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FOREWORD

On behalf of the Organising Committee, it is with great pleasure that I welcome you to the inaugural AusIMM Sustainable Mining 2010 Conference in Kalgoorlie, Western Australia, the first AusIMM Conference to focus on operational aspects of meeting sustainable development challenges.

As our mining businesses emerge from the trough in the global commodity cycle, we face increased community and media scrutiny in tackling the ongoing challenge of maintaining the triple bottom line. These social, environmental and economic pillars are critical to the mining industry’s ‘social licence to operate’. Mining activities are expected to be more than financially and technically sound – they must also balance and embrace the evolving needs of the environment and community.

As with all new conferences, it has been both challenging and exciting to develop a technical program that will both interest and enhance the conference participants. We have put together a program of 41 multi-disciplinary papers, including 13 keynote and conference feature speakers, covering themes such as: Sustaining the Business; Increasing Energy Efficiency of Mining and Processing Operations; Reduction, Reuse and Remediation; Sustainable Water Use; Sustaining People, Regions and Communities; Communities and Local Adaptation; Regulatory Frameworks and the Business Case; Health and Safety and Human Resources; Looking Backward, Moving Forward – Lessons from the Goldfields; Climate, Energy and Environmental Risk; and The Future of Mining.

The Conference program includes a strong local focus, offering delegates firsthand experience of how projects and operations deal with mining in close proximity to and below a regional city, and how regional infrastructure can assist with project security and community survival through challenging times. The conference will also show how cooperation and a concerted effort are required from industry, government and community to develop a successful approach to achieve sustainability.

The Kalgoorlie region is a brilliant example of long-term cooperative development between mining and the region – still going strong after 117+ years, despite numerous technical challenges, and changing regulatory requirements and social expectations.

I would like to thank all the authors and presenters for their contributions, the reviewers for their time and dedication, and the sponsors for making the conference an important contribution to the minerals industry. I would also like to thank The AusIMM Kalgoorlie Branch, Dr Bob Fagan (WASM) and local mine operators, Silver Lake Resources, Norton Goldfields and MacPhersons Reward for their involvement in assisting with mine site visits, and to Coombees Capability, Snowden and CSIRO with Goldfields Esperance Development Commission, for organising the preconference workshops. Finally, I would like to acknowledge members of the organising committee and The AusIMM Services team.

I hope that all delegates will participate in the technical and social sessions thus ensuring that the ideas, solutions and technologies presented will be a benefit to all.

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Conference Chair
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Trade-Level Skills Formation to Support Automation in the Mining Industry

Dudley1, R McAree2, P Lever3, D Jones4 and M Sprigg5

ABSTRACT
The resource industry must prepare for the inevitable shift towards automation as an operational objective. Although this may seem like a distant concern, many mining companies and equipment manufacturers are already conducting full-scale automation trials. The necessary technology is advancing at a rapid pace yet the training of people to support it at the trade level lags far behind. Those given the responsibility of installing and maintaining automated equipment in the mining environment require a unique set of skills and knowledge. These training needs demand attention to ensure that the wider uptake of automation is sustainable and achieves its full potential.

This paper documents work undertaken by CRCMining and the Mining Industry Skills Centre towards establishing a training framework seeking to address the needs of trade level personnel tasked with the support of automation equipment. A comprehensive definition of the skills and knowledge required by the hypothetical automation-specialised tradesperson is presented. The training pathway identified for these personnel is also described. This work forms part of the Mining Industry Skills Centre’s Automation Skills Formation Strategy, funded by the Queensland Department of Education and Training.

INTRODUCTION
The mining industry has a digital future. The emergence of autonomous mobile equipment and the explosion in the number of logic controlled devices throughout the last decade are but the first signs of the wave of change that will reshape the industry over the next 15 years. Driverless haul trucks and autonomous blast-hole drill rigs are currently being evaluated while automation capability is being developed for the full suite of mobile equipment. The pursuit of automation is rapidly being recognised as a chief operational objective. It promises safer and more efficient operations and scalability in the face of rampant demand for resources. Through performing selected tasks precisely and consistently, automation can also deliver significant energy savings.

The rapid pace of technological change in the industry brings a significant challenge: the industry needs to ensure that its workforce has the skills and knowledge to support these new technologies. Far from costing the industry jobs, the uptake of automation appears set to exacerbate skills demand. The introduction of automation must be accompanied by a supply of personnel capable of deploying and maintaining it. The mining industry is no stranger to skills shortages and guaranteeing this supply is no trivial task.

