final report

Google Glass Augmented Reality: assessment of opportunities of use and potential value to red meat industry

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Executive summary

This project is one of a series which aims to bring the benefits of augmented reality to the red meat industry. This report details the investigation into the augmented reality platform Google Glass Enterprise Edition. This investigation was performed to understand the potential applications of the technology to the red meat industry.

Specifically, the current report covers the following topics:

1. Google Glass platform
2. Google Glass experience
3. Applicability of the Google Glass platform to the Australian red meat industry
4. Potential projects which may be performed with this technology

The investigation found that Google Glass 2 is a good platform compared to its peers. The platform has significant computational power for size and excellent usability, making it a significant step forward for the smart glasses industry.

The platform has the advantages of being wearable with a hardhat and not obstructing the view of workers in a live environment – making it applicable to industrial applications. The ruggedness of the headset is questionable however, and it may not be possible to deliver a solution which would stand up to the wear and tear of use by a producer or could be deemed food safe/waterproof to work in a meat processing facility.

The user experience of the Google Glass Enterprise Edition is significantly ahead of competitors. The swipe interface on the side of the device is intuitive and extremely responsive. The user experience is made possible by the relatively strong on-board processing capacity of the Glass which allows it to keep up with user input more capably than competing solutions.

The display on the Glass is generally usable and high resolution, however it may freeze on occasion and cannot be seen well when used in high light environments such as in direct sunlight. The camera in the Glass is excellent for a smart glasses implementation however it is not high-resolution enough to read barcodes and higher resolution is desirable for many applications.

Across the handful of Google Glass headsets Wiley procured during 2019, there was significant inconsistency in terms of the software installed and the operating system thereon. Furthermore, different headsets (which appeared to be running the same OS and the same software) responded differently to voice commands. In one case, it was not possible to open proprietary software, developed by Wiley, using voice commands or direct inputs.

In a genuine use-case, the hardware would be procured from a solution partner. These groups provide the hardware to support their software, often with rolling hardware replacement schedules and high levels of accountability for the reliability of the software installed. In this way, the challenges outlined above of inconsistent software are less likely to be an issue in genuine implementations.

It is important to note that these partners would provide all software required. With this in mind, the fact that the Glass has no simple way of installing apps from an app store is worth consideration but may not be an issue in many situations. Smart glasses would or would not have access to the Google Play store on a case by case basis depending on the nature of their distribution. Generally, solutions designed for enterprise will not have access to the store but those designed for consumer use will. In this way, if the hardware is sold as a solution for a warehouse it will come fit for purpose, but will not be able to install apps from the Google Play store.

The hardware procured for this investigation was purchased from an entity called Streye. The Streye platform comes with apps for remote mentoring, Streye Checkr; which is used for checklists and compliance verification, Streye Alert; which gives the worker head up alerts for goings on in the plant and Streye link which is used for looking up information.

Overall, the Google Glass Enterprise Edition is a good test platform for verification (checklists), voice calling and information presentation applications and can be recommended for experimentation and development for these use cases. Because the platform is typically distributed for enterprise applications development may be challenging however, as this investigation demonstrates, this challenge can be overcome.

The platform has notable overheating difficulties out of the box when the camera is used in video mode. For this reason, the platform cannot be recommended over competitors for experimentation requiring sustained use of the video camera.

It is possible that the RealWear HMT-1 would be a good alternative for harsh environments and video-based implementations. The HMT-1 is specifically designed for wet and harsh environments and is essentially an android tablet, because this device can be consumed as a consumer (non-enterprise) product, it would have access to the app store and relatively easy development.

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1. Details of the Google Glass platform

1.1 Overview

The Google Glass Enterprise Edition became available in early 2017. As the successor to the Google Glass, it was one of the most widely anticipated smart glass releases to date. The Google Glass Enterprise Edition represents several improvements made over the previous incarnation; providing superior resolution, easier interaction, greater processing power and more memory. One particularly noteworthy change was the addition of a hinge to the device, making the Glass easier to store.

These factors come together in what was arguably the best smart glasses on the market at the time of release. The unique glass display artfully shows the information required by the user, without obstructing their view, and is certainly a better user experience compared to other smart glasses tested. The interaction is light, fast and intuitive, the battery lasts long enough to be productive and the package is well polished and easy to use.

