Final report

Trial of HMT-1 industrial wearable computer in processing environments

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Abstract

This project was designed to identify core functionality, potential productivity and safety improvements enabled by the RealWear HMT-1 (Head-Mounted-Tablet 1) wearable computer and leading voice-operated software, in meat (http://ncmc-co.com.au/) and animal-processing (https://centreplus.com.au/) facilities. The RealWear HMT-1 is a voice-controlled, ruggedised (water, dust and drop-proof), monocular-heads-up-display Android-powered computer, with microphone noise cancellation up to 95db, 10 hours battery-life and a hi-res 16mp camera. Software chosen was Librestream Onsight for Remote-Calls in poor connectivity areas, and Intoware WorkfloPlus which enables workers to execute workflows and dynamic forms hands-free, while easily recording indisputable visual-proof (photos and videos) with automated report-formatting.

Through initial meetings, handover and training on the wearable devices and regular communication on conference-calls, we identified strong use-cases, built custom workflows, and enabled the workers at these facilities to start operating the devices autonomously on-site. Training in how to create Workflows without assistance, was also provided.

This report is a 'how to' guide for implementation and potential, validated use-cases within the red meat industry, and details how an off-the-shelf device can be activated same-day, and used for 'virtual walk-throughs' with off-site experts, improve internal communication, auditing or training of new workers and capture the knowledge of older experts leaving the industry. Much of this report translates into many aspects of the supply-chain and domestic agricultural production

Executive summary

Background

This research is a follow-on from some work conducted around wearables in the MLA, and was enabled by a new generation of very ruggedized wearable technology called RealWear. The question to be answered was whether hands-free wearables will enable deeper digital transformation in the red meat industry, and where that technology is most effectively deployed.

The target audience for this study was originally meat and animal processors, but as we ventured further into the use-cases, we discovered much broader opportunities across the agricultural sector (most especially as the pandemic arrived post the kick-off of this study).

The results of this research will be used to provide turn-key options for integration with those industry stakeholders who are focused on data, safety and accountability and foresee the inevitable and exciting convergence of the meat industry with digitisation.

Objectives

1. Carry out an initial site visit to Processing plant and integrate the Realwear HMT-1 Devices into their systems.
2. Consult remotely to a sheep processing facility to set-up and enable stakeholders to use HMT-1 and software.
3. Deliver a milestone report including preparation, remote support, software upload, set-up of Foresight device management system, test workflows creation, analysis of results, recommendations and Case Study.
4. Deliver and final report – end of project interviews and analysis.

Methodology

Knowing the success factors of wearable device implementation from other industries, we applied the same core applications of 'Remote Expert', 'Voice-operated Workflows' and 'Media Capture' to the animal processing environments. Many of the issues that the industrial world is experiencing around connected worker and digital transformation, are universal to the agricultural world which also suffers from tyranny of distance, high-level safety and accountability standards and a general skills crisis in regional areas especially.

Results/key findings

The key findings were that connected worker digital transformation is not happening in the industry due to the need for workers to use both hands. Much of the data inputs are coming through plastic covered PC keyboards or hand-held code scanners – and the practicality of those is extremely limited. Hence, we received excellent feedback and, without a lot of experience, workers were able to use and see vast potential in a hands-free wearable computing system.

Benefits to industry

While an obvious benefit to industry will be increased productivity, less downtime and far more effective knowledge-succession and remote communication of special knowledge, the availability of a point-of-view (PoV) camera that can so easily hi-res photo-take and video record is a game changer. From an auditing perspective, we can move beyond RFID or printed barcodes and provide WYSIWYG visual evidence of each point in the supply chain. Further to that, we can also start to

grow a data-tagged visual library so that the industry can start to train visual AI bots to augment inspection data capture processes.

Future research and recommendations

Because of the universality of our findings and the off-the-shelf availability of the solutions, we recommend a Webinar for the industry and for the wider RDC community. We also recommend examining the wearable device usage further down the supply chain, doing a proper implementation of software with MSA grading and also starting a PoV-video-based knowledge library from older industry experts as an invaluable, searchable database for generations to come.

Veterinary

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1. Background

This project aims to evaluate and validate the usage of hands-free wearables in the processing environment. Inevitably, it is the meeting-of-minds of two important stakeholders in the adoption and usage of wearable technology, which is so important. This stakeholder reconciliation is universal across the industrial world and industries that are engaging the most with this technology, such as Mining, Oil & Gas, Manufacturing, Utilities, Aerospace, Automotive, Defence, Healthcare and Energy.

These stakeholders are:

- The Experts that know the technology and its strengths and limitations intimately. In this case, Virtual Method.
- The industry-end-users who don't yet know what the device is capable-of, but theorise where it can add the most value for their every-day processes and challenges. In this case, NCMC and Centre Plus

There have been a number of investigations into the use of 'Wearable Technology' and so-called 'Mixed Reality or XR' technology, to address issues that the red meat and livestock industry faces, but it has only been in the last 1-2 years that 'XR' (Augmented Reality, Assisted Reality and Virtual Reality) technology has become mature and available. This maturation and tipping-point then provides a potential feasibility for this technology not only being used in the research, but also being available off-the-shelf so that the research outcomes might lead to immediate gains and enhanced value, for industry stakeholders who wish to engage with this innovation.

In our initial analysis of the meat processing environment, we determined that **Assisted Reality** would be the most practical methodology to apply. This is different to **Augmented Reality**, whereby a user has two see-through lenses over two eyes and sees 3D animations spatially attached-to/anchored-to the world around them, or **Virtual Reality**, whereby a user cannot see the real world at all and is 100% immersed in a virtual world. These technologies have applications in the meat and livestock industry, but not within the scope of this research and the certain outcomes we hoped to achieve.

Working with the NCMC and Centre Plus, our hypothesis was that we could create a turnkey solution that can be implemented in any and every facility, to optimise operations, create a higher standard of auditing and also leverage human workers, creating more value out of their employment and increasing human resource ROI against full automation

From the outset of this study, Virtual Method identified certain areas that could be the fastest and greatest gains for workers, using the technology. These included:

- **THE KNOWLEDGE REPOSITORY:** The acquisition of special knowledge from subject matter expert workers who may retire (especially) or leave a job and take their knowledge with them.
- **REMOTE POINT-OF-VIEW TELEPRESENCE**: The ability to dial-in an expert anywhere in the world, through an online conferencing system, who can then see 'through a worker's eyes' and talk them through the triage of an issue + potentially provide the worker with a break-fix solution on the spot.
- **VISUAL-EVIDENCE-SUPPORTED TASKS & WORKFLOWS**: Taking processes that are currently done via paper or a fixed-point computer in the plant, and allowing workers to perform these tasks and create data for reports, anywhere they need-to, by voice.

We have been able to test these items in the deployment of devices and software, but other use-cases have also come to the fore, some of which we have been able to test as an addition to the original scope. These include:

- Using the wearable to do MSA Meat Grading
- Using the device for the high-speed processing of sheep during a shearing session
- Using the device to scan and translate Chinese Language labels so that the cut of meat can be verified before packing and shipping
- Verification of the condition and treatment of live animals arriving and being processed before slaughter and possible opportunity to engage with veterinarians remotely

NCMC was identified as an ideal candidate due to their appetite for innovation and importance placed upon product quality, because they also have a tannery on-site, and because they are scrutinised quite extensively as a major exporter of Australian meat products to Asia. **Centre Plus** was added to the piece, because of the ingenuity and innovation of Mark Mortimer, who has written programs for sheep processing data-collection, as well as his personal appetite to embrace and understand any piece of technology that might help his industry.

Ultimately, we intend to provide meat and livestock companies and individuals with a roadmap for their own innovation, and to start to work with advanced technology which, as a side-benefit, proves to a younger generation that there is real innovation in agriculture and an opportunity to engage with technologies that are every bit as advanced as other industrial industries that are recruiting them away from regional areas.

