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CENTRE FOR SOCIAL RESPONSIBILITY IN MINING

UNIVERSITY OF QUEENSLAND

REMOTE MINING OPERATIONS ECONOMIC IMPACT ON AUTOMATED MINING OPERATIONS

APRIL 2012

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1.0

1 EXECUTIVE SUMMARY

This report has been prepared in response to a request by the Centre for Social Responsibility in Mining (CSRM) at the University of Queensland. In conjunction with a number of other universities and the CSIRO, CSRM has been engaged to conduct research into the impacts on regional communities of remote operation and automation of mining activities.

A change in workforce structure of the mining industry due to a move towards the automation and remote operations of key functions may not only impact on the number of residential workers, it may also have an affect on population driven services and the local industry base. Research conducted by CSRM suggests that there is potential for 50% of in-pit roles (for an open-cut iron ore mine) to be converted into automated operations. This may lead to an overall contraction of the mine site employment by approximately 34%. The change in workforce structure may have a flow through effect on other industries of employment in mining towns, creating employment, economic and social impacts.

Pracsys attempted to profile the employment figures and workforce structure for all operational open-cut iron mines in the Pilbara. Due to the difficulties faced with collecting this data, an exemplar mine site provided by the CSRM was applied to each of the operating open-cut iron ore mines. The automation of haul trucks would lead to a change in the current employment structure, leading to a conversion of job type for the residential and FIFO workforce.

Under all scenarios and options modeled there is a net change in direct employment. The change in employment in each of the scenarios is a combination of first, second and third order jobs lost at each of the mines within a 75km radius of the selected town, due to automation and remote operations. The scenarios that result in a positive impact on residential employment are Scenario 2: Smart Regions and Scenario 4: Regions Fight Back, with the remote operations centre located in town.

Under all scenarios and options modeled there is a net change in the town population and the number of occupied households. The results show that there is a positive change in population and number of occupied households when the remote operations centre is located in the town. The scenarios that have a positive impact on residential population are scenario 2: Smart Regions – town and scenario 4: Regions flight back - town. This would be expected as they are also the scenarios that results in a positive change in residential employment. The results show that the greater the change in employment, the greater the change in population. A loss or addition of one job in town does not result in a decrease or increase in town population by one. The model has been constructed to represent the household structure of two regional towns in the Pilbara shire of Ashburton, "Town A" and "Town B". The residential workforce is made up of families, group households and lone persons. The change in residential workforce results in a change in population of entire families as well as group households and lone persons.

Under all scenarios and options modeled there is a net change in convenience retail expenditure captured in town. The scenarios that have a positive impact on retail expenditure captured in town are scenario 2: Smart regions and scenario 4: Regions fight back, with the remote operations centre located in town. The less expenditure leaked

from town, the greater the chance of town business survival. A population change due to a change in the workforce structure may impact upon the population driven community services in town.

A change in the residential workforce due to automation may lead to a change in population driven community services and funding (in particular, services relating to health and education). Metal ore mining and school education are the top two industries of employment in both Town A and Town B. The automation of key mining operations may have a significant economic and employment effect on the Shire of Ashburton.

Indicative data provided by the CSRM suggests that 8% of the total workforce (for Rio Tinto mine sites) is indigenous. Approximately 50% of these personnel are residentially based workers living in the Pilbara.

2.0

2 INTRODUCTION

2.1 PROJECT OBJECTIVES

This report has been prepared in response to a request by the Centre for Social Responsibility in Mining (CSRM) at the University of Queensland. In conjunction with a number of other universities and the CSIRO, CSRM has been engaged to conduct research into the impacts on regional communities of remote operation and automation of some mining activities.

This report demonstrates some aspects of the social and economic impacts that automation and remote mining operations has on the Pilbara towns of Town A and Town B.

There are a number of automated mining operations that may potentially change the workforce structure of an open cut iron ore mine. Operations that may be subject to automation include haul trucks, rail (train drivers and loading), drilling and blasting. CSRM has identified haul trucks as being the most likely operation to be automated. This report is therefore based on modeling the workforce impacts of replacement technology for haul trucks and the affects these technologies have on the mining communities.