In the context of this paper, automation is broadly defined as the intelligent management of a system using appropriate technology so that its operation can occur without direct human involvement. This intelligence is realised through computer-based systems that might be as small as embedded microcontrollers or as large as a distributed network of tens or hundreds of computers communicating across a mine site. The systems under autonomous control range between component systems, which may simply involve operation of a valve up to complete systems such as a dragline or a coal ...
preparation plant. The tasks performed by these systems might be as basic as switching a lubricant pump when required or as complicated as the autonomous operation of an entire mine.

Recognising the skills challenge appearing on the horizon, the Mining Industry Skills Centre commissioned this research with funding provided by the Queensland Department of Education and Training. CRCMining was given a brief to identify emerging trade-level skill requirements associated with the industry's increasing use of automation technologies. CRCMining's study focused on:

- the identification of the present and anticipated future profile of the industry's engagement with automation,
- the definition of the skill and knowledge requirements for trade-level staff supporting automation, and
- the identification of a pathway for the skilling of these staff.

The information gathering stage of the study centred on interviews with personnel spread throughout management, human resources and site operations representing the principle players in automation in the mining industry, ie mining companies, original equipment manufacturers (OEMs) and technology support contractors. Observation of site personnel performing automation related maintenance work also greatly aided the specification of skill and knowledge requirements.

The interviews revealed a picture of automation in the mining industry as an inevitable outcome, unique in its demands on personnel and unsupported by any structured and sustainable training pathway. The definition of the skill and knowledge requirements allowed for an assessment of the size and scope of the anticipated automation skills gap. With this information, a feasible skilling pathway was identified, relying on the Certificate III in Electrotechnology Electrician (or equivalent) as a foundation qualification to then be augmented by a number of post-trade level modules built around the required automation skills and knowledge.

Taking these findings, the Mining Industry Skills Centre assembled the 'Strategy for Automation Success' (Mining Industry Skills Centre, 2010) focusing on workforce development and planning. More specifically, six key goals were identified with an implementation plan staged over the next ten years. These goals are linked to:

1. transparent communication,
2. investing in apprentices,
3. establishing a change management framework,
4. building automation support structures,
5. developing the role of automation support staff, and
6. enhancing training capacity.

The Mining Industry Skills Centre has begun the process of implementing this strategy through engagement with industry, unions, government and the vocational education and training sector.

THE SKILLS DEMAND IN CONTEXT
Automation in the Australian mining industry is pushed forward by some and pulled by others. Employers will inevitably react to this technology advancement in a way fitting with their own engagement. The identification of the present and future profile of the mining industry's automation engagement requires an analysis of the forces driving automation progression and the key concerns they will bring to employers. All these factors contribute to providing the automation skills demand in the mining industry with a unique flavour requiring an equally distinct solution.

Forces driving automation
Automation in the mining industry is advanced by four key forces. These are:

1. the corporate force,
2. the OEM force,
3. the site force, and
4. the R&D force.

The pervasive nature of these forces and their far-reaching scope means that increasing use of automation is inevitable.
The corporate force describes the company-wide strategic push for automation. This top-down force is typically fuelled by an organisational imperative to optimise operational efficiency. A number of large mining companies driven by this force have established automation trials on a grand scale (see Hayes, 2009 and Coal International, 2008).

The OEM force is the second key force driving automation in the resource industry. The automation product market is fed by OEMs and small-to-medium enterprises (SMEs) commercialising automation related products, equipment and services. Demand for these products, equipment and services arises from the perpetual desire of mining companies to improve their operational efficiency and is supported by OEMs looking to provide product differentiation to increase market share. As these products are taken up by the industry, the industry in turn becomes more reliant on them. New advancements coming onto the market enable further penetration of automation and generate still greater demand.

The third force driving automation comes from the mine-site itself. Implementation of automation technology is driven at this level by technicians and site engineers, who, as part of their routine work, seek the most efficient, reliable and least expensive solutions to their problems. Automation components increasingly provide the most suitable option. Programmable logic controllers (PLCs) and microcontrollers, for example, are now routinely installed to replace logic previously provided by relays, timers and sequencers as the need arises. They are also used to implement better and safer control over various aspects of the mining system. In this way, automation related technology grows organically within sites from the bottom up.