2. Objectives

Establish that workers can use wearable technology and see value in it

Prove that invaluable knowledge can be captured better by a 1080p-filming camera and microphone next to an expert's eyes, than any other method

Prove that someone can be trained, in real-time, to do a task remotely when their skillset falls short of achieving an acceptable outcome

Demonstrate that maintenance tasks can be verified as being done correctly and on-time by having a worker watch, verify and record data from a maintenance session

Prove that workers can perform numerical data entry tasks (such as MSA Grading) without having to use their hands at all

Prove that the facility requires less visitors, which would reduce risk and increase productivity

Identify the potential for integration with other systems and databases

3. Hypothesis

If we can validate the usage of wearable technology in the meat processing environment, there will be a number of direct and fairly immediate benefits:

1) The amount of computing interfaces and hardware will be reduced in the facility. Computing is worn + mobile, which greatly decreases risk of production faults through ICT issues and reduces the outlay for physical infrastructure and upgrades etc.
2) We can create greater value and productivity out of the existing human workforce. As some voices in the industry recommend that we move to full automation[1], Assisted Reality and human skills-augmentation can provide more value to the meat processing industry so that the ROI of *full* automation, relative to human labour, is lessened and employment is retained.
3) The risk of infection is reduced because the surfaces touched and processes engaged-with are fewer with a hands free, voice-activated computing interface.
4) More business can be developed from overseas markets as potential buyers are able to tour the facility remotely + immersively through the facility and appreciate the care and quality that is maintained in Australian meat processing.
5) Australian export meat will have a higher perceived integrity-level as processes are tracked more thoroughly, consistently and visually through the paddock-to-pallet process. All supply chain integrity can be documented with graphic evidence so that any claims of product being sub-standard can be summarily refuted.
6) Less disruptions to production as new equipment is commissioned or serviced, as on-site stakeholder can be trained more effectively over large distances, domestically or internationally.
7) Workers will experience less cognitive load as they are able to transfer readings from equipment and measurements into workflows and connected databases, within 3 seconds and using their working memory or phonological loop[2], rather than committing data to become neural synapses and greatly increasing the risk it is transposed incorrectly.
8) Capture the knowledge of Subject Matter Experts who are retiring from the industry and have acquired Special Knowledge of processes, systems and equipment that lives only in their memory. In popular culture, this is known as the 'Silver Tsunami'[3] per the skills shortage that is resulting from 'silver-haired' baby-boomers retiring from the workforce and taking their invaluable knowledge with them. The unavailability of that knowledge, when it is needed (such as a production line going down) typically costs companies very large amounts of money.
9) Foreseeably, in the recording of visual information relating to animals, alive and post-mortem, a database can be built-up in order to facilitate machine learning so that at some point, an AI 'bot' may be able to identify any issues autonomously. This is outside the scope of this study.
10) As more and more Industrial Internet of Things sensors are incorporated into 'smart-plants' so that workers can look at equipment or codes and be delivered real-time data about the plant's systems. This is outside the scope of this study.

[1] https://www.abc.net.au/news/rural/2020-07-31/post-pandemic-automation-for-food-security/12506930

[2] Baddeley AD, Hitch GJ. The phonological loop as a buffer store: An update. *Cortex*. 2019;112:91-106. doi:10.1016/j.cortex.2018.05.015

[3] https://www.intheblack.com/articles/2019/02/01/hold-back-the-silver-tsunami

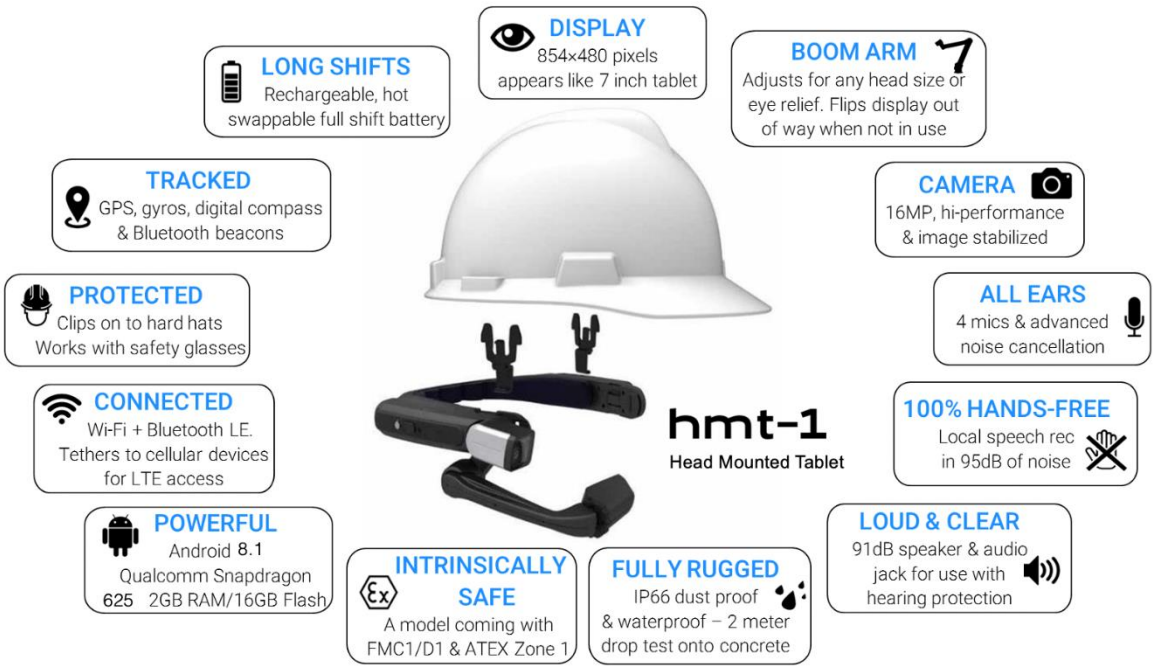
4. Assisted Reality

The RealWear HMT-1 (Head-Mounted-Tablet One) was the chosen device for these studies, because it is untethered, rugged and more powerful than other wearable technologies in the market right now. The Microsoft HoloLens 2 was considered, but was ultimately omitted because:

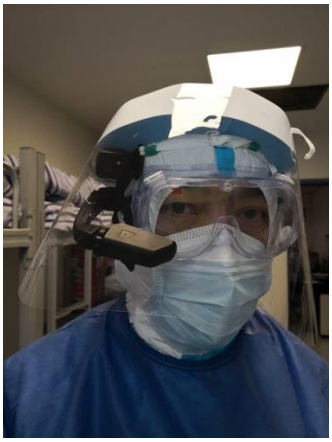
- Short battery-life of 2-3 hours.
- Not ruggedized so will break when dropped or hit against a hard surface.
- Overheats and shuts down at +35° – rated for +10° to +27° degrees only (RealWear rated -20° to +50°).
- Cannot be washed or sprayed to sterilise (specialised UV light equipment only).
- Doesn't work with PPE.
- Less software solutions around the use-cases identified. Would be perfect if it was important to view objects and animations in full 3D or leave notes connected to equipment virtually.
- Almost double the price of a RealWear HMT-1.
- Issues with eye fatigue due to dual lens (stereoscopic) waveguide lenses causing accommodation-vergence eye-strain issues when workers view screens and 3D items within 1.25 metres from their eyes, for several minutes or more.

4.1 Components of the hardware

The features of RealWear HMT-1 allow it to be mounted to hard-hats, used by some meat processing facilities, or sterilised silicon, or head-bands (or ballcaps, which are less suitable to our purposes). It can also be swapped from left eye preferred to right eye, very quickly.







**RealWear HMT-1 hardware and non-helmet/hat mounting options*

4.2 Software

To facilitate the use-cases outlined in this study, we used Canadian Headquartered software company, **Librestream (**https://librestream.com/**)**, and their **Onsight Connect** tool for Remote Expert teleconference capabilities, and we used UK Headquartered software company, **Intoware (**https://www.intoware.com/), and their **WorkfloPlus** software for voice-operated dynamic forms and data collection in-the-field. These software partners were chosen because they integrate together very well, and also because they specialise-in working in environments with sporadic or reduced connectivity. In addition, because they can be adopted and scaled quickly, as well as integrated into other incumbent systems and processes – such as ERP and CRM and Microsoft Dynamics etc.

Both these software tools have been proven in remote, heavy industry. Microsoft Teams and Cisco Webex are also available on the RealWear HMT-1, for the Remote Expert use-case at least, but we opted to ensure we used the highest quality product with Librestream, in this trial, because there were too many variables around whether or not we could get a good signal in various parts of the NCMC Plant, and we didn't want to risk poor fidelity viewing and communications dropping therefore.

5. Context of Applications in other industries

5.1 Remote Expert

Many industries have begun to employ the use of *Remote Expert* software on wearables, most especially since Covid-19 began to economically-impact our world, reducing the ability of workers to travel to sites and assist or train lesser skilled workers 1:1.