In conjunction with the report, Pracsys has built a predictive model that allows the user to assess the workforce and population effects of automation and remote operation on two mining towns in the Pilbara region – Town A and Town B.

2.2 CONTEXT

The Pilbara region is located in the north of Western Australia, with an area spanning 507,896 square kilometers. The Pilbara is of significant economic importance to Western Australia and the nation due to its abundance of natural resources.

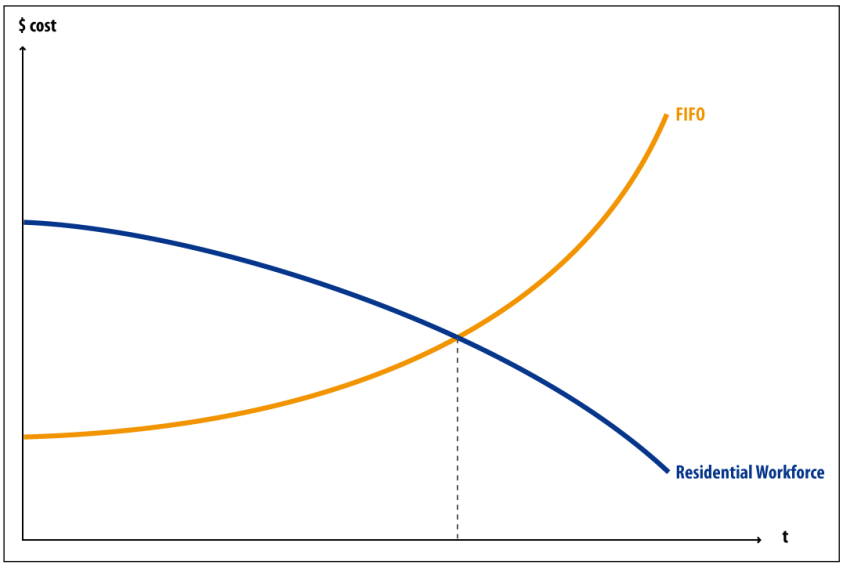
"The region supports a permanent population base of approximately 56,000. Local governments in the region are, however, subject to the unique pressures generated by and extremely large Fly-In-Fly-Out (FIFO) workforce, in addition to the permanent population. It is estimated that the current FIFO population in the region is 55,000" (Pilbara Regional Council, 2011).

According to the Pilbara Industry's Community Council (PICC), FIFO employment will out-number residential employment in the Pilbara by 2015.

As the world reaches peak oil, the marginal cost of FIFO personnel is increasing, while the marginal cost of residential personnel is decreasing.

The transition into remote controlled automated mining operations in the Pilbara

Figure 1: Marginal Cost of FIFO and Residential Personnel



Source: Pracsys 2012

may result in an initial change of the overall mining workforce, with a slower growth in sector employment, and may also lead to a significant conversion in the nature of employment.

One key concern associated with automation and remote operation technologies is the loss of employment opportunities in local and regional communities and the resultant social impacts and consequences that arise from such activities. The alternative to this issue is the possibility of increased employment opportunities in local and regional communities and the positive indirect and induced impacts that occur as a result of the potential increase in employment.

An impact model has been developed by Pracsys to estimate the direct and indirect employment and economic effects of an overall change in workforce structure as a result of key mining operation functions being automated and remotely operated. This analysis considers an exemplar open-cut iron ore mine, with a particular focus on the Pilbara region of Western Australia. With minor alterations, the model is equally applicable to other types of extractive industries and other locations, to the extent that they are suited to automation and remote operation.

2.3 REPORT STRUCTURE

The report is structured as follows:

- Economic Impact Model
- Economic Impact Analysis
- Results
- Conclusions
- Recommendations

To better understand the full extent of the economic and employment impacts that arise as a result of automation, the current situation (town profile, industries of employment, community services, etc.) of Town A and Town B and the mining industry structure has been documented.