The R&D force is applied by the sector collaboratively seeking advancement of technologies through research, development, and demonstration. The Australian Coal Association Research Program (ACARP) is a good example of how the industry works collaboratively to solve its problems through innovative research and development. A second aspect to the R&D force is individual companies engaging with R&D organisations on a fee for service basis to address company specific problems.

Concerns for employers
Employers seeking to establish a sustainable relationship with automation must consider the staffing structures they put in place and the implications automation may have for safety, change management and their approach to training.

Support structures
The character of automation support staff and their place in the wider workforce is relevant to determining the level and type of skills and knowledge they require. There are three potential support structures that deserve consideration:

1. dedicated engineering,
2. qualified site layer backed up by a college of experts, and
3. contracting to automation support service providers.

Within the 'dedicated engineering' support structure, engineers are tasked with complete responsibility for automation support. They also closely direct trade staff for any practical work required. The critical skills and knowledge associated with automation are possessed by these engineers and they perform the majority of tasks. These engineers may be placed on site or directly linked to site by an advanced communications network. When necessary, tradespeople can use 'wearable computers' that provide bi-lateral augmented reality that allows the on- and off-site engineering staff to interact by proxy in information rich environments.

Within the 'qualified site layer backed up by a college of experts' support structure, selected personnel are up-skilled to function at a level between the engineer and the conventional tradesperson. They provide the first layer of support in the field for automation applications. In this capacity, they perform standard commissioning and maintenance work as part of the predictable support life cycle. Outside the predictable support life cycle such as when an automation application is under development, being trialled or failing due to non-standard faults, the site automation support staff provide the link between the application and the off-site engineering support team or 'college of experts'. The site personnel provide application data and results in exchange for solutions and recommendations from the college of experts. Automation support staff perform tasks that are within their expertise and exploit the wisdom of the college of experts in performing tasks outside their expertise.
Companies absolve themselves of the skilling problem by transferring the responsibility for automation support to contractors when exploiting the ‘contracting to automation support service providers’ support structure. Contractors offer an automation support service which can be tailored to the equipment or system supported. They then just become one more contractor on site as opposed to the creation of a new subgroup of employees. Contractors, exclusively focused on the support of their particular automation application, are then free to source personnel and address skill needs by whatever avenues are available. This presents a challenge for the contractors but rids the original company of any associated risk. If the contractor’s scale permits, elements of the previous two structures may be exploited.

Safety
New technology brings new safety risks and hazards. The introduction of automation across mining industry sites must be accompanied by processes and procedures that are focused on minimising the likelihood of harm.

Automation presents a real challenge for those in charge of safety in that it will bring a major change in the way equipment is viewed and the roles of those supporting it. Also important to safety is the effective support of equipment such that it performs its required function in a predictable and harmless way. Trends towards de-engineering the workforce and unchecked reliance on external contactors have the potential to increase the likelihood and consequence of failure of automated equipment.

Change management
The change management issue associated with automation introduction is a serious one. The resource industry has a conservative approach to change, and the implementation of new technologies and processes must overcome a well established culture and mindset. Despite this conservatism, automation is being introduced at a surprisingly rapid rate. As with all major changes introduced in the mining environment, relevant procedures must be developed. This has major implications for both safety and productivity. For example, the introduction of a fleet of autonomous haul trucks must be accompanied by new processes relating to traffic management and vehicle approach.

The culture change issue for site staff associated with changing job roles and skill requirements must also be carefully addressed. The miner identity is a strong one and it is critically important that the introduction of new technology does not alienate workers from the source of their feeling of self-worth (Abrahamsson and Johansson, 2006). Employees must be aware of the reasons for automation and the impact it will have on them. The potential advantages of any change are easily eroded by personnel who have no interest in seeing it succeed. Resistance to change must be overcome by linking the benefits of automation to the personal impact it may have on improved safety, working conditions and up-skilling.

Approach to training
There is an impression that automation will dramatically reduce skill requirements. While this may be true for certain roles and segments of the process for which stable automation is feasible, the reality is that the average worker will require up-skilling not down-skilling. For companies prepared to accept this as the reality, the net change in terms of workforce size is very likely to be positive. Adler (1986) observed in the days of automation introduction in banking and manufacturing that ‘for every task transferred from worker to machine, there is a new task created – that of deploying the enhanced machine capabilities’. The complexity added by automation to equipment that is already difficult to deploy and maintain should make this observation particularly relevant to those in the mining industry. Put most simply, underestimating the skill requirements attached to the introduction of automated equipment is more attractive but inevitably more risky than the inverse.