One such use-case is the Mining, Oil & Gas industries. Companies like BHP, Rio Tinto, Oz Minerals, BP, Shell, Schenck Process and Honeywell Process Solutions have all started to employ the use of RealWear and other wearables, to allow their workers to communicate and assess expensive break-fix scenarios (especially) when down-time can cost thousands of dollars per-minute. In addition, specialist animal health-leader, APIAM, has started to use RealWear devices for pen-riders on horse-

back, so they can document and submit reports for animal triage, when they identify Bovine Respirator Disease, hands-free on the horse's back and with the device mounted to an equestrian safety helmet.

Ford Australia is using HMT-1's to allow specialist technicians to see through the eyes of mechanics in dealership workshops, and provide guidance on any difficult issues, saving travel time and ensuring the workshop doesn't grind to a halt. In Europe, Lexus and Porsche are using the devices in a customer-facing capacity, calling customers' mobile devices from underneath or in the engine-of vehicles, showing them wear and tear, work performed, and providing visual evidence of any costs that may need to be covered in the service. They can also receive confirmation of proceeding, in this call.

The AEC industry has also started to use Remote Expert so that investors can view property remotely, whether its under construction or an as-built commercial or residential premises.

In Wuhan, China, and at St John's Hopkins University in the US and in a number of other hospitals across the world, doctors and nurses wearing full PPE are performing their duties in ICU's and surgeries, telestrating to colleagues, loved ones and students who cannot (or cannot easily) enter the areas of risk that these medical professionals work-in.

Its notable that some software, including Librestream Onsight utilised in this trial, can work over sub 300mbps data speeds, such as those provided by remote Satellite data systems from companies like Inmarsat. This allows skills to be easily transferred to very remote areas, where and when it is needed.

5.2 Hands Free Workflows

Also known as dynamic forms or checklists, workflows are an integral part of standard operating procedures, quality assurance and regulatory compliance as well as health & safety. By using hands-free workflows on a wearable device, workers can maintain maximum situational awareness for safety while be able to access sensors such as a 16mp camera and flashlight, so that they can create more visual evidence (photos and videos) than was ever possible with written forms or keyboard entered forms which are typically fulfilled with the use of hand-held/occupied phones or tablets.

A major international oil company employed HMT-1's and Workflow software in their offshore oil platforms in the first half of 2020. Before they started using wearables and hands-free workflows, they were averaging the completion of 7 tasks a day. The ease of data collection and physical freedom caused the average to increase to 30 tasks a day, within the very first week of implementation.

British rail is using Workflows for their workers on sections of rail to do inspections and maintenance. At the end of their workflow, the software uses the device's GPS to detect what section of train line they are on, and automatically appends that to the report so that there is no chance of error.

APIAM Health are using workflows for assessment of animals with Bovine Respiratory Disease. Hands-free, they can document the animal tag number, record photos and/or video of the unwell animal and, zero-touch, have a treatment triage-form output and emailed, ready for the animal

hospital to review, before they have even exited the pen. And all the info captured can auto-trigger any back-end system such as an ERP system like SAP, or Salesforce or any other tool being used to handle central organisational processes and data.

Airbus Helicopter engineers in the US are also using HMT-1's while inspecting parts and making notes of damage, and measuring each component. By using the hands-free interface and entering data into Workflow software within a second of making a measurement, they have increased worker productivity by 41% and decreased errors to almost zero.

5.3 Other Applications

The capabilities of wearables extend well beyond the use cases outlined above, in our experience and research. The on-board processing is using a Snapdragon 635 chip which makes the wearable powerful as any other high-end Android phone or tablet. In the last quarter of 2020, the chip is likely to be replaced by a Snapdragon XR-1 chip which has AI processing capabilities, and which means that machine learning can be done while the user is wearing the device, in the field.

Other common use-cases for wearables include visualization of Industrial Internet-of-Things data. This is being used by MacDonald-Miller Facility Solutions in the US, to allow HVAC operators who manage HVAC for all of the facilities on Microsoft's global headquarters campus in Redmond, Washington. By walking up to an air-conditioning unit and scanning the code with the headset camera, all of the sensor data (such as active vs inactive pumps and filters) from that unit is relayed from Microsoft Azure IIoT Cloud into the HMT-1 heads-up-display so that the technician can diagnose the issue 'from the inside'. They can also switch units on and off by voice, speaking to the wearable which then speaks to the online HVAC equipment. Within 12 months, this solution saved Microsoft more than $20M in facilities costs.

In addition, thermographic cameras are available from Librestream and FLIR, that allow an operator to see their environment thermographically. Oz Minerals are using this to check the temperature of workers as they enter a mine-site. Electricians are using thermography and wearables to allow them to identify hotspots from frayed/loose wiring.

Finally, the wearable device is also being used by miners in Western Australia as a heads-up-display for DJI Mavic Pro Drones, as they conduct surveys and asset inspections from the air. Remote viewers can also dial in and share the view of the drone as it navigates the geographical landscape.

5.4 Product Availability & Onboarding

Because RealWear HMT-1 is an off-the-shelf product, the processes by which a business can acquire and activate a device are quite simple:

1) Acquire the device from an official reseller, such as Virtual Method (https://www.virtualmethod.store/) whereby you can buy the unit and accessories and have them delivered in about 5 days

2) The HMT-1 device costs **$3,120** and comes with a 2 year warranty

3) We recommend also buying a Carry-case ($63.10), Workband for comfortable anywhere-use ($56) and a Flexband ($106.10) if you work in environments whereby you would need to wash + sanitise the device + wearing mechanism regularly. If your work environment is noisy (more than 65 decibels), we recommend PPE-rated audio earbuds ($169) and if you intend the use the device outdoors, wind noise filters ($29.97).
TOTAL Investment: _____$3,481

4) When you first receive the device, download the ***RealWear Companion App*** onto your iPhone or Android Phone.

5) Open the app on your phone and tap 'Configuration', 'First Time Set-up'. Enter your wifi or phone hotspot details.

6) Attach your HMT-1 to your Workband head-mount.

7) Power on your HMT-1. It will want to configure and will be looking for a QR code – which you will already have ready on your phone's screen, from doing the Configuration process in the RealWear Companion app. Hold the QR code up to the RealWear Camera.

8) Now, your device will be online.

9) Go to https://www.realwear.com/products/Foresight/ and apply for a Foresight account (for over-the-air device management

10) To get started with Remote Expert, and if you have a Microsoft Office 365 account (and Teams), fill out this form: https://www.realwear.com/solutions/microsoft-teams/#C1

11) RealWear will add Teams to your Foresight account which you can see under MENU: 'Device Management'>'Application Catalogue'>'Applications Posted By RealWear'.

12) Go to MENU: 'Devices' in Foresight. 'Add new device' (yours) by typing in the serial #.

13) Go to MENU: 'Policies' and create a new policy. Add apps to that policy by choosing them (Teams at least) from the drop-down list. Save it.

14) Back where you listed your device, edit the 'Device Settings,' scroll to the bottom and drop-down the 'Policy Template' to choose the policy you just created – and Save it.

15) Now, within minutes, Teams will be deployed to your RealWear HMT-1 over-the-air (OTA) and you can sign-in and start calling, using your Microsoft Single-Sign-On.

16) You will note that you can also add apps like Librestream and WorkfloPlus, that were used in this Research Study, to your device. If you contact Virtual Method, we can arrange for a free trial.

17) FINALLY – the most important point is that you wear your device correctly. Watch this video to determine whether you should have the Heads-Up-Display (HUD) over your left or right eye.

18) And then ensure you manoeuvre the HUD so it sits just below your eye, almost touching your upper cheek, facing upwards. It is not meant to block your view, just be a screen you glance down-at when you need-to (to frame the video-camera or watch/read an instruction task).

These steps above will get you up and running in less than 30 minutes, pending the response time from RealWear per Foresight and Microsoft Teams access. And once you have a handle on Foresight, setting-up and deploying another 2, or 200 devices over-the-air, is simple. You just need the Serial numbers. NOTE: if your company uses a Mobile Device Management (MDM) system such as Airwatch, SOTI, Intune or MobileIron, there are options to use these systems to connect to the devices as well.

6. Outcomes

6.1 Initial Stakeholder Meeting

The first on-site meeting occurred in late January 2020, and involved key members of NCMC as well as stakeholders from the MLA and AMPC. We spent several hours reviewing the technology and then did walk-throughs of the meat processing plant, kill floor, yards and tannery.
On this day, the ideas that were proposed by the stakeholders were:

1) Use the devices to record point-of-view (PoV) video and document special knowledge and skillsets that may form the basis for training and task-succession within the facility.