According to various review sites, the Enterprise Edition is a vision of our future with significant potential, some of these sites also discuss the platform's significant challenges. The major inhibiting factors being the high cost of the devices as they stand and a lack of supporting apps.

Technology commentators are quick to ask whether these devices will replace the mobile phone. It is perhaps more prudent to ask whether the technology, like the mobile phone, will reach a point of ubiquity; such that every worker in a facility may be adorned with it, unlocking network benefits (similar to the uptake of mobile phones).

The Google Glass Enterprise Edition has been specifically developed with businesses in mind. Tom Ballard, the CEO of Upskill, stated that Google considered everything about the way people were using the device when they created the Glass 2. Everything from the way it folded, to charged, to how people may interact, was overhauled in this latest iteration to make it more useful for businesses.

The current section discusses Google Glass Enterprise Edition platform (@2019) itself from a more technical perspective.

1.2 Advantages and disadvantages

The following is a brief overview of the advantages and disadvantages of the Enterprise Edition.

Advantages

- Intuitive and easy to wear design
- Simple hands-free photography options
- Head movement tracking and head gestures expand the repertoire for possible interactions
- Vastly improved battery life
- Faster and more reliable Wi-Fi connection
- GPS integration

Disadvantages

- Prohibitively priced
- Photography not good enough for many industrial applications
- Apps both practical and downloadable are limited
- Device to device software inconsistent
- Voice responses unreliable
- Devices are prone to overheating and shutting down for arbitrary amounts of time

1.3 Specifications

The technical specifications of the Enterprise include:

- Qualcomm Snapdragon processor
- Dual-band 802.11n/ac Wi-Fi
- Assisted GPS & GLONASS
- Barometer
- 32GB storage memory
- 780 mAh battery
- 8MP still camera with 720p video
- 640 x 360 screen
- Wink and blink sensor

1.4 Alternative Hardware

The Real Wear HMT 1 headset presents an excellent alternative to the Glass for the red meat industry. With significantly greater processing capacity, similar ease of use and out-of-the-box ruggedization Real Wear is an excellent alternative hardware platform for situations which require rugged AR performance. The HMT 1 retails for $2,500 USD – very comparable to the price point of the Glass. The HMT 1 is effectively an android tablet which can be mounted on one's head and operated hands free. Further, the HMT 1 has excellent noise cancelling for voice commands, enabling the headset to receive voice commands in a loud environment and by all accounts the voice interface is excellent. The HMT 1 is already certified to work with a hard hat, adding yet another advantage to this headset. Information is not available on whether this platform suffers the same teething problems as the Glass (over-heating and inconsistent performance).

Also worth considering is the Osterhout Design Group's R-7HL. Similar to the HMT 1, this device is ruggedized out of the box. This device however, is less easy to use than the HMT 1 and has reduced capability compared to the Real Wear solution. The R-7HL retails for $3,500 USD, not a prohibitive sum compared to the Glass and the HMT-1 but certainly not an insignificant increase in cost when considering an enterprise implementation. The R-7HL meets USA ruggedized laptop standards and has a similar user interface to the Glass. Whether or not the processing capacity of this headset is sufficient to render a user experience as smooth as the Glass is unknown. This platform could make a good solution for the red meat industry, however experimentation will be required to understand applicability on farm or at other sections in the value chain.

While the HMT-1 would have access to the app store as it is an android tablet, the R-7HL cannot be spoken for as it operates on a custom operating system. Access to the app store would make it easy to install new software. Further, given the well tested background of the android operating system, it is unlikely that the HMT-1 device would face the same pre-installed software difficulties as the Glass.

The Microsoft Hololens 2 release features a customization program which allows third parties to change the form of their headset while maintaining functionality. The Hololens 2 is the most anticipated augmented reality device to date and by all accounts will be the most impressive hardware ever released. With this in mind, it is likely that a hardhat incorporated Hololens would be an excellent solution for the red meat industry. Whether or not a Hololens can be made waterproof or food safe remains to be seen however there is certainly the possibility that this platform could be deployed in the red meat industry to great effect.