Future trends
The movement of all sites towards automation as an operational concern is foreseeable and the rate of uptake is likely to be greatest over the next 15 years. The widening penetration of automation is the most obvious change that will be seen in the near future. Currently, automation is engaged on a small scale relative to the number of mines, processing plants and export facilities in Australia. There are close to 500 sites associated with the mining industry and while some may be engaging in automation through the ‘site force’, only a handful of pioneering trials can claim automation as an operational concern.
The growing scale of automation must also be anticipated. Currently, most automation effort is concentrated on the component or subsystem level providing semi-autonomous operation. In five years, the integration of semi-autonomous subsystems will likely allow for increasing focus on automation at the equipment level. As the reliability of autonomous equipment is enhanced, there will be a gradual shift of focus onto automation of unit operations. The integration of multiple pieces of equipment will lead to fully autonomous operation cycles such as dig, load, haul then dump.

At present, the grand-scale automation initiatives are at a proof-of-concept stage and so wage and training costs are not as restricted as they might be otherwise. Companies seek to provide the necessary skilling by the most rapid means available. This can result in an overreliance on engineering graduates when adequately trained tradespeople might suffice.

There is also an emerging trend among OEMs to encapsulate and protect the 'intelligence' built into their equipment. Once upon a time, site employees were able to make modifications to PLC logic associated with equipment operation. Nowadays, only OEM personnel can implement changes on their proprietary systems which are password protected. This increases site reliance on OEM support staff and OEM dependence on a sustainable and skilled employee base.

Development engineers will necessarily be at the forefront of automation scale progressions. They stay to ‘babysit’ new technology through its commissioning and robustness improvement phase then move onto the next project. Once the development engineers move on, the spread of technology they were previously involved with must become the responsibility of others. What was once considered high-tech and the sole domain of engineers slowly filters through to become the responsibility of technicians and eventually trade personnel. In response to this trend, there must be some preparation for those who follow behind the development engineers. Importantly too, this preparation must respond to the subtly changing technology focus that the different scales of automation will bring.

Quantifying the skills demand
Any skilling framework created to prevent an automation skills shortage must be achievable and attract demand from industry. While the precise demand industry would have for such skilling is beyond the scope of this study, it is relevant to identify what the industry would consider desirable in a training implementation and whether this is achievable.

It is possible to roughly quantify the size of the demand for automation support staff if some simple assumptions are made. There are approximately 500 mining industry related sites in Australia including operating mines, processing plants and export facilities (Geoscience Australia, 2010). All of these sites are likely to employ higher level automation to some extent over the next 15 years. Consider that each site will require a minimum of three to five staff to give 24 hour coverage and meet service demand across the operation. The attrition rate of staff with appropriate skills is ten per cent: typical of the electrical trade profession in the mining industry (NCVER, 2005). To satisfy the requirement for a minimum of three staff per site within 15 years (providing a national personnel base of 1500 people) and accounting for the standard rate of attrition, approximately 190 new automation support staff would be required each year.

A unique problem
The automation skills challenge as faced by the Australian mining industry is but one part of a much wider skills shortage caused by increased consumer demand and rapidly advancing technology. However, the formation of automation skills for the mining industry presents a special challenge for a number of reasons. The mining industry is characterised by the remoteness of many of its sites, the variety of its operations and the limited skilled labour pool from which it can draw. These characteristics place a number of unique constraints on any training framework introduced to the industry. Training must be able to overcome the following difficulties:

• remoteness of sites restricts accessibility to training,
• experienced staff with critical roles can seldom be excused from site for training purposes,
• little individual-driven incentive for up-skilling exists due to already high reward rates, and
• vastly different operations may have different skilling priorities.

It is important that the training pathway specified addresses these unique issues while also minimising the more general difficulties associated with skills formation.
CRITICAL AUTOMATION SKILLS AND KNOWLEDGE

The 'Automation Technician' is the term used hereafter to describe the model employee whose dedicated role is the trade-level support of automation technology in the resource industry. Although other workers may indeed interact with automation technology, they will defer to the Automation Technician for the performance of higher level tasks associated with installation and maintenance. In identifying the ideal characteristics of this proto-person, and thereby their potential training needs, it is necessary to consider what type of tasks they would typically perform and what kind of technology they might be expected to work with. To provide some perspective to the analysis, it is also worthwhile to make some predictions about how these tasks and technology might change and evolve over the next 15 years.