2) In the cold-store packing area, workers are currently using hand-held, bulky scanners to verify the items they are packing. Opportunity: to create a workflow to validate and visually record the condition of items being packed give workers a hand-mounted barcode scanner such as the Honeywell 8670 to increase efficiency/productivity by (estimation and based on other case studies) at least 100%. Also, develop a piece of software that can estimate whether a pallet has the proper amount on it by gauging volume relative to box size.

3) In the packing area, have a piece of software translate Arabic and Chinese over the top of the label so that workers can check whether the label is correct to the contents in that box**,** and in order

to prevent rejection and any accusation of intentional mislabelling by any Chinese or Arabic-speaking country, at the point of import.

4) In the Controls room, maintenance of the Controls boxes could be conducted more regularly - using a RealWear-integrated thermographic camera to look for heat-spots that indicate loose or fraying wires etc. We can put together workflows for this.

5) Also in the Controls-Room, the remote CCTV manager could get better eyes on anything going on inside the plant by having a stakeholder in that area move to close-up and do a remote expert call.

6) In the boning-room, the tickets come through and are printed + pinned to the end of the table. If the ticket could be scanned for a workflow that related to that information which would then appear on the workers Heads-Up-Display and which they could then confirm-against, it could increase compliance.

7) In the boning-room, the correct cutting of meat is critical. Opportunity is to PoV-video-record the best workers doing the task correctly and use that video footage and narration as training for new workers.

9) In the labelling room, a lot of the equipment is quite specialised and can be temperamental. If, when it breaks down, a worker could receive remote assistance, they could get up and running again.

10) In the meat-grading area, the current method for recording the data is physically-clunky (eg - PH levels, marbling score etc). If the barcode on the carcass could be scanned by the HMT-1 wearable, and the data recorded by-voice in the heads-up display, speed and accuracy would be improved as the workers would have their hands free to use the measuring tools.

11) In the Tannery, workers at the hide-pressing machine currently have to punch-in numbers to:

- Register the hide #
- Rank the hide quality
-

It was discussed that the RealWear device may cause the workers to be able to enter the numbers faster, and therefore allow them more time to check each hide.

12) At the receiving dock, it was identified that the device could register the load of cattle arriving, video the cattle exiting the truck of their own volition, could register the yard they are being put-into, verify the qty, and then could also be handed-off to add the verification of the vet + then auto-

notify the Controller that the pen is ready for processing. A report would be available to send to the Co-op member who owns the cattle, showing this whole process and its compliance.

As a result of this initial meeting, we needed to re-set the expectations of what the most turnkey applications are and where the easy-ROI is, for the NCMC and meat processing community, and what would require deeper scoping and integrations with 3rd parties involved (such as other software companies or service providers who maintain equipment etc). We managed to maintain the scope and focus of the research project ultimately, but the possibilities of wearables did inspire a lot of ideation and excitement around innovation, which was great to see.

6.2 Methodology & Application of Assisted Reality during the research trial - NCMC

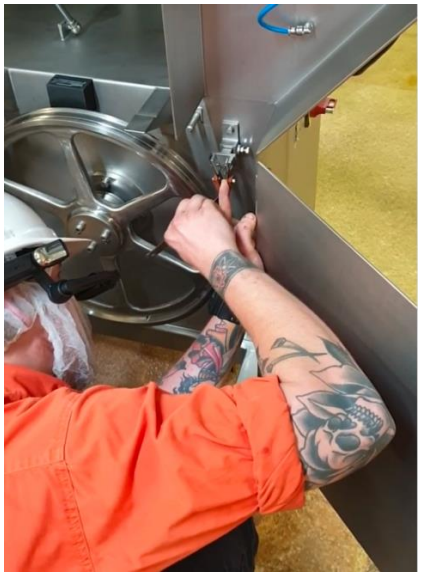
6.2.1 NCMC Final User-Cases

Once we had provisioned several HMT-1 devices to NCMC, we then sought to identify the key areas where we wanted to prove value. Initially, we hoped to assist an Italian based equipment manufacturer to provision a large and expensive piece of tannery equipment that had just arrived at the plant. The Italian company was unable to provide anyone on-site to instruct the building of the equipment. For some reason, the Italian company pushed back on the idea of telepresence to wearables and used more traditional PC conferencing methods. It was generally agreed at the NCMC end that this was disappointing, as it would have made the whole process a lot easier to receive instructions whilst doing the assembly tasks at the same time.

Instead of using the tannery equipment therefore, we turned our attention to other machines that require remote expertise and workflows. One that received special attention was the **Blade-stop 400 band saw machine**, which is a meat-and-bone-cutting tool that requires a process of several steps to ensure it is in good working condition for safe work.

Maintenance was identified as a good opportunity because of how important it is to both hygiene and safety in meat processing, and also because it is conducted quite regularly across a wide range of equipment. Typically and traditionally, the steps required for maintenance of the machine are printed-out on paper, and are followed manually – with no real-time input-data to verify that tasks were done and *when* they were done and by *whom*. From an insurance and OH&S perspective, by providing very high-quality verification of these processes, if ever the vigilance of NCMC maintenance was called into question, every maintenance that has ever been done could be produced within minutes and verified beyond reproach.

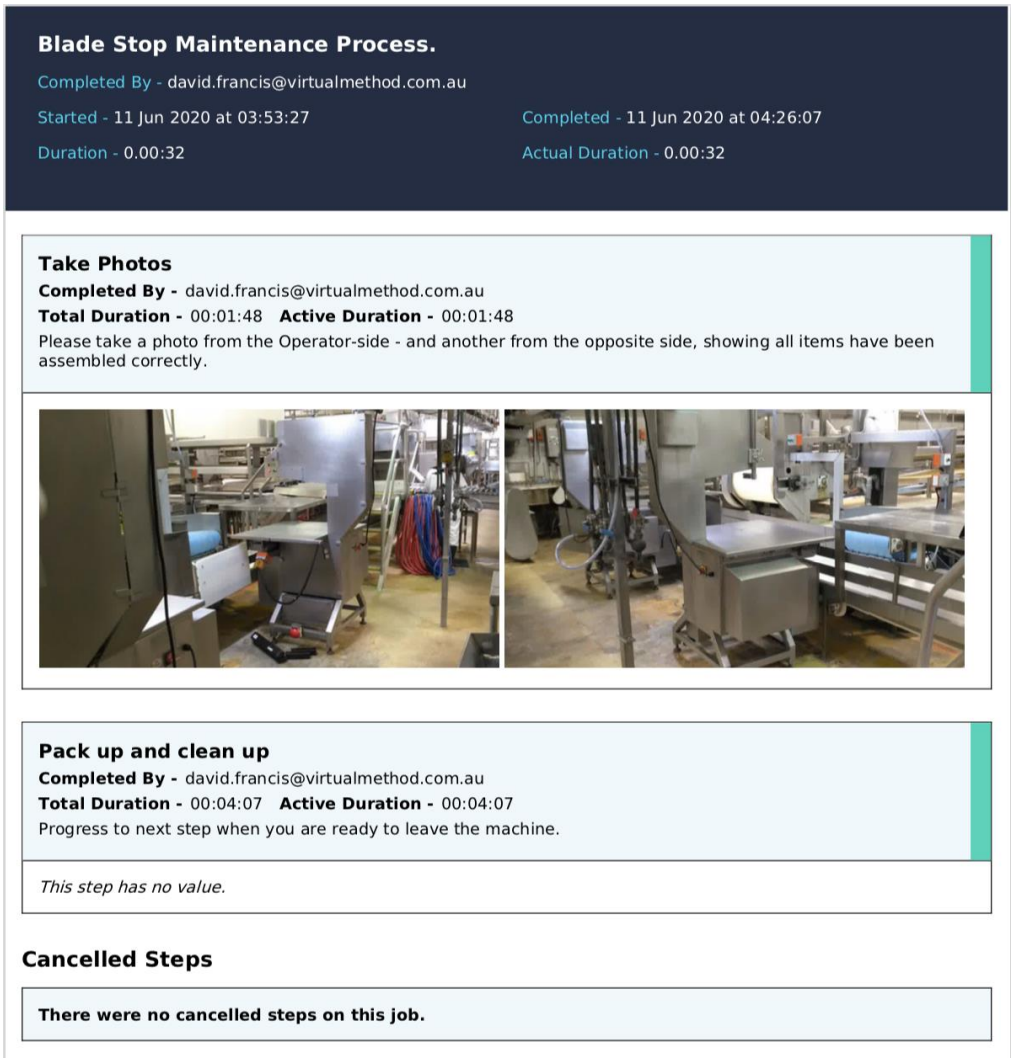
The tasks involved in the machine maintenance were firstly video-recorded by NCMC and were sent to Virtual Method, along with the task-list. Virtual Method then turned these into an interactive, dynamic workflow that was then remotely provisioned to the HMT-1 devices NCMC had in their possession, through the Workflow software: WorkfloPlus. The WorkfloPlus tools allowed us to create the workflows easily and with no code required. We just entered the steps, added any video or images, confirmed the data input type required, connected the steps to run in the correct order (and made multiple paths for any yes/no options) and then updated the workflow in the cloud.