The context that surrounds the mining industry and the profile of Town A and Town B establishes a foundation for a comprehensive analysis. The scenario description provides background information and reasoning for the results and outcomes. The analytical section of this report records the assumptions used in the model and the results for each of the scenarios.

The conclusion section of the report is set out to provide information on the findings, implications, required follow up work and recommendations that result from automated mining technology and the economic and employment impacts it has on local and regional communities.

3.0

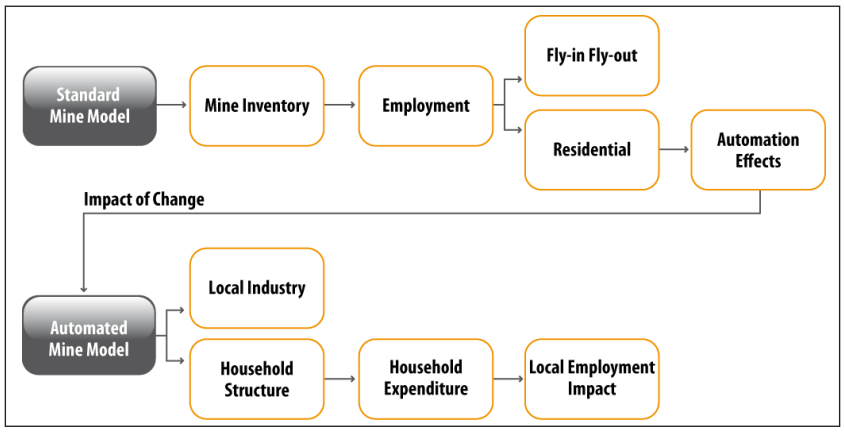
3 IMPACT MODEL

3.1 BASIS FOR ANALYSIS

The basis for the analysis was to examine the economic and social impacts that the transition into automated mining operations technology would have on a mining town and the community. The analysis took the following factors into consideration:

- The location of people living and working on the mines/in mining towns (Town A or Town B)
- The potential that particular jobs may be automated
- The level of automation (non-automated, partially automated or fully automated)
- The affect that a first order job (the job that can be automated) will have on the second and third order jobs
- Whether the worker is employed on a Fly-in Fly-out (FIFO) basis or lives permanently in a nearby community (residential)
- The location of the remote operations Control Centre (on site, in the town selected or in Perth).

Figure 2: Employment Change Due to Automation



Source: Pracsys 2012

A series of scenarios were developed to depict the different levels of direct change in employment due to automation. These scenarios were modeled to capture the indirect and induced economic and employment impacts that result from such technological changes.

The change in employment due to automation has a localisation and urbanisation effect. The localisation effect may impact upon the employment retained in local industry. Direct input to mine operations such as truck management and maintenance contracts may be replaced with specialised FIFO maintenance teams. The location of the remote control centre will also affect local industry in terms of the number of residents employed and the type and quality of employment.

The urbanisation effect will lead to an alteration in underlying population household structure. The introduction of automation will result in a change of residential workforce and probably a further shift away from nuclear families.

Localisation effects arise from the co-location of firms and businesses in the same type of industry. The benefits for localisation economies include labour pooling, the development of industries due to the increasing returns to scale in intermediate inputs for a product and the relative ease of communication and exchange of supplies, labour and innovative ideas.

Urbanisation effects arise from individual and corporate efforts to reduce expense in commuting and transportation, while improving opportunities for jobs, education, housing, and transportation. Urbanisation permits individuals and families to take advantage of the opportunities of proximity, diversity, and marketplace competition.

The local urbanisation and localisation effects may have significant social and economic impacts on the town.

A contraction in the mining residential workforce may result in a contraction of town population and a reduced number of occupied dwellings. Fewer households in town will lead to a contraction in town economic activity and expenditure captured by local businesses. An increase in the mining residential workforce may result in an increase of town population and an increased number of occupied dwellings. A greater number of households in town may lead to an increase in town economic activity and expenditure captured by local businesses.

The change in population may lead to an impact upon the population driven community services provided in the town. The number of primary and secondary schools are dependent upon the number of family dwellings in the catchment area. The number of police and doctors required to service the town is dependent upon the population of the town.