1.5 Major features

1.5.1 Voice commands

The voice commands built into the Google Glass Enterprise Edition are exemplary for smart glasses. The ease of interaction is among the best in the industry, although it must be noted that voice interactions are still a developing field and occasionally the smart glasses will not hear a command or will respond incorrectly. This was especially apparent when new software was installed. From the perspective of the red meat industry, the voice commands are almost good enough for implementation in a live environment and certainly good enough for use in a quieter warehouse or office setting.

1.5.2 Built-in speakers

Unlike the previous Google Glass Explorer Edition, the Enterprise Edition has built-in speakers. The Explorer Edition used bone conduction speakers for sound which, according to many reviews, were acceptable (if a little lacking). The speakers in the Enterprise Edition are enough for their purpose and a substantial improvement over the previous. It is Wiley's opinion that this speaker would not be enough for a loud industrial environment and workers would need Bluetooth headphones if they wanted to listen to sound from the Glass. This would present potential OHS challenges in the form of interfering with the hearing of the operator. Depending on the risks of the environment and whether the user can wear earmuffs, it may be best to use some small, unobtrusive Bluetooth headphones underneath the earmuffs. If it is not possible to obstruct the hearing of the user, it may be possible to implement Bluetooth bone conduction headphones or use the in-built speaker.

Wiley believes the speakers are enough for the investigations proposed in section 4. Depending on the loudness of the surrounding environment, it is likely that it will be possible to develop useful outcomes from these trials.

1.5.3 Swipe pad interaction

One of the major features of the Enterprise Edition, as compared to other smart glasses, is the user interaction. There are two major aspects to this, the touch pad and the speed of processing. In many existing sets of smart glasses, the processor is insufficiently powerful to process user inputs in a prompt fashion. This is not the case for the Enterprise Edition.

The Enterprise Edition has highly intuitive swipe controls, much like a smart phone, except the user touches the side of the unit. When one swipes the side of the unit, the display responds quickly. The user can easily navigate menus, a virtue uncommon in smart glasses currently on the market. This feature is important in the context of an industrial use-case. The Google Glass is the first solution which has been enjoyably usable. With alternative solutions taking up to a second to respond, it is unreasonable to expect an industrial worker to tolerate such a solution. In this way, the Google Glass Enterprise is one of the first sets of smart glasses which can be genuinely useful in an industrial setting.

1.6 Major drawbacks

1.6.1 Lacking applications

The smart glasses industry is still in its infancy. As a result, the applications of this technology are still being conceived. Although the Google Glass Enterprise has the capacity to install 3rd party apps, there are very few apps available and of them, even fewer find everyday use. There is no app store or similar for the Glass, further compounding the difficulty of installing third party apps.

This should not discourage further development with the platform. As more and more applications become available, it is likely that uptake of smart glasses will exponentially increase – thus growing the ecosystem and the number of useful apps. Furthermore, given the fact this technology is being evaluated for industrial applications, the presence or absence of consumer apps is less of a direct issue and more of an indication of the current state of the ecosystem.

Wiley purchased the Enterprise from Streye with their custom software package installed. Currently, arrangements like this appear to be the primary way in which users acquire useful software for their Glass. Because the Glass is not provided for consumer use, it does not have access to the play store. This can be overcome but it is expected that one will use the software pre-installed on the platform at time of purchase from the enterprise solution provider. Other companies able to provide the Glass Enterprise are as follows:

- Xperteye
- Augmedix
- Brainpower
- C Vision
- Chironix
- EyeSucceed
- Hodei Technology
- Icarus
- Upskill
- Wizzan

1.6.2 Overheating

Wiley experienced several overheating incidents during computer vision experiments using the Enterprise Edition. These overheating incidents occur with no warning and tend to last up to half an hour. In this time, the unit will not respond to any inputs from the user. The Glass will simply turn off and stay off until the temperature has decreased to ambient.

In the case of applying the Glass to meat processing facilities, there will be challenges with cooling. Wiley believes that many applications will have computer vision elements. In these cases, the Glass will be prone to overheating.

One way to overcome this may be to utilize the Glass in a refrigerated environment. These environments present their own challenges in the form of moisture and impact. It is evident that the Glass will need to be ruggedized in order to find widespread applications in the red meat processing industry. Unfortunately, ruggedization adds weight, impairs user experience and negatively impacts overheating; significantly mitigating the usability of a ruggedized device.

