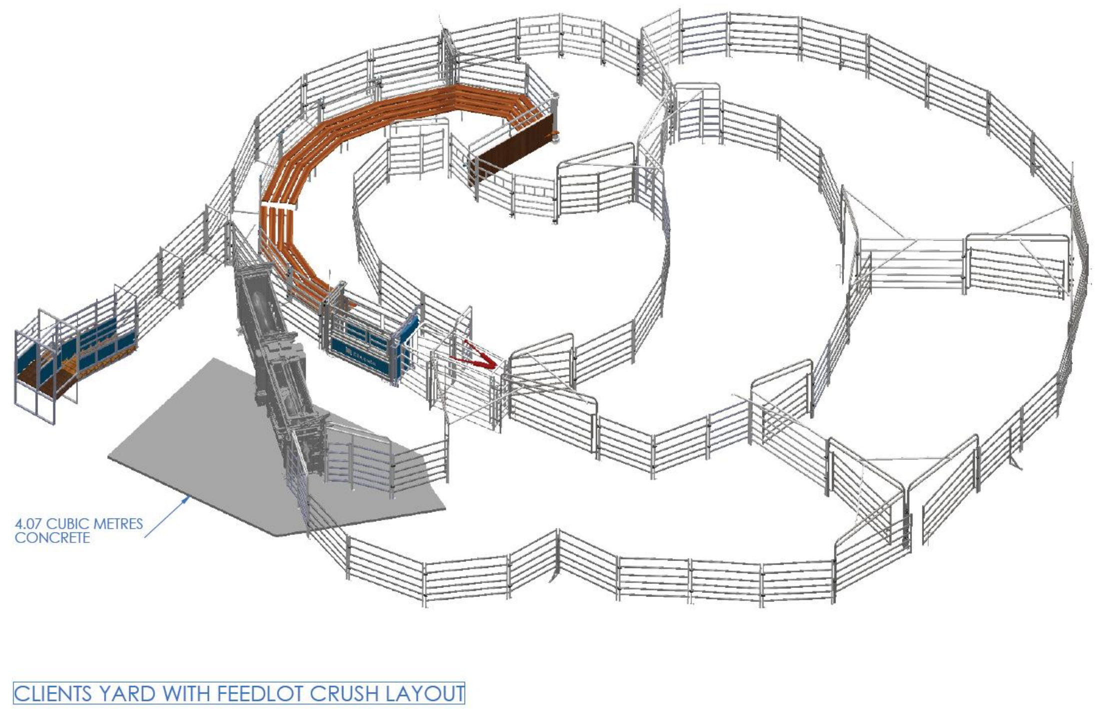
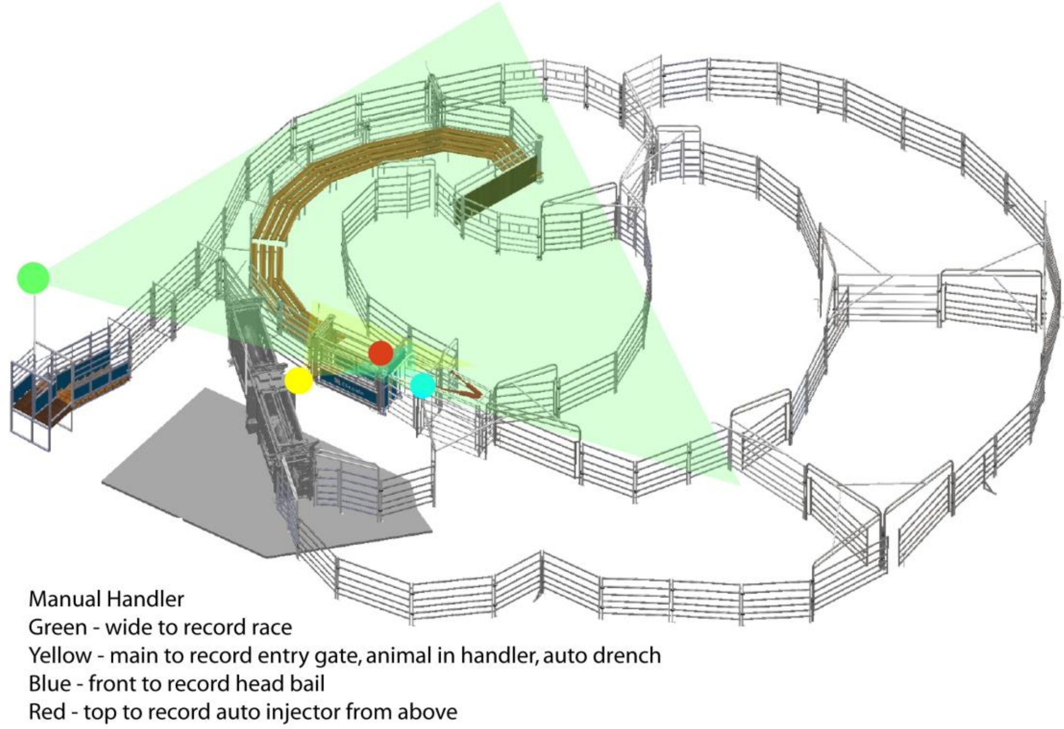