**In the images above, note the worker's need to use 2 hands for tasks, which means a hand-held device for tasks and calls would not be feasible or safe.*

The maintenance worker was then able to see the task on the list of what he was required to do, that day, in the Android app on the HMT-1. He could then perform the tasks hands-free, whilst occasionally viewing a short video of what was required at a certain step that was more complex. This meant that the worker could have a lower skillset than would otherwise be required, as he was being trained very clearly and just moments before being required to perform that task. One of the most obvious benefits of using a wearable to do this, it became clear to us as observers, was the consistent need for the worker to handle a tool with one hand, while steadying a piece of equipment or their own bodyweight, as they calibrated and disassembled plus assembled the equipment.

It is notable how many workers in agricultural circumstances especially, need to maintain maximum visual awareness and also need to engage *two hands* to do tasks. 'Digital Transformation' and 'Connected Workers' are therefore unlikely to become a feature of Australian industries until the limitations and friction of traditional phone and tablet interfaces are recognised.



Blade Stop Maintenance Process.

Completed By - david.francis@virtualmethod.com.au

Started - 11 Jun 2020 at 03:53:27 Completed - 11 Jun 2020 at 04:26:07

Duration - 0.00:32 Actual Duration - 0.00:32

Take Photos

Completed By - david.francis@virtualmethod.com.au

Total Duration - 00:01:48 **Active Duration -** 00:01:48

Please take a photo from the Operator-side - and another from the opposite side, showing all items have been assembled correctly.

Pack up and clean up

Completed By - david.francis@virtualmethod.com.au

Total Duration - 00:04:07 **Active Duration -** 00:04:07

Progress to next step when you are ready to leave the machine.

This step has no value.

Cancelled Steps

There were no cancelled steps on this job.

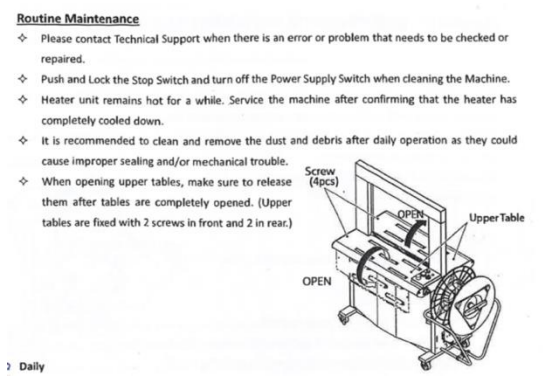
**Above: a sample from the report that was instantly output and emailed to NCMC stakeholders after the worker had completed the tasks.*

From the completed Workflows we are also able to feed the data into Microsoft Power BI Reports so that, over time and several or more workers, we can visualise and understand trends in the geolocation of tasks performed (in this case, in just one plant), the time taken to execute and how many times issues were identified, and where. Right at the end of the study, integration with Zapier also became available. This means that the Workflows can automatically trigger actions in more than 2000 other apps including those from Google G-Suite and Microsoft, such a Dynamics.

The next piece of equipment that we decided to trial the HMT-1 around, was the **Strapper**, which is a machine that tightens and clasps-shut a strap around meat in packaging, to keep it secure during transit.

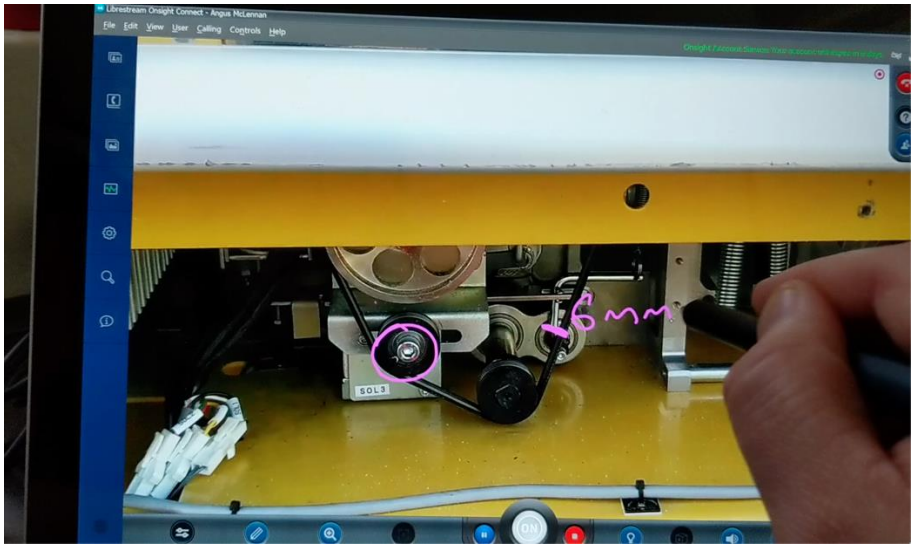
For this task, we imagined that it was a worker's first time doing a maintenance on the machine and that they would be calling a remote expert (eg – the manufacturer's customer service person or trainer), to talk them through the correct administration and procedures. NCMC supplied Virtual Method with the written tasks and diagrams, to act as the Expert on the call. Using Librestream Onsight Connect, the call began.

During the call, it was very clear for the remote expert to see where the worker was directing his attention. Undoubtedly, there is some technique to using the heads-up display to aim the camera when it is required to show an item being questioned or addressed as part of the training. But the worker very quickly got used to the interface and, while the camera drifted a bit as the worker was busy undoing screws etc, when he need help, it was clear to the remote expert exactly what was required. The remote expert was also able to annotate over the Live view of the worker, and also on top of photo captures. This way, the worker/trainee could more easily understand exactly where they needed to perform a task, when they could potentially otherwise be confused by several items that would fit the same auditory description.



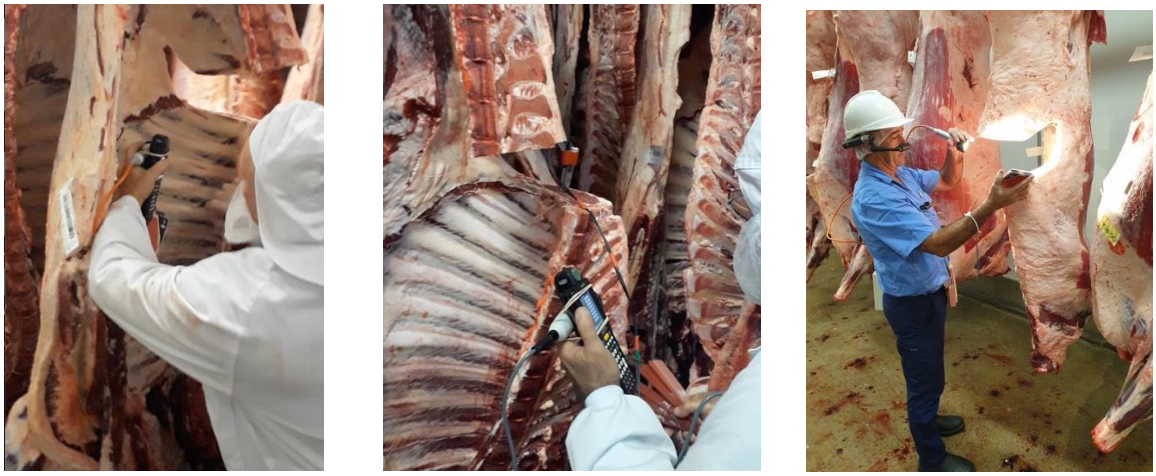
**Angus (the NCMC worker in Cassino NSW) hears the Expert's voice as he prepares to act under the Remote Expert's instruction to remove the front panel.*

During the call, the latitude and longitude of the worker is confirmed on-screen. All photos taken at 16mp hi-res, as well as videos, are uploaded to a web-based repository so they can be reviewed later for training optimisation or as proof-of-work-performed. We found the communication easy, fluent and it didn't at all get in the way of the worker achieving the outcomes required.