This overheating challenge is one of the main roadblocks when considering the Google Glass for the meat industry. While it may be possible to waterproof or ruggedize the Glass, it is likely that it will be difficult to both ruggedize and waterproof, without significantly increasing overheating.

Wiley cannot recommend the Enterprise Edition for computer vision or processing intensive applications as the unit will overheat regularly, rendering it essentially useless in these cases. This is not to say the Enterprise cannot be used for applications such as image collection or quality checking, merely that video collection or heavy on-board processing may lead to overheating.

1.6.3 Outdated operating system

Although the processor has had a significant upgrade from the first generation of Google Glass, it runs on API 19 (Android 4.4 KitKat) which is now 6 years old. Newer releases of the Android operating system have much more performant runtimes, with better garbage collection, which handle the types of applications which would be most pertaining to the red meat industry more effectively. That said, the digital garbage collection on the current Google Glass is much more effective; leading to better memory performance and decreased likelihood of application crash.

Wiley does not believe this aspect is particularly detrimental when considering the Enterprise for the red meat industry. It is likely that the Enterprise will be upgraded in further editions. Additionally, the operating system as it stood was not a significant roadblock to implementation in the platforms experimented within this investigation. The enhanced garbage collection of more advanced editions is not totally essential for success with further project development.

2. Google Glass platform experience

2.1 Launching applications

Generally, the gesture-based interactions with the current generation of the Google Glass application launcher works well if slightly unintuitive. The built-in voice commands for the camera and photos app also work as expected.

There were two main issues encountered during development with the app launching experience:

The first is that apps installed onto the device did not appear in the launcher, as they would on a normal Android device. Additionally, the open source custom launchers built by 3rd party developers (Streye) to resolve this issue, are now 5 years old and are not compatible with the updated Android development environment. For the purposes of this project, this resulted in having to use the voice commands to launch the app.

A touch-based launcher could be developed; however it is somewhat troubling that it is not possible to simply launch apps using the built-in interface, like a typical android device.

The second issue was related to the voice commands themselves. Initially, the use of custom voice commands, e.g. “Start meat grading” was attempted. Google glass comes with built in commands; approved main voice commands and approved contextual voice commands. Wiley attempted to use custom commands which were not included in these categories.

This worked well with one of the Google Glass units. The other three units were either very unreliable with the custom commands, often starting recording video, or simply did not work. This may have been because they didn’t have internet access, but the device and the documentation didn’t provide any feedback to confirm or deny this.

The workaround was to use some of the built-in commands. The benefit of these built-in commands is the on-board voice recognition is highly optimised to understand these commands; resulting in more reliable app launches. The issue is that none of the built-in commands directly related to the tasks, thus documentation had to be written to explain how to launch the application in its 2 different modes. This contrasted with using the logical “start meat grading” command, whereby one would say “okay google, open settings”, which was re-routed to open the meat grading app.

Along with the inconsistent operating system and the overheating problems, the inability to launch applications, in any straightforward fashion, is a leading challenge for the implementation of the Enterprise in the red meat industry.

2.2 Usage

Once an app was running, general usage of the app via the touch-based controls worked well, with minor UI changes to ensure a simple progression through the stages of the meat grading. The main challenges were heat and camera related, as opposed to user interface.

Due to the processor intensive work done by the trial meat grading application the Google Glass devices would heat up and eventually shut themselves down if the app was used for too long (15 – 30 mins). This would have a significant impact on a meat grader’s viability in a commercial setting, where an operator is relying on the devices throughout a full workday.

Regarding the camera, it was found that resolution was not high enough to read a barcode in normal conditions. This low resolution may be addressed in a hardware update but at present the hardware is insufficient for the needs of the meat industry. Further, it may be

addressed by use of a USB camera or similar, however this will significantly degrade the usability of the platform.

This is likely to be a limiting factor in any implementation involving computer vision processing and is another significant limitation to the platform in its usefulness to the Australian red meat industry.