Consider the Automation Technician working within the aforementioned 'qualified site layer backed up by a college of experts' support structure. The selection of this particular support structure for focus is based on the fact that it demands the highest level of skills and knowledge from trade level personnel. Consequently, the skills and knowledge addressed here include (and may exceed) those required by staff working in any of the other support structures reviewed. It is relevant to consider not only the skills and knowledge the Automation Technician must possess to perform standard automation tasks but also the skills and knowledge useful to functioning as part of this support structure. Most significantly, the access to the college of experts provides a seamless extension of the site automation support staff's skills and knowledge and suggests the need for breadth over depth.

Key automation support tasks

Tasks are the specific work activities personnel must carry out when performing their role. Attached to these tasks are a set of skills that must be developed to enable one to perform effectively. Identifying key tasks associated with automation in the resource industry provides an indication of the range of skills those in automation support roles require.

The tasks considered here are those relating to automation that are unlikely to be performed by engineers once the 'babysitting' phase is complete but are beyond the scope of responsibility of the typical tradesperson on site. More specifically, the tasks of interest are those which would be chiefly performed by an Automation Technician should such a character exist.

In general, the automation technology being introduced at present is sometimes lacking robustness even after the 'babysitting' phase is complete. Consequently, many of the key tasks encountered on site relate to the diagnosis of faults and monitoring or managing new technologies.

Given that new technology will always be coming down the pipeline, the need to undertake fault diagnosis, monitoring and trial management work will not diminish. However, as automation gains wider penetration there will necessarily be more activity associated with installation and maintenance support.

In 15 years it is possible that site-wide integration of automated equipment may provide some autonomous operation cycles. This will necessitate greater attention to the integration of different equipment and consideration of entire sites as the top-level automated system. Unit communication will be critical.

A summary of the key tasks linked to automation support is provided in Table 1. The specific actions and responsibilities attached to these tasks were determined through consultation with industry and observation of personnel performing automation work on site. Tasks at five years include those now. Similarly, tasks at 15 years include the now and five year tasks.

Table 1 is not exhaustive; there are many other tasks automation support staff may perform. This list does, however, aim to cover the core tasks which could be considered generic across the industry. It is difficult to predict how tasks might change over a 15 year horizon. Nevertheless, it is reasonable to assume that most tasks are connected to a base set of skills that will remain fairly constant over this timeframe. The translation of tasks into skills will be explored fully later.

Key automation technology

The types of technology a person must work with link directly to the knowledge they must possess. The resource industry involves a diverse range of operations and makes use of a wide variety of equipment. The technology relating to the automation of this equipment is similarly diverse.
TABLE 1
Key automation support tasks.

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<td>15 Years</td>
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<tr>
<td>Manage technology trials</td>
<td>Now</td>
</tr>
<tr>
<td>Diagnose faults from a wide range of potential problems</td>
<td>Now</td>
</tr>
<tr>
<td>Execute test plans</td>
<td>Now</td>
</tr>
<tr>
<td>Gather information and assemble reports on diagnosis and solution</td>
<td>Now</td>
</tr>
<tr>
<td>Correct faults up to a certain level of complexity</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td>5 Years</td>
</tr>
</tbody>
</table>

The technologies relevant to automation now can easily be determined through inspection of the equipment and systems currently being exploited on sites. The technology that is under development by OEMs and SMEs is likely to appear on the market over the next five years. In addition to these new technologies, there will be a general advancement in the features and capabilities of existing devices and components.

Research centres, operating with a longer term perspective than OEMs and SMEs, are engaged in developing the kind of technology that will be implemented around the 15 year horizon. Examining the devices and components currently being explored in related research provides the best possible future prediction of automation technology.

A summary of the key technologies relevant to automation is provided in Table 2. The devices and components identified are categorised by six main technology fields: communication, sensing, computing, actuators, electronics and safety systems. The required technologies in the table accumulate for five and 15 years.

**Essential skills and knowledge**

The skills and knowledge required by automation support staff are a function of the tasks they must perform and the technology they must work with. A competency map is used to categorise and identify linkages between the skills and knowledge required by automation support staff.

The range of skills and knowledge identified have been grouped according to four top-level skills: communication, problem solving, planning and organising, and technology. Figure 1 shows the
### TABLE 2
Key automation technology.