The purpose of this model is to allow the user to modify the residents and FIFO configuration of each mining operation, and to select the level of automation for the particular mining function.

The model is therefore driven by three main inputs:

1. Whether an operation is automated or non-automated
2. Whether a worker is FIFO or residential
3. The location of the remote operations centre

The model aggregates all operating open-cut iron ore mines in the Pilbara and assigns a FIFO/residential split to the workforce. If a mine is located further than 75km from the nearest town, then 100% of the workforce will be made up of FIFO workers. If the mine is located 75km or less from the nearest town, then a 30/70 split is assigned (30% residential, 70% FIFO). This percentage workforce split may be changed in the model under the assumptions tab. Based on Pracsys benchmarking, the default split is 30/70.

The workforce of the mine is broken down into first order employment (the job that can be automated), second order employment (subordinate roles to the automated job) and third order employment (support jobs for the mine). Each of the levels of employment is further assigned a FIFO/residential split. The total number of residential jobs for each mine is calculated. This employment ratio may be changed under the assumptions tab on the model. Aggregating all Pilbara mines allows the user to visualise the direct employment impacts of automated mining operations on mining communities. The change in residential employment has a flow through effect on the number of occupied households and the town population. The change in the town structure may have indirect and induced economic and employment effects.

The objective of CSRM is to quantify and qualify the social dimensions of autonomous and remote operations technologies “in order to inform decision-making about the uptake and implementation of these technologies” (Cluster Research Report 25).

This model uses assumptions, benchmarking and information provided by the CSRM to reach particular outputs. With the information and data Pracsys was able to obtain, this report gives an understanding of economic and social impacts on remote mining towns.

3.2 DATA

The CSRM provided Pracsys with the employment structure of an exemplar open-cut iron ore mine. This data was used to determine the ratios between the first order jobs (jobs that can be automated), the second order jobs (subordinate to the automated operation) and third order jobs (support roles for the mine site).

An inventory was conducted on all operating open-cut iron ore mines in the Pilbara. From the mine inventory, sixteen mines have been included in the model. The distance of each mine site was calculated to Town A and Town B to determine the FIFO/residential split. All mines that fell within a 75km radius of the town were assigned a FIFO/residential workforce split. All mines that fell outside the 75km radius were assigned 100% FIFO personnel. Of the sixteen mines, five fall within a 75km radius from Town A and three fall within a 75km radius from Town B. By aggregating the workforce for all mines within the Pilbara, the residential and FIFO employment was calculated for both Town A and Town B.

Town A and Town B were profiled; outlining the current number of households, population and household expenditure. Family, group and lone person household ratios were applied to the town population and the population employed in mining.

Due to the nature of the subject matter, it was difficult to obtain all data required to conduct a conclusive analysis. In the absence of data, benchmarking, variables and assumptions were utilised. The following data was optimised for the construction of the model:

- ABS Census Data, 2006
- ABS Household Expenditure Survey, 2010
- ABS Census Table Builder
- Autonomous and Remote Operations Technologies in Australia, CSRM

This data and research enabled Pracsys to build a working analytical model that represents the effects of automation. This report gives an understanding of economic and social impacts on remote mining towns.

4.0

4 ANALYSIS

4.1 CURRENT SITUATION

The current town profile for Town A and Town B have the following characteristics and population driven community services.

Figure 3: Town A Characteristics

Population	2,721
Family Households	629
Group Households	29
Lone Person Households	136
Average Household Size	2.9
Median Household Income	$2,507
Labour Force	1,473
Labour Force Participation Rate	54%
Indigenous Population	5.8%
Indigenous Workforce	2.7%

Source: ABS Census Data, 2006

The indigenous workforce in Town A is 2.7%.