2.3 Distribution

Out of the box, the Google Glass units didn't provide any mechanism for downloading and installing applications, for example Google Play (similar to how one would use the App store to install on one's phone). With some work a solution may be built, however, investigating this was outside the scope of the project. For this project the test applications were installed on the devices manually, via the command line. This worked well for this scenario but required a technical operator to manage. This command line approach may not be appropriate for wider use of the platform. This poses yet another challenge to the practical use of the platform. However, this shouldn't be an issue for enterprise implementations, as these are often supported by ably-qualified IT professionals.

2.4 Development

Initially, development for the new Google Glass Enterprise Edition was easy to set up and required very little modification. After this initial success however, some significant hurdles were encountered. While these hurdles were generally surmountable, they stack the deck against anyone trying to develop for the Glass, in the same way one would for a typical smartphone.

Outdated SDK (Software Developer Kit)

When attempting to integrate more touch-based controls into the application, difficulties were encountered integrating the now 5-year-old Google Glass SDK. This was due to incompatibility with the current Android support libraries. The current Google Glass Enterprise is not compatible with the current Google support libraries, due to an outdated software development kit. It is suggested that the next iteration of Google Glass would be run on an up to date operating system and SDK. This change would make the Glass much easier to develop for and encourages further implementation.

A lack of compatibility with Google support libraries is a significant challenge for development, forcing developers to create new applications from scratch; increasing development cost of working with the Glass.

Lack of Commercial machine learning (Firebase) and Augmented Reality (ARCore) support

An interesting use case for this type of device would be on-device machine learning for image recognition (e.g. meat grading) and augmented reality (e.g. measuring). Currently,

however, Google's commercial machine learning (Firebase MLKit) and augmented reality (ARCore) do not support Google Glass.

Tensorflow is a machine learning specific software library upon which machine learning applications may be built. However, the library was not written by Google and is not optimized for the Glass. In terms of machine learning, it might be possible to use a custom solution based on tensorflow or tensorflow lite; but would require significant development effort and know-how without any commercial support.

This fact severely limits applications of the Glass in situations which may require the analysis of video or images.

Outdated and inconsistent camera API

The camera API provided by the Google Glass uses the now-obsolete Camera1 API. This API was removed in Android API 21 in favour of the Camera 2 API; providing much more control, with more consistent access to the camera. In addition, the camera on the Google Glass provides the raw data inverted (compared to other Android devices e.g. Vuzix, Samsung Galaxy s7) which required a change to the image processing specifically for the Google Glass. This specific issue would be less relevant for apps designed specifically for the Google Glass, but creates significant development overhead when supporting multiple devices.

While the inversion of images is a relatively small change to any application, it represents yet another roadblock to developing apps for the Glass.

2.5 Documentation

The 5-year-old documentation for the original Google Glass is mostly still relevant to the Enterprise Edition. However specific documentation for the Enterprise Edition Google Glass could not be found. This is another contributing factor to development overhead and making implementation of successful apps more challenging.

3. Applicability of the Glass to the red meat industry

This section will discuss the experimental and platform aspects mentioned in previous sections, with specific focus on applicability to the red meat industry. There are several advantages and limitations to the platform, as it relates to red meat. The primary challenges are:

1. Lack of AI firebase support
2. Lack of Google Libraries support
3. Difficulty launching apps using approaches other than voice commands
4. Unreliable voice commands
5. Inconsistent operating system
6. Overheating

7. Low quality camera
8. Camera 1 API
9. Inverted images
10. Lack of strong documentation
11. Lack of App store like distribution protocol

The major strengths of the Glass, as they apply to the red meat industry, are:

1. Vastly superior usability/ user interface
2. Relatively strong processing power – if limited by overheating
3. Relatively high image quality both in display and camera (still not good enough for many applications)
4. Growing developer network and non-Google operating systems unlocking more possibilities

The challenges presented by the 11 points outlined above are not unique to the Google Glass, they range from 'easy to overcome' to 'Uptake preventing'. The android operating system is designed to work an any mobile device in largely the same way. The fact that the device behaves so differently, compared to other android devices, is a significant disadvantage.

The most preventative aspect of the Glass is the software inconsistency across the four devices. With very inconsistent performance and responsiveness from the different devices, it is not possible to purchase many devices and expect them to perform effectively. With this risk, Wiley suggests purchasing from another supply partner other than Streye.