<table>
<thead>
<tr>
<th>Technology fields</th>
<th>Devices and components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication</strong></td>
<td>Fieldbus technologies (Modbus, Profinet, CAN)</td>
</tr>
<tr>
<td>Now</td>
<td>Wired computer networks</td>
</tr>
<tr>
<td></td>
<td>Fibre optics</td>
</tr>
<tr>
<td></td>
<td>Radio-frequency transceivers</td>
</tr>
<tr>
<td></td>
<td>Radio-frequency identification</td>
</tr>
<tr>
<td></td>
<td>3G cellular wireless</td>
</tr>
<tr>
<td></td>
<td>Wireless digital communication</td>
</tr>
<tr>
<td>5 years</td>
<td>4G cellular wireless</td>
</tr>
<tr>
<td>15 years</td>
<td>Beyond 4G cellular wireless</td>
</tr>
<tr>
<td><strong>Sensing</strong></td>
<td>Strain gauges</td>
</tr>
<tr>
<td>Now</td>
<td>Binary sensors</td>
</tr>
<tr>
<td></td>
<td>Encoders and resolvers</td>
</tr>
<tr>
<td></td>
<td>Linear variable differential transformer (LVDT) sensors</td>
</tr>
<tr>
<td></td>
<td>Range sensors</td>
</tr>
<tr>
<td></td>
<td>GPS</td>
</tr>
<tr>
<td></td>
<td>Inertial sensors</td>
</tr>
<tr>
<td>5 years</td>
<td>Scanning sensors</td>
</tr>
<tr>
<td></td>
<td>Machine wear sensors</td>
</tr>
<tr>
<td></td>
<td>Machine vision</td>
</tr>
<tr>
<td></td>
<td>Navigation sensors</td>
</tr>
<tr>
<td>15 years</td>
<td>Hyper-spectral sensors</td>
</tr>
<tr>
<td></td>
<td>Ground penetrating radar</td>
</tr>
<tr>
<td><strong>Computing</strong></td>
<td>Programmable logic controllers</td>
</tr>
<tr>
<td>Now</td>
<td>Embedded PCs</td>
</tr>
<tr>
<td></td>
<td>Operating systems</td>
</tr>
<tr>
<td>5 years</td>
<td>Multicore computers</td>
</tr>
<tr>
<td><strong>Actuators</strong></td>
<td>Electrical drive systems</td>
</tr>
<tr>
<td>Now</td>
<td>Hydraulics</td>
</tr>
<tr>
<td><strong>Electronics</strong></td>
<td>Analog to digital (A/D) and digital to analog (D/A) converters</td>
</tr>
<tr>
<td>Now</td>
<td>Digital components</td>
</tr>
<tr>
<td><strong>Safety systems</strong></td>
<td>Safety integrity level (SIL) rated systems</td>
</tr>
<tr>
<td>5 years</td>
<td>Units of mitigation</td>
</tr>
</tbody>
</table>

The competency map corresponding to the Automation Technician at 15 years. Even at this horizon, the skills and knowledge areas shown in italics are those that are required to perform tasks that will also leverage the support of a college of experts to some extent depending on the complexity of the application. By extension, the depth of understanding and level of skill required for these areas is reduced. That is to say, to perform tasks under the detailed direction of others, only a level of skill and knowledge sufficient to facilitate this interaction is necessary. The competency map at 15 years is relevant as it represents the most mature profile of the Automation Technician and lists the skills and knowledge that should be targeted by a skilling pathway.

**A SKILLING PATHWAY FOR THE MINING INDUSTRY**

The sizable impact automation will have on the mining industry and the unique skill requirements it brings suggests that a skilling pathway must be made available for automation support staff. This skilling pathway will necessarily leverage some existing training avenues to minimise implementation difficulty and to exploit existing trainee flows. Any new components required to establish the training framework need then only to focus on bridging the skills and knowledge gaps between what is required and what is already being provided. The strategy attached to the development of this skilling pathway must also target the more general issues associated with skills formation such as change management and workforce organisation.
FIG 1 - Automation competency map at 15 years.
Available training

With the essential skills and knowledge of the automation technician accurately described it is possible to determine what existing training might be relevant to developing such an employee. It is desirable that the existing training framework be utilised where possible to minimise implementation difficulty. A search for appropriate existing training avenues was conducted as part of this study. Extensive investigation did not reveal any existing training that was capable of supplying the entire set of required skills and knowledge in a consolidated, sustainable and mining industry focused form. In response, it was necessary to identify a base qualification requirement on top of which further training could be added. The base qualification would need to: provide a relevant foundation of skills and knowledge, provide a sufficiently large pool of candidates and satisfy any regulatory or licensing requirements attached to the work to be carried out.