Figure 4: Town A Top Five Industries of Employment

Industry of Employment	Percentage of Total Workforce
Metal Ore Mining	629 (43.3%)
School Education	94 (6.5%)
Supermarket and Grocery Stores	54 (3.7%)
Other Mining Support Services	53 (3.7%)
Building, Cleaning and Gardening services	34 (2.3%)

Source: ABS Census Data, 2006

Figure 5: Town A Population Driven Community Services

Service	Quantity
Primary Schools	2
Secondary Schools	1
Police	7
Doctors	3

Source: Pracsys benchmarking 2012, Department of Education and Training

Figure 6: Town B Characteristics

Population	1,607
Family Households	361
Group Households	11
Lone Person Households	93
Average Household Size	2.9
Median Household Income	$2,344
Labour Force	870
Labour Force Participation Rate	54%
Indigenous Population	5%
Indigenous Workforce	2.0%

Source: ABS Census Data, 2006

The indigenous labour force in Town B is 2.0%.

Figure 7: Town B Top Five Industries of Employment

Industry of Employment	Percentage of Total Workforce
Metal Ore Mining	465 (54.1%)
School Education	33 (3.8%)
Other Mining Support Service	32 (3.7%)
Supermarket and Grocery Stores	25 (2.9%)
Employment Services	24 (2.8%)

Source: ABS Census Data, 2006

Figure 8: Town B Population Driven Community Services

Service	Quantity
Primary Schools	1
Secondary Schools	0
Police	2
Doctors	1

Source: Pracsys benchmarking 2012, Department of Education and Training

4.1.1 Ashburton Employment Self-Sufficiency and Self-Containment

The Shire of Ashburton has the flowing employment self-sufficiency and self-containment ratios in the top fifteen industries:

Figure 9: Ashburton ESS & ESC

Industry of Employment	ESS	ESC
Total	149%	85%
Metal Ore Mining	175%	90%
School Education	95%	95%
Other Mining Support Services	227%	73%
Supermarket and Grocery Stores	95%	92%
Exploration	183%	83%
Local Government Administration	99%	94%
Building Cleaning, Pest Control and Gardening Services	99%	76%
Sheep, Beef Cattle and Grain Farming	82%	63%
Employment Services	140%	80%
Accommodation	174%	75%
Cafes, Restaurants and Takeaway Food Services	191%	87%
Other Non-Metallic Mineral Mining and Quarrying	106%	93%
Hospitals	90%	90%
Mining, nfd	200%	58%
Heavy and Civil Engineering Construction	285%	69%

Source: ABS TableBuilder, 2006

Employment Self-Sufficiency (ESS) is the proportion of jobs located in a geographic area (region, corridor, local authority, etc) relative to the residents in that same area who are employed in the workforce – regardless of where they work. The ESS in metal ore mining in the Shire of Ashburton is 175%. This means that there are more jobs available in metal ore mining located in the shire than can be filled by locals alone.

Employment Self-Containment (ESC) is the proportion of jobs located in a geographic area that are occupied by residents of that same area, relative to the total number of working residents of that area. The ESC in metal ore mining in the Shire of Ashburton is 90%. This means that 90% of the jobs filled in metal ore mining are filled by local residents.

Metal ore mining and school education are the top two industries of employment in both Town A and Town B. The automation of key mining operations may have significant economic and employment effect on the Shire of Ashburton.

A change in residential workforce may have direct and indirect social and economic impacts on the local community.

4.2 INDUSTRY STRUCTURE

As explained earlier in this report, the economic impact from a change in mining industry employment depends on the extent of localisation of mining industry inputs. If most inputs are 'imported' from other regions, then the loss of mining industry jobs from automation and remote operations may be felt mostly outside the local community. Conversely, if most inputs are generated locally, the loss of mining industry jobs from

automation and remote operations may be felt more keenly within the local community.

Metal ore mining is the top industry in both Town A and Town B. The network of metal ore mining operations plays a large role in the local industry. Figure 10 is a representation of inputs required to sustain the mining industry.

CSRM provided Pracsys with an example of labour force break down of an open-cut iron ore mine. This employment profile has been applied to each of the operating open-cut iron ore mines located in the Pilbara. The automation of haul trucks may lead to a change in the current employment structure, leading to a potential contraction/expansion of the residential workforce.