In addition, the lack of firebase AI support and Google libraries support is a challenge. The development of effective software is entirely dependent on a strong understanding of the capabilities of the device and the supporting library. The supporting library represents thousands of hours of development work, with functions and data structures which can significantly cut the time taken to develop a new application. The lack of Google libraries support makes it exceptionally time consuming to develop new applications on this platform.

The lack of Firebase support is additionally challenging, as it is necessary for machine learning framework incorporation and more advanced computer vision applications. Without the computer vision library, it will not be possible to implement high quality computer vision applications expediently. While this can easily be overcome with an update to the Google Glass software – and may be addressed in a patch or further edition of the Glass – it is highly preventative of the development of computer vision applications on the Glass.

The overheating challenge further compounds the reduced usability of the Enterprise Edition to the red meat industry. Even if it were possible to develop a strong, AI driven

application for the assessment of meat or any other computer vision application, it would not be possible to support the application on the hardware, due to overheating. In our experience, the devices will overheat in a matter of minutes when recording video. This says nothing for the intensive computer analysis which would have to be performed with an onboard AI application.

Wiley believes this is a significant challenge to the implementation of computer-vision based applications to the Google Glass platform and can only be resolved with a further iteration of the device.

The lack of Firebase support is rendered somewhat irrelevant by the relatively low-quality camera – 720p; which, in the interest of fairness, is excellent in comparison to other smart glasses platforms. However, it is not good enough to perform the computer vision analysis in most cases. The Glass, as it stands, is not fit for computer vision or video intensive applications. The Glass may be able to take still photos of high enough quality to scan a barcode, but this is largely the extent of its abilities.

With the most preventative difficulties discussed, it is possible to cover issues which are not preventative, but merely inconvenient. These include the Camera 1 API (which contributes to development time and delays), the lack of an easy way to install software, the lack of an effective way to launch software and other challenges. These make it more resource-intensive to develop on the glass, as compared to other platforms such as android phones. As was discussed in the previous section, it is estimated that these add up to make developing on the glass 50% more resource intensive, as compared to other android platforms.

Finally, the lack of waterproofing, food safety and ruggedization will quickly render the glass useless in a live abattoir environment.

As a note, if one were considering the Glass for an on-farm environment; the platform's suitability would be moderate to high. Provided dust were kept to a minimum the units could foreseeably operate well on remote properties. The display on the Glass works well in a relatively high light environment but will never be as good as other smart glasses with a non-see-through display. The obvious challenge for remote properties will be connectivity. If the apps developed for the Glass rely on Wifi connectivity, this will be a significant roadblock for the platform on-farm.

Based on all these factors, Wiley believes the Glass has some potential for experimentation within the red meat industry. It is by far the best smart glasses solution on the market in terms of ease of interaction and sleekness and is the best avenue for experimentation therein. That said, with significant drawbacks, it cannot be recommended as an enterprise solution yet.

Wiley suggests the Glass is useful to further understand the experiments outlined in the following section and, as a test bed, to realize the potential of augmented reality in the red meat industry.

The Glass is recommended for office and clean/low impact commercial implementations. Given high ease of use and relatively fast computing times; the devices are well suited to simple image collection or simple information display, in environments which will not damage the devices through either dust or water.

4. Potential projects in Australian red meat

Due to the limited processing power, small screen, sub-optimal camera and outdated software of the current iteration of the Google Glass, the real time on-device computer vision potential is limited. The Google Glass best suits implementations that fall into the categories as outlined below.

The following section illustrates how three different projects could be implemented using the Glass. These are;

1. Guided processes which can be implemented in 12 weeks
2. Data capture which can be performed in 14 weeks
3. Remote mentoring which can be performed in 8 weeks

Each of these projects includes some time from professional developers to ensure proper implementation.

4.1 Guided processes

The Google Glass platform, with the software included in the Streye software kit, is capable of displaying instructions for processes and forcing the worker to check boxes that they have completed various tasks in the correct order. This application has potential in maintenance tasks for the whole industry. Quality assurance can be increased by taking images of the project location, such that there is a record of the action taking place and the state of completion. The development of these processes is relatively easy and should be approachable by the average facility maintenance manager with some guidance.