The Certificate III in Electrotechnology Electrician was identified as the most appropriate prerequisite qualification for subsequent automation skilling. It provides a solid foundation of core electrical skills and satisfies licensing requirements. It is also the most commonly taken qualification among those considered relevant to automation, suggesting access to a suitably large pool of candidates. Recognition of prior learning demonstrating equivalent competency to the Certificate III in Electrotechnology Electrician is also considered appropriate.

Gap analysis

The skill and knowledge outcomes of the Certificate III in Electrotechnology Electrician (EE-Oz Training Standards, 2009) were compared to those identified in the automation competency map. Those elements not covered by the pretraining must form the content of automation specialised skilling. Listed below are the key areas for which significant gaps were revealed:

- basic computing (introduction to operating systems and programming),
- computer networking,
- radio frequency data communication,
- control system principles,
- PLC and SCADA systems,
- fieldbus technology,
- sensors and actuators, and
- functional safety.

Importantly, training addressing these skills and knowledge must be developed around technology and equipment relevant to the mining industry. Strong leadership is required to ensure the relevance of training material developed and currency in the face of technology advancement.

Strategy for automation success

Taking CRCMining’s findings, the Mining Industry Skills Centre has assembled a skills formation strategy staged over the next ten years. The strategy focuses primarily on workforce development and planning.

Workforce planning must be undertaken to minimise the risks attached to automation introduction and maximise the potential advantages. The Mining Industry Skills Centre’s strategy aims to ensure that the implementation of automation is accompanied by the development of relevant procedures and the organisation of effective support structures. An obvious part of this will be the development of job roles outlining the scope of work for each member in the support structure and relevant measures addressing culture change. These proactive measures are designed to not only ensure automation yields its full benefits but also to minimise the potential for harm to workers and staff indifference.

Workforce development has been identified as critical to ensuring the required number of automation support staff will be available. Relevant to this is the need to increase the uptake of electrical apprentices to ensure that the pool of people from which Automation Technicians will be drawn is well stocked. In addition, there is a clear need to develop a formal training framework around the skills and knowledge identified as essential to automation support staff. This framework demands the development of formal training material and an increased capacity of providers to deliver the required training.
A significant challenge for the Mining Industry Skills Centre in carrying out the skills formation strategy will be obtaining engagement from the industry itself. Conservative and reactionary, the mining industry is keen to see the production benefits automation promises but is loathe to invest in the skills formation that must take place at the same time. The Mining Industry Skills Centre thus also intends to invest significant effort in communicating the need for action to key stakeholders.

CONCLUSIONS
The Australian resource industry is inexorably moving toward automated operation. The costs and benefits of this change are intimately linked with the skills to support the technology. Investigation of the key issues facing employees engaging with automation has revealed that there is a need for wider capability growth. In particular, appropriate training for those deploying and maintaining automated systems is critical. Such training must be placed within a formal framework to ensure consistent content, availability of training providers, safe engagement with automation and sufficient qualified personnel.

This study has identified a broad range of skills and knowledge that are required by staff performing automation support work at the trade level. The skills and knowledge cover four broad areas: communication, problem solving, planning and organising, and technology. The majority of these skills and knowledge pertain to the area of technology, but in general the requirement is for breadth over depth. Use of the Certificate III in Electrotechnology Electrician as a base qualification on top of which automation specific training can be provided reduces the skills and knowledge gap to a manageable size.

The Mining Industry Skills Centre's skills formation strategy is now the vehicle for promoting workforce development and planning in preparation for large scale automation uptake. The proactive measures it encourages are significant for the industry and its workforce. The consequences of taking a reactive approach to automation skilling will be a major skills shortage unmanageable by insufficient and ill-prepared training providers. In such a scenario, the mass introduction of automation technology will fail to yield its full advantages and may in fact place unnecessary safety risks on personnel inadequately trained to support it. Addressing automation skill needs before they are found to be in dire shortage will advantage all stakeholders, and allow the industry to leverage the full benefits of its digital future.

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REFERENCES