4.3 SCENARIO DESCRIPTION

The Pilbara towns of Town A and Town B have been analysed in each of the following scenarios. Based on the Roundtable event held in Sydney on November 24th 2011, the following scenarios were modeled.

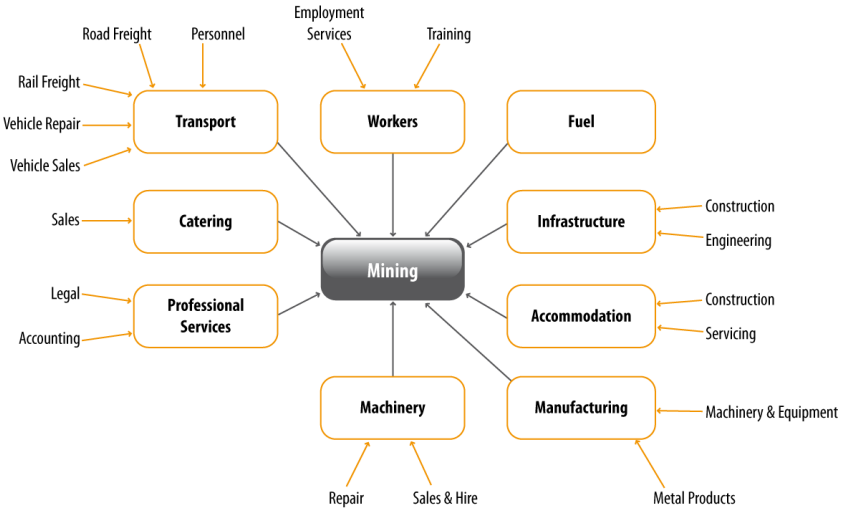
The level of automation (50% or 100%) was chosen arbitrarily for the purpose of the sensitivity analysis.

4.3.1 Scenario 1: Brave New Mine

Autonomous mining is mainstream. Automated mining operations are world standard with expertise employment for the remote operations located in capital cities, with limited semi-skilled on-site roles.

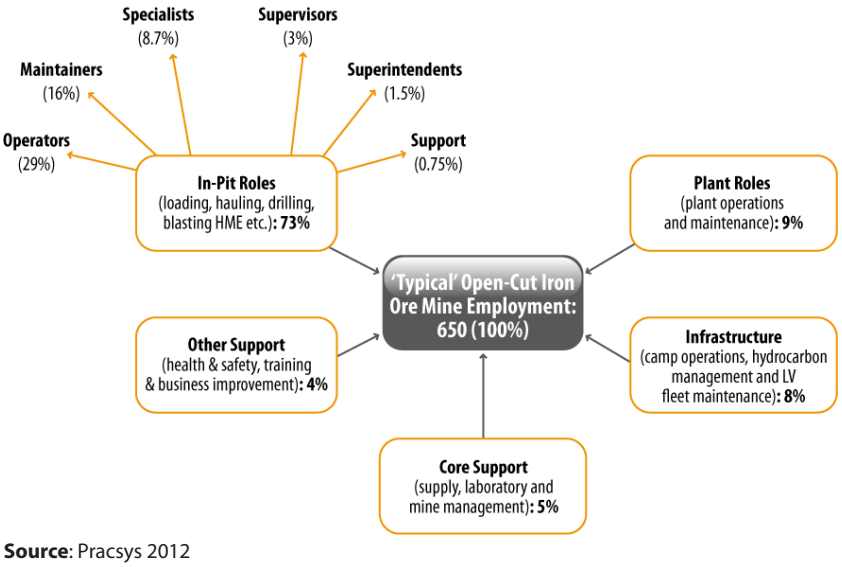
Under Scenario 1, 100% of human operated haul trucks are replaced with automated haul trucks. The job of the truck driver is replaced with a remote driverless truck operator. The replacement job is removed from the site to a remote operations centre located in Perth.

Figure 10: Network Map for Mining Industry



Source: Pracsys 2012

Figure 11: An Exemplar Open-Cut Iron Ore Mine



Source: Pracsys 2012

4.3.2 Scenario 2: Smart Regions

Autonomous mining is mainstream, with regional-based remote operations centres. Automated mining operations are world standard. There are limited semi-skilled on-site roles. The employment and services of the automated mining operation are carried out from regional hubs. This scenario allows the user to select the regional hub as either a town or site.