**The Remote Expert, working off a Microsoft Surface Pro in Sydney, uses a Surface Pro Pen to annotate the screen which instantly appears in front of the worker's eyes.*

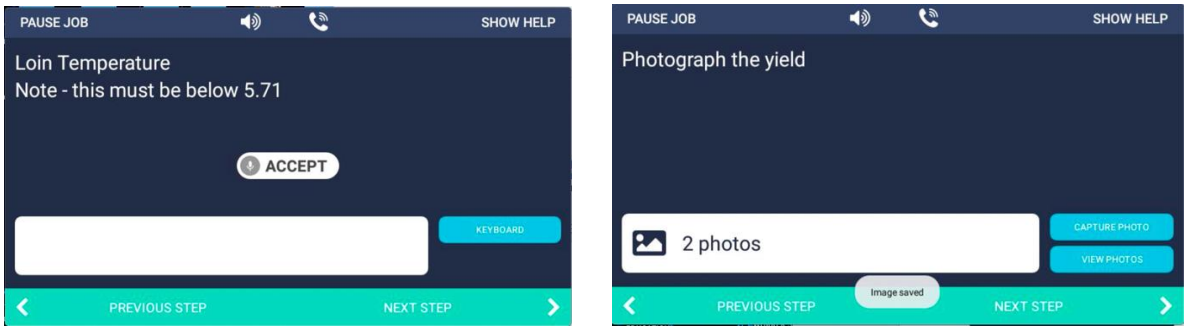
The third use-case we actively addressed was **MSA Meat Grading**. It was identified that the meat graders have to carry a number of items of equipment with them as they perform their tasks. They typically carry a flashlight, a hand-held mobility device which has a keyboard for typing, a digital meat PH-tester, and several swatch-books plus measurement tools. The effective use and fluency of working with these items takes a long time to get used-to, physiologically. Our hypothesis was that by using an HMT-1 wearable and by entering the data by-voice, we can free up at least one hand to generally speed up the processes. We could potentially also reduce the risk of any repetitive strain injury from having to hold a device all day and finger-type.



Left and centre, meat graders use hand-held mobility. On right, hands-free with HMT-1

We also hypothesised that if we can speed-up the grading process, we can also use the readily available head-mounted-16mp-camera to take hi-res photos of the yield (the side-section of meat) so that we can begin a visual database of images against the data points of the meat and resulting grade. With several thousand photos at some point down the track, we can then start to robustly train an autonomous Visual AI to be able to grade meat (even an AI that is worn and running in a head-mounted-tablet!).

The process of meat grading was set-up as a workflow in WorkfloPlus. We were set-back a little while by the initial unavailability of 128-bit barcode scanning as an input option, but Intoware (the makers of WorkfloPlus) incorporated this so we could effectively scan the barcodes that were attached to the carcasses. In practice at Virtual Method, we were able to achieve workflow completion in less than 60 seconds. In the grading room however, and with workers not yet used to using a voice operated system and data inputs, it took 2-3 times as long. We also weren't able to use the HMT-1 beyond testing, and for Live grading, because the software doesn't yet have access to the database and algorithm that recommends the MSA grade based on the data inputs. But if that algorithm was available, we could have started to implement and employ the HMT-1 as a new input device, ongoing.



**Two of the data input screens from the MSA Meat Grading Workflow, as seen in the heads-up-display.*

Finally, we sought to use the HMT-1 for one of the most simple but powerful use-cases: **IP acquisition**. Given the aging population with 750 workers retiring every day, the skills gap which is noted to be at critical levels in Australia[4], and the poor or non-existent methods for the inter-generational succession of special knowledge (that isn't written or recorded anywhere), we wanted to test the basic function of a worker recording tasks-undertaken, as videos, from their poinht-of-view (PoV). We identified an NCMC worker who will be retiring at the end of this year, and who comprehensively and solely understands the electrics and systems for an older part of the NCMC plant. We had him perform tasks while wearing the HMT-1 and recording what he was doing. It was a challenge to compel the worker to voice-narrate every step he was doing as, if he was talking to a trainee beside him (as it can often be with an actual trainee), but the device very effectively created a record of the task so that if that worker retires (or is unavailable before then for any reason) and there is no properly documented record of the process, any other worker can step-in, play the video on the HMT-1 and pause after each instruction to do it in real time. If that task was to repair or replace a piece of equipment that would get the plant up and running again, having that knowledge available when and where it is needed could save NCMC very large amounts of money.

6.2.2 Results - Challenges

Undoubtedly, as with any new interface, the greatest challenge is achieving a level of physical fluency and comfort with a new device. This is the case if you swap from Android to iPhone, or a Canon Camera after using a Nikon for years. Irrespective of how tech-savvy you are, it takes time for the eye and the brain to get used to the monocular display-screen of a wearable, despite the fact it poses no eye-health safety issue (as opposed to dual-lens AR headsets that are known to cause issues because of *accommodation vergence conflict*[5]). One NCMC worker commented: "The eye piece is a lot to get used to". The neural plasticity of our human visual systems allow us to adjust to change quite quickly, but if someone has a history of eye difficulties, it can at first feel like an impediment, until the eye gets used to it. Also noteworthy is that the HMT-1 can be worn with glasses (and PPE eyewear).

[4] https://www2.deloitte.com/au/en/pages/media-releases/articles/work-human-australia-faces-major-skills-crisis-120619.html

[5] https://docs.microsoft.com/en-us/windows/mixed-reality/comfort

Another challenge was voice-recognition. Even though the RealWear device has near perfect background noise cancellation for the microphone, up to 95db, some workers struggled with the device understanding them clearly. Since the trials were conducted, RealWear has added 'Australian' as a language for the device, which is a mode that now allows the speech recognition to better understand the vowels and consonants of Australian diction. We anticipate that the new voice addition will avoid any ongoing issues. The NCMC meat grading foreman said: *"It would be pretty good if we can get over the pronunciation issues, like if it would react to what you say the first time then we would be ripping through bodies."*

We also experienced challenges in working with voice-activated software at high-speed. For Meat Graders, while they can work fast with the headset (after becoming accustomed to the wearable and voice interface), the repetitive nature of saying "keyboard" every 7-10 seconds, to open up the speech-to-text data entry field, was flagged as something that may serve to irritate the worker. We have since approached the software developer who is working on a method to bypass this step and open the data entry-field + 'active listening' straight after the previous step is completed.

Another issue was positioning the camera relative to where action was being filmed. More than a third of issues that occur around wearables have to do with the wearing-position of the device and the accessory being used. The NCMC workers used ballcaps and the helmet-mount. Since we conducted the trials, a 'work-band' has been brought-out that is a far more stable mount that won't have a ballcap bill get in the way of filming. In addition, there is now a silicon head mount that is being used in food and pharmaceutical manufacturing as well as surgical theatres. The silicon can be washed and sterilized quickly and easily. One worker noted that a head or chest-mounted GoPro might perform a similar task, but it was also noted that with a GoPro you are 'filming blind' in that there is no opportunity to check what is and isn't in-shot per the viewfinder of a heads-up display. You also can't point to something and have someone watching the video know exactly what you are pointing-at, unless the GoPro's lens was mounted 5cms away from your preferred aiming-eye, as the camera of a RealWear HMT-1 is. A lipstick-camera that is often used for the PoV-capture of professional motorbike riders (attached to helmets) would likely be the only other device that could achieve this filming and hand-telestration capability. But you would only find-out upon post-task review of footage.

One last item that was noted was that the worker had to lean-in to the barcode of the animal they were processing.

It is notable what the overall Research Project Lead said, paying special attention to the identification of a resistance to change: *"I can see NCMC using this piece of technology however I could see it taking a longer period of time in order to implement the technology in significant ways. This is not due to the headset itself but in the inability for people to accept change and take on new challenges. There is an old saying that I definitely do not agree with but can hold true for many that goes 'why fix what isn't broke' and it usually stems from what I said previously people aren't willing to accept change so readily."* It must be noted that thus statement was made before the height of

Covid shutdown, and that NCMC have started to use the devices outside of the scope of this research trial.