In order to further develop this implementation, first a test application/use case would have to be found. Based on discussions with members of the industry, the most beneficial process to develop with this approach is initial training purposes.

Once the desired process is identified, it would be a relatively simple matter of developing slides and videos to show the user as they performed the task in a step-by-step way; allowing them to complete the task correctly and quickly, without mistakes.

This project would gather feedback from users and those learning to perform the tasks. The KPI for this process would be speed of learning and the number of mistakes made by the person learning. It would be expected that the heads up display markedly reduces the amount of time taken to learn a process and reduces mistakes in the genuine operating environment.

In the ag industry, one could foresee guided processes aiding in irregular maintenance, presenting the steps for maintaining equipment to the farmer while working through the process. This kind of instruction would work best for processes which are completed every 6-12 months and are prone to error due to assuming one knows the steps but imperfect memory leads to mistakes. The approach could also aid animal husbandry, giving the farmer the steps needed to care for their animals once a problem is noticed and walking them through the procedure without taking their hands off their work.

This project would have three main steps:

1. Consult with industry to identify the key processes which can be helped with such an implementation
2. Agree with industry partners regarding the kind of implementation and the testing approach
3. Commence development of demonstration and testing protocol – minimum viable product edition
4. Test the product in a live environment; ensuring enough data is gathered to make meaningful conclusions about the learning outcomes and quality control of the process.

The whole timeframe of this project would be approximately 3 months – with a rough timeline for the investigation provided below.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Engage industry partners												
Consult with partners and determine ideal process												
Consult with partners and determine ideal KPIS												
Consult with partners and determine ideal testing regime												
Produce initial consultation milestone report												
Agree with partners for further progression												
Develop Guided Process MVP												
Develop strong understanding of the process												
Develop slides and instrucitonals for the process												
Develop checkpoints and quality checks for the process												
Test Guided process MVP in lab												
Test MVP on site												
Educate an agreed number of workers												
observe results												
report writing and analysis												

Among the proposed, Wiley judges this project to provide the highest value for money. In terms of its applicability to the industry, ease of implementation and ease of expansion, this approach has a lot of room to grow for relatively little development work.

Furthermore, due to the relative simplicity of the system, this approach is likely to be one of the easiest to develop; delivering maximal value for money to MLA and the meat industry.

The notable risks of this approach are that it may not turn out to have enough use cases, or value in those uses cases, to make sense. If this technology can be bested by instructions by an experienced operator or by a leaflet, it will not be necessary to implement such a technologically advanced system.

The likely niche for this technology will be in the incorporation of whole training courses into easy to ingest, step-by-step instructions. The volume of information and the possibility for automated verification of training may be of value to clients.

4.2 Data capture

It is well known that data is the currency of the digital age. Data collection protocols are becoming more prolific and more effective. However, there is some data which needs to be collected through photographs, or recorded while the operator would benefit from not having to take their hands off the work to record the measurement.

These use cases are the home of augmented reality smart glasses for data collection. With the ability to take high resolution images and record voice, these headsets enable new data collection approaches which may enable significantly enhanced efficiency in tasks which involve quality checks, hands on information collection or employee monitoring.

The camera and voice input on the Google Glass unit could be used for data capture with the more intensive data processing handled server-side. This would allow operators to collect information in a hands-free manner whilst performing their normal duties. An example of this, in the context of meat grading, would be collecting data to train a machine learning model that grades meat.

This could be used across the whole operation, to collect information from the workers through the day such as tiredness, engagement and any other information which could be collected through the camera, wearer monitoring sensors and voice commands.

In terms of implementations to on farm activities, the camera on a Glass could be used to count the number of cattle in a pen, to evaluate an animal for health and wellbeing based on gait or appearance, or indeed to overlay information onto objects in the farmer's field of view, making the pump appear with relevant information to its current functionality.

If the approach were developed to monitor fatigue among workers, a camera to track worker eye movements would have to be implemented, along with some proprietary software – although solutions for this currently exist.