Under Scenario 2, 100% of human operated haul trucks are replaced with automated haul trucks. The job of the truck driver is replaced with a remote driverless truck operator. The replacement job remains in the region.

4.3.3 Scenario 3: Fly-Over Economy

There is a sporadic uptake of autonomous mining. The expertise employment for the remote operations is located in capital cities.

Under Scenario 3, it is assumed that 50% of human operated haul trucks are replaced with automated haul trucks. The job of the truck driver is replaced with a remote driverless truck operator. The replacement job is removed from the site to a remote operations centre located in Perth.

4.3.4 Scenario 4: Regions Fight Back

There is a sporadic uptake of autonomous mining. The remote operation of automated jobs is restricted to a regional scale. This scenario allows the user to select the regional hub as either town or site.

Under Scenario 4, 50% of human operated haul trucks are replaced with automated haul trucks. The job of the truck driver is replaced with a remote driverless truck operator. The replacement job remains in the region.

The model compares the employment effects on mining towns based on:

- The level of automation
- The location of the remote operations centre

4.4 ASSUMPTIONS

The model used assumptions about key inputs and variables. While the mining operations model has been developed to be flexible, such that employment and workforce ratios, level of automation, and other parameters that affect the net change in employment can be changed and the output will self-adjust, the output reported is based on a number of predetermined values. The extent to which these assumptions hold true in the market will affect the validity of the results.

All assumptions used in the analysis are located under the 'Assumptions' tab in the model. Cells that are highlighted green may be changed. A change in any of these variables will affect the outcomes of the model. Cells that are highlighted blue will self-adjust to reflect a change in other variables. Cells that have no fill are not to be changed.

The following assumptions underpin the structure of an exemplar open-cut iron ore mine:

Figure 12: Exemplar Open-Cut Iron Ore Mine – Employment Ratios

Job Description	% of Total Workforce
In-pit roles (loading, hauling, drilling and blasting, HME, other)	73%
Plant (plant operations and maintenance)	9%
Infrastructure (camp operations, hydrocarbon management, asset management and LV fleet maintenance)	8%
Core support (supply, laboratory and mine management)	5%
Other support (health and safety, training and business improvement)	5%

Source: CSRM, University of Queensland 2011

The introduction of automated mining operations may effect mining employment in:

- 1st order jobs (replacement job due to technology)
- 2nd order (subordinate employment)
- 3rd order (support employment)

The exemplar mine site has a workforce of 650. The following assumptions have been made in reference to the number of jobs that will be lost due to 100% automation of haul trucks.

Figure 13: Employment Ratios

Total Jobs	650	100%	% Residential
1st Order Jobs lost	130	20%	30%
2nd Order Jobs lost	71	11%	7%
3rd Order Jobs lost	13	2%	10%
Jobs remaining	436	67%	

Source: CSRM, University of Queensland 2011

- Automation may cause an overall conversion of 130 first order jobs. It is assumed that 30% of these employees are residential workers.
- Automation may cause an overall conversion of 71 second order jobs. It is assumed that 7% of these employees are residential workers.
- Automation may cause an overall conversion of 13 third order jobs. It is assumed that 10% of these employees are residential workers.

These figures and ratios are based on the information provided to Pracsys by the University of Queensland. The ratio of first, second and third order jobs lost as a result of automation are flexible variables that can be changed under the 'Assumptions' tab in the model.