6.2.3 Results - Successes

While there was no doubt that working with a whole new digital form-factor and voice-operated user-interface was quite a leap from the incumbent processes and systems at NCMC, the response to the wearable device and its capabilities was overwhelmingly positive. Some key quotes from feedback forms said:

"There are going to many use cases on this plant that the technology will be useful for".

"This gives us the ability to create more accurate future projections for many aspects of this company".

- Engineering Manager

"I am extremely interested in the technology [for virtual tours of the plant]*"* .

"Would love to talk more about integration of the headset, especially with iLeader. If it can be integrated with iLeader then you would have many companies that would be jumping up to have a look at this technology". "[It] would be great for doing our product monitoring, so that one of our QA members goes along and sees a defect just says 'take photo' and it sends it through to our servers and automatically fills out the forms required."

- Quality Assurance Manager

"The headset was really good if you don't know how to do a job. At least you could have the recorded footage or pictures or even the workflow of someone performing the task prior to yourself and you can do the job according to that".

"So long as you have all the pictures and videos of an expert doing a job, then anyone can do the job."

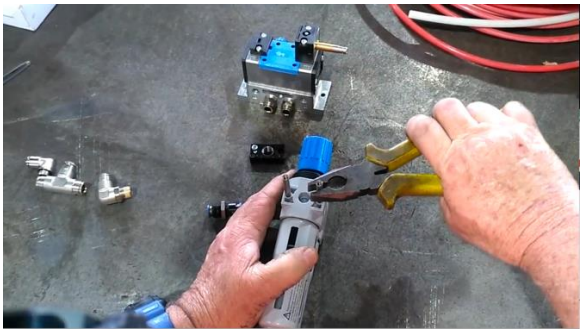
- Fitter & Apprentice (who predominately tested the Blade Stop Maintenance Workflow)

"The headset is extremely useful"

"For example if Franny (our leading hand electrician) had full access to plans without needing to contact the draftsperson first and has those on the fly then this would save heaps of time."

"You could certainly use it in confined spaces and if would be very useful for communicating to someone outside and using the light and even getting the expert outside the give you all the information based on what you are seeing."

- Another Fitter & Apprentice (who predominately tested Remote Expert for the Strapper machine)



**Hide-stamper's pistons being replaced + a Veal Bleed Chain Lifter receiving maintenance, performed by an older worker, who owns the knowledge around these critical equipment processes.*

Overall, the feedback was very positive, with the main friction points not stemming from the limitations of the device, but rather the fact that the device was picked-up and used from a cold start by all the stakeholders involved in the trial, and not for an extensive period of time so that they could get used to the new wearable-and-voice-operated user-interface. The form-factor of a head-mounted wearable was noted as being very comfortable and unintrusive, and most of the workers involved were able to ideate and nominate potential use-cases, quite soon after they had trialed the device.

From what we saw in this research trial, it is reasonable to confirm that the device can-and-will, with the correct implementation and software, be validated to:

1) Cut down the time involved in MSA Meat Grading and eradicate any risk of repetitive stress injury from hand-operated digital devices.
2) Allow almost instant triage and support of break-fix, production-impeding issues, and more accurate estimation of down-time.
3) Allow a high-proof-level, image-driven Quality Assurance process and advanced + automated reporting.
4) Allow potential customers to tour the facility without the need to fly + drive to Cassino, be inoculated for Q-Fever and take time and resources to walk through the whole premises themselves, and overcome any issues of language barriers by using annotation and pointing to items, while sharing a visual point-of-view.
5) Reduce the risk of Covid infection from workers and outside maintenance professionals moving through the facility, when they can have an aural + visual conversation at a distance.
6) More effectively capture the special knowledge of workers who are nearing retirement and/or without whom, the cost of re-acquiring their knowledge would be very high.
7) Allow lesser-trained workers to perform tasks, when they will be autonomously trained, and have their actions verified, while doing the task.
8) Enable the collection and collation of images, to build a classified database, so that an AI may learn from thousands of photos (the only way to effectively train a visual sorting system, for example).

6.3 Methodology & Application of Assisted Reality during the research trial – Centre Plus

6.3.1 Centre Plus Final User-Cases

Centre Plus was brought into this research project later in the piece, as Mark Mortimer (Partner and Data Analysis Manager) was identified as an exceptional innovator in the processing of sheep and tracking of genetic traits. Mark has developed a system of using barcodes and a barcode-scanner, to speed-up the processing of sheep during shearing and increase the quality of data gathered during this process. Centre Plus specialise in producing a merino with high productivity, superior wool and characteristics. The meticulous scoring and recording of each animal's traits, combined with full DNA testing and the use of genomics creates an environment where each animals' potential is maximized.

Today Centre Plus is an innovative merino stud, focused on producing the exceptional all-purpose merino.

The use-cases identified in our initial discussions included:

1) Using the device and a Workflow to enter data-points from receiving the fleece from the shearer, through to classification and baling.
2) Record special knowledge tasks being performed in the shearing shed – such as the act of shearing itself (noting, for example, that Victoria has found itself 500 shearers short in August/September due to the unavailability of interstate shearers)
3) Use the device to capture data about the genetic traits of a sheep, including visual data so that a visual database can be built-up for machine learning and faster, more automated identification of merino breeds and traits.

In order to do these tasks, we again employed Intoware WorkfloPlus software as well as the native camera-recording functionality of the RealWear HMT-1 wearable.

**The Centre Plus team, using the RealWear HMT-1 in the shed and the field.*

6.3.2 Results - Challenges

One of the main things that Mark focused-on was Time-and-Motion of using a wearable device vs the incumbent system of using a hand-held scanner to scan the barcode on the original ticket output from the sheep's RFID tag and then provide data inputs by scanning barcodes for colour, style and weight. In this way, the first response was similar to NCMC, in looking for the device to speed-up existing processes.

3 primary criticisms of the device from device wearers at Centre Plus were:

- a bit uncomfortable after 2h (was feeling sick looking the screen + heavy on the temples)

- lots of repetitive words
- slow when a lot of noise around

We have addressed these, below:

The workers were using a tri-band strap to mount the device to a ballcap. While this method is OK for certain periods of time, the tri-band strap was primarily designed to work with a rigid bump-cap rather than a soft ballcap. There are other choices for device wearing such as the Workband, which are more stable and a much more comfortable form-factor. Noted that this would be more suited to this environment in future usage. We also noted a silicon strap would work much better for Akubra wide brimmed hat wearing.

Mark put the workflow straight to work in active shearing sessions. Because of the difficulty scanning the barcode at 10-20cms and entering classification + weight data at high-speed (most especially as a brand new voice-interface) and possibly because of the unavailability of Australian accent-tuned speech recognition to reduce the need to repeat phrases, the workflow + wearable couldn't perform the process as quickly as the incumbent barcode scanner system. That said, it was one of the very first times the participants had used the device + voice interface, and it was under the full pressure of a Live production process at full pace.

The same issue as NCMC meat grading, relating to speech-to-text inputs, was identified: to bypass the need to say 'keyboard' which eats up time, but is also a point of intense repetitiveness if the same word is spoken several times in a minute, every minute. A per NCMC, the bypassing is now a feature being looked at by the Developers.

The RealWear HMT-1's camera needs a barcode to be held around 10-20cms from the head-mounted camera, to read a 128-bit barcode. To make this much faster, the barcode could (should) be read by a hand-mounted barcode scanner ring such as the Honeywell 8670. The ring scanner would then scan the code directly into the workflow for that fleece. OR the HMT-1 could be tethered to the RFID scanner-wand – whereby the number could go straight into the workflow without the need for a printed barcode at all.

It was also identified that Mark felt that cognitive load was generally increased during usage. Working-memory and the phonological loop will prevent the need for neural synapses if data is transposed *within 3 seconds*. Given the limited usage of the device, and speech-to-text issues not being overcome on trial days, the data would suggest that his observations are correct and that there was indeed cognitive load created. **But** by omitting the keyboard entry function and with optimisations (now), there is no reason why any user should experience any cognitive load, engaging with the wearable interface.