The notable benefit of implementing fatigue detection solutions would be the reduction of injuries and increased efficiency of workers.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Engage industry partners														
Determine most relevant data to collect														
Engage with workers to find how to collect the data														
Agree on experimental protocol with staff and operator														
Agree with partners for further progression														
Develop Data Collection MVP														
investigate hardware requirements														
Develop bespoke data collection software and API														
Upgrade hardware if required														
Test MVP on site														
report writing and analysis														

In this case, like the first project, the most notable risk is being unable to find a meaningful use-case for the technology. While it is possible for the Glass to collect meat grading information for example, and perform rudimentary computer vision analysis, this must be easier to use and more effective than competing approaches.

The notable strength of using the Glass in many of these examples is a strong, easy to use quality standard check behind whatever data needed to be collected. This can take the form of a photograph of the meat sample or gauge in question. In this way, the worker can keep their hands free to do their work, while the Glass collects the information, potentially enhancing efficiency.

4.3 Remote mentoring

One of the most powerful possibilities unlocked with the advent of smart glasses is that of remote mentoring. Most commonly used in the aerospace industry, remote mentoring allows an expert to give instructions to a person on the ground from potentially thousands of kilometres away. This is a preferable alternative to flying an expert engineer/mechanic to the site, for a repair which might only take a few minutes. With the naturally spatially disparate nature of aviation, this is a natural choice for the industry.

In the context of the red meat industry, there may be instances in which users need instruction with regards to how to perform a piece of maintenance or other works. This may be due to the spatially distributed nature of companies. Having only a few expert maintenance professionals on staff, it may be economical to use their expertise wherever it is needed, using a remote uplink into a set of smart gasses, as opposed to flying that individual to site.

On farm, this approach would see the producer get guidance in machine maintenance such as tractor works or pump maintenance. This kind of support would require the engagement of the relevant company which provided the hardware but for the purposes of a demonstration project, it is certainly possible to deliver useful insights to the producer on site.

Even locally, the process may save time by giving instruction to the worker who needs it immediately; rather than having to wait for the expert to move all the way across the farm or facility, which could be very large.

The opportunity and potential benefits of this project are fewer than the other projects proposed. However, it is reasonable to foresee a future in which smart glasses, like the Glass, are ubiquitous. In this future, one would very likely use this feature in the same way instant messenger services are used within the office.

The project to experiment with this use case would be structured as follows:

1. Discuss with industry members the situations in which they may use the technology – both under current circumstances and in a future in which everyone wears the headsets.
2. Having agreed upon situations in which it might be used, artificially use the technology for these situations (for a given duration) in the facility.
3. Gather feedback from the users, and estimate the amount of time saved or lost, by using the augmented reality headset for this use case.

Because the software for this use case is already in circulation and commercially available, this project would have no development period; reducing costs and the timeline for the prospective project. The timeline for the project is as follows:

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Engage industry partners								
Consult with partners and determine use cases								
Consult with partners and determine ideal KPIS								
Consult with partners and determine ideal testing regime								
Produce initial consultation milestone report								
Agree with partners for further progression								
Test MVP on site								
Perform an agreed number of trials								
Observe results								
Produce final report								

5. Conclusion

The Google Glass Enterprise Edition platform is by far the most capable augmented reality smart glasses platform yet tested by Wiley. The Glass does have its limitations in overheating and software maturity, but it represents a major step forward for consumer augmented reality platforms. While Wiley doesn't expect this platform to play a major role in the red meat industry, it can be said with confidence that it is a good test bed for further experimentation and development. Wiley expects the next generation of Google Glass will overcome the issues of application launching, overheating and lacking camera resolution. Whether or not Google will invest the effort to make the Glass rugged enough for a full industrial environment, remains to be seen.

Of the project concepts proposed in the preceding section; remote mentoring and computer vision-based information gathering will likely find issue in the overheating challenges associated with the platform. Furthermore, all applications will face difficulty in launch and stability, if the experiments thus far are representative.

It is prudent to conclude with a comparison between the Glass and rival systems on the market.

At the time of writing, it has been well over a year since the Glass was released and there are strong, reliable and easy to use, ruggedized industrial augmented reality implementations, which represent strong competition for the Glass.

Wiley suggests the Glass is best suited to simple office or clean, low impact commercial situations, with industrial applications falling outside of the platform's optimal capacity (for the time being).

On this basis, Wiley can recommend the Google Glass as the best platform for simple information display and some remote mentoring applications.