Figure 2. Existing yard with prototype

9.10 Camera plan



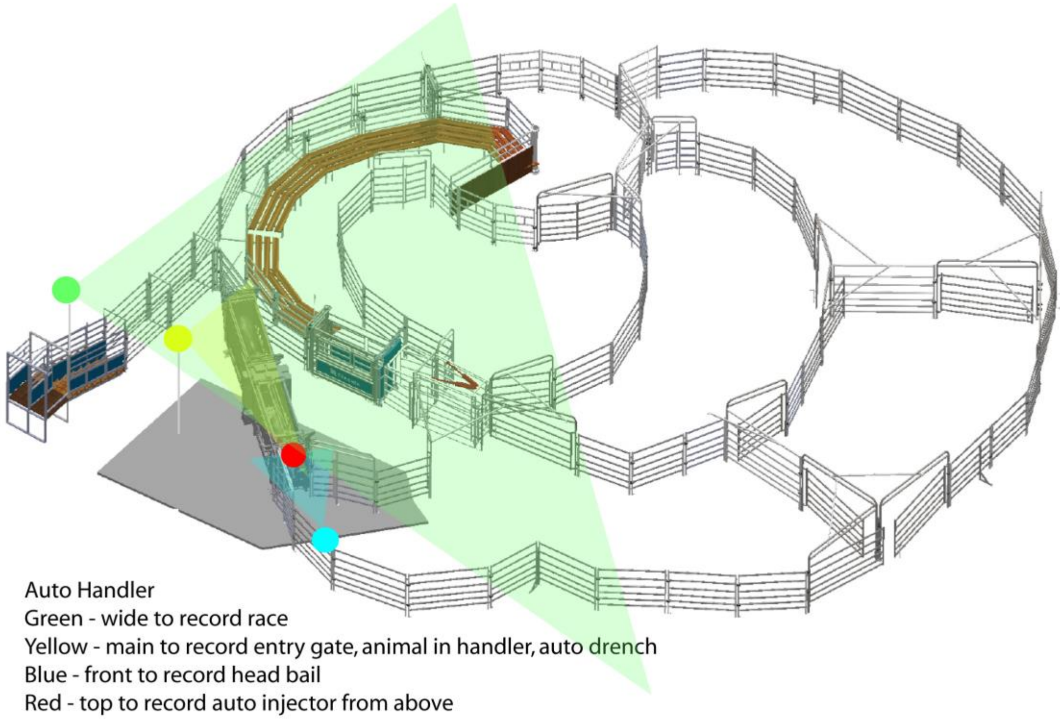


Figure 3. Camera plan