6.3.3 Results - Successes

While the RealWear HMT-1 usage in the flow of fleece-grading did require optimisations, the potential of the device was validated – and with those optimisations in-place, the wearable workflow could be faster and would require no more infrastructure than the wearable itself and an RFID reader. Further to that however, was the use-case of capturing knowledge from skilled workers. Centre Plus arranged for an experienced shearer to record his technique as he sheared a sheep, through his eyes. The resulting footage is quite extraordinary as anyone can start to understand the processes involved in thoroughly, safely and cleanly extricating a woollen fleece. And because of the up-to-95 decibel noise cancellation of the HMT-1 microphone array, the shearer's voice can be heard clearly over the top of a very, very loud shearing shed environment.

It has also opened up the possibility for shearers to digitally note and mark sheep that have any potential health conditions, on the fly. In a country where so much special knowledge has not been

transposed and is therefore not being passed on to a younger generation, this wearable form factor has proven we can memorialise that knowledge for generations to come. Not to mention that the incorporation of new and innovative technology to this industry makes it more likely a younger generation will buy-in to the future of agriculture.

We also happened to validate that a RealWear device can work with an Akubra (importantly).

Finally, we also had it qualified for us, from Centre Plus, that taking tablets or phones into an environment with heavy machinery, blades and kicking hooves is simply not practical – and so a hands-free device is the only safe option.

Some notable success-related quotes from Mark Mortimer:

"I found the editing software easy and simple to use. Without any training from just an example workflow I was able to build my own workflow and upload to the device and start using it."

"We were able to get a picture of the fleece linked with its RFID on 500 animals at real work speed with a full extra labour unit. With changes to software there is definitely room to dramatically change the speed of data capture. I would be interested in seeing where it ends up."

"Comments by the extra labour unit who co-used the device over the two days: it was reactive and pleasant to use."

It is additionally worth noting that this was the first time Mark was able to capture images of the fleece-composition itself, and start to build a visual database of fleeces. He captured more than 500 images that were registered against animal tags, in just a few hours.

This was a recommendation that Virtual Method made. The reason why: if we can optimise the workflow and current data capturing, for the wearable device, we can add the visual image-capture and *still* beat the current physiological workflow processes for time and effort. *And* if we get enough of that visual data, relative to the grading of fleeces by the workers, we can train a visual AI to start to identify fleece grades automatically. Further to that, a camera sensor can see in a wider visual spectrum than a human being, so the camera may start to record and note visual nuances that cannot be picked up by the human eye – but which ultimately might provide new data points that relate to other areas of fleece quality and utility. But we'll never know, until we build that large, visual database…

**PoV view of the shearer, recorded hands-free and with commentary.*

7. Conclusion

After several months of engaging with various stakeholders across NCMC, and around 1.5 months with Centre Plus, the solutions identified and tested have given rise to many more opportunities that

aren't addressed by this report. Where our initial hypothesis was to address certain scenarios we identified in theoretical factoring, more and more use-cases were picked-up – and continue to be picked up in the present (we have heard from NCMC, for example, since writing this report).

Typically, the first place that people who haven't yet used wearable computing look, is at tasks that already have some sort of digital interface – such as the MSA Grading or the Fleece weighing and grading. But when you can carry a high-powered mobile screen and data input device, hands-free and everywhere you go, more opportunities tend to open up around scenarios that haven't received any sort of digital transformation because computers, phones and tablets have always been completely impractical.

Whether it's kicking/rearing-up animals or walking through swinging carcasses, we saw that situational awareness is extremely important in these physically demanding animal-handling and red-meat-processing environments. From a physical safety perspective alone, we believe we have proved that a wearable interface that doesn't obstruct a viewer's peripheral awareness, and is the only safe and practical computing medium through which red meat industry workers can be empowered to be a part of real digital transformation as they have their skillsets augmented in real time. This represents a significant stop-gap and optimization of the *existing* red meat industry workforce, without having to look to jump-to complete automation yet, at a time when doing-so is such an enormous infrastructural expense (and is prone to fairly short cycles of technology redundancy).

The extension of personal, physical safety considerations is food safety for the red meat industry. We have shown that *hands-free* computing can be used in place of touchscreen interfaces, reducing (for example) the risk of Covid-19 infection in meat processing, which has been a hot topic in the media. The proactivity of adopting wearable computers could also go some way to proving innovation, accountability and a willingness to change the perception of the industry amongst those who would seek to be critical of red meat production - for whatever reason.

We have also seen that any program of wearable integration needs the proper backing of internal advocates and a dedicated stakeholder per-site, to ensure the devices are used optimally and processes switched-over from traditional methods. While making a point-of-view remote expert call when someone needs expert advice will definitely achieve hardware + software ROI and save expensive production downtime (usually, on a single occasion), wearing the device all-day *just in case* these semi-anomalous scenarios arise, is not practical. It is only when you are running transactional, daily maintenance, inspections, grading and education programs on the headsets with speech to text and image/video-input-based dynamic forms with back-end reporting and analytics, that the form factor's utility will be most appreciated by the Connected Worker. And these things are not hard to do. Mark at Centre Plus was created his own Workflows on day one of accessing the software.

There are certainly aspects of software that need to be tweaked for some use-cases, and there is a usability and adoption-piece that needs to be conducted through structured training, but not a single meat & livestock industry person who operated and tested the device during this trial, rejected its usage and potential in any way. Without exception, every stakeholder expressed excitement and *hope,* that wearable computing can and will become a part of their working-life. And they expressed that it would when the customization they need (and which is possible) is enacted outside of the bounds of this research report. In the last 12 months, we have seen more potential in the agriculture sector, than any other, with a younger generation especially wanting to embrace enabling technology. But we are also witnessing the baby-boomer generational titans of primary

industry retire. As we also proved was possible in this research report, and all other use-cases aside, if we just used this technology to capture that incredible knowledge, those undocumented skills, through *their eyes* and narrated by their voices in-situ in the plant or in the field, before it disappears forever, it could save the industry millions and build a videographic database for the next generation.

We would most like to thank Greg Williams at the MLA, Brian Armstrong at NCMC and Mark Mortimer at Centre Plus, for their support and vision to complete this important research for the industry.

8. Future research and recommendations

There are several key areas of further investigation that this Research Report raised:

1) The one thing that stopped us from being able to use the HMT-1 for **MSA Grading** was that we didn't have access to the database and/or algorithm that recommends the grade, based on data inputs. We would ideally like to pursue this and receive that data, so we can look at replacing the current hand-held devices with wearables. With the ability to take photos as well, this could potentially extend the MSA Standard grading processes out to anyone who wishes to grade a carcass.
2) It would also be ideal to set a similar trial up at another meat processor's facility, so we can better establish what are industry-wide needs and solutions versus those that were potentially idiosyncratic to NCMC.
3) Given the ability to have a camera so readily-available to workers, without getting in the way of work in any way, shape or form, there is an opportunity to address the Supply Chain from pasture to truck to feedlot to meat processing plant and hand-over a single, continuous workflow against a lot of animals, which is rich with time-stamp, date, geolocation and *visual evidence* of the safe and responsible treatment of the animals when they were alive. It would be a worldwide industry-first, to use the RealWear devices and WorkfloPlus software, to demonstrate the creation of a report, an audit that is evidentially bullet-proof, for anyone who questions the integrity of the supply chain.
4) With an older generation leaving the land, and the challenges of knowledge-succession to a younger generation, there is an opportunity for the industry to start a knowledge-library: recording narrated procedures through the eyes of the very best of an older generation, before that knowledge is lost forever, and creating an invaluable 'bank' of information. Using in-video analysis and AI from Microsoft, we could also make that database searchable, so that a younger generation can search by term or task, and be taken straight to where, before he retired, 'Coopey' showed exactly how to do that task with 'Bremen cattle', and why.
5) Also, because so much of this report is difficult to 'mind's eye', when so very few people have yet had the opportunity to try head-mounted, voice activated computing, we recommend that a **video case study** be commissioned, so that we can show the devices and software working in-situ and demonstrate the benefits of hands-free computing. This could also be used more widely in the promotion of Australian Meat industry innovation.

MAJOR RECOMMENDATION**:** That we conduct a Webinar for the industry and other RDC's, to demonstrate the practical application of the wearables in all the video footage we have, and help identify cross-RDC opportunities and ways to legitimately and safely enable digital transformation and human worker augmentation, on the land and through the supply chain.

As the Red Meat and agricultural industries further and more deeply embrace this next major computing interface, we also open up opportunities and create excitement for the next generation, who want to see the industry defining its future, innovating and moving forward. This is not technology-for-technology's-sake, but rather the real augmentation and digital-upskilling of our human workers, so that the expertise and quality know-how in this country can be democratised and universally applied to *everything* we produce in Australia.