The following assumptions underpin the ratio of jobs lost to jobs gained when an operation has been automated:

Figure 14: Automation Change in Employment - Job Replacement Ratios

	First Order Employment	Second Order Employment	Third Order Employment
Non-Automated	1	1	1
Automated	0.25	1	1

Source: CSRM University of Queensland 2011, Resources Policy (Bellamy and Pravica), 2010

- 4:1 ratio of drivers lost to remote operators gained (first order jobs)
- This assumption can be changed in the model under the 'Assumptions' tab to reflect a different employment outcome
- It is assumed that one residential worker will occupy one residential household

- 1:1 ratio for second order jobs lost and second order jobs gained
- Jobs gained is only relevant if the remote operations centre is located in the town or on site
- It is assumed that the impact to the town is jobs lost and no gain if the remote operation centre is located in Perth (or other major cities outside the mining regions)
- 1:1 ratio for third order jobs lost and third order jobs gained
- Jobs gained is only relevant if the remote operations centre is located in the town or on site
- It is assumed that the impact to the town is jobs lost and no gain if the remote operation centre is located in Perth (or other major cities outside the mining regions)

The level of automation in this report is solely focused on the remote automated operations of haul trucks. Non-automated means that none of the mines have taken up automated haul trucks, semi-automated refers to a 50% uptake of automated haul trucks and fully automated refers to a 100% uptake of automated haul trucks.

The flowing assumptions underpin the FIFO/residential split of personnel on a non-automated mine site:

Figure 15: Distance Assumptions Truck Drivers

Mine < 75km to Town	Ratio
FIFO	70%
Residential	30%

Source: Pracsys Assumptions

Mine > 75km to Town	Ratio
FIFO	100%
Residential	0%

Source: Pracsys Assumptions

- 75km from town is the driving threshold. Once a mine site is located further than 75km from town, the mine personnel is made up of 100% FIFO
- This mine site personnel breakdown applies to first, second and third order employment
- If a mine site is located 75km or less to town, then the mining personnel is assigned a 30/70 split: 30% residential workforce and 70% FIFO workforce
- This ratio may be changed under the 'Assumptions' tab in the model
- Changing the ratio will result in a net change of residential employment due to automation
- This mine site personnel breakdown applies to first order employment

The flowing assumptions underpin the FIFO/residential split of personnel on an automated mine site, with the remote operations Centre located on site:

Figure 16: Distance Assumptions Automated Operators

Mine < 75km to Town	Ratio
FIFO	85%
Residential	15%

Source: Pracsys Assumptions

Mine > 75km to Town	Ratio
FIFO	100%
Residential	0%

Source: Pracsys Assumptions

- The mine site personnel ratio of FIFO/ residential split is reduced when a role has been automated
- This assumption is based on the remote operations Centre being located on site
- This assumption has been applied to first order jobs only
- Second and third order jobs retain the same FIFO/residential ratios prior to automation

The following assumptions underpin the FIFO/ residential split of personnel on an automated mine site, with the remote operations centre located in town:

Figure 17: Remote Operation Centre Located in Town

Mine > 75km to Town	Ratio
FIFO	30%
Residential	70%

Source: Pracsys Assumptions

- It is assumed that there is a higher residential/FIFO split if the remote operations centre in located in town
- All mine sites within the 75km of Town A and Town B (depending on which town is selected in the model) have been aggregated to show the total impact of employment due to automation

The following assumptions underpin the household composition of Town A and Town B:

Figure 18: Household Composition

	Town A			Town B		
	Population (% Composition)	Mining Workers (% Composition)	Households (% Composition)	Population (% Composition)	Mining Workers (% Composition)	Households (% Composition)
Family	90.9%	83.4%	78.7%	91.6%	80.7%	78.0%
Group	2.5%	3.3%	3.6%	1.6%	2.2%	2.4%
Lone Persons	6.6%	13.3%	17.7%	6.7%	17.1%	19.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: ABS Census Data, 2006

Figure 19: Average Household Size

	Average Household Size	
	Town A	Town B
Family	3.36	3.42
Group	2.00	2.00
Lone Persons	1.09	1.00

Source: ABS Census Data, 2006

The following assumptions underpin the town expenditure and the convenience retail leakage rate:

Figure 20: Residential Expenditure Assumptions, Town A and Town B

Income Quintile	4
Average weekly household spend - convenience retail	$288
Average weekly household spend - comparison retail	$493
Convenience Expenditure Leakage Rate	20%
Comparison Expenditure Leakage Rate	100%

Source: ABS Census Data 2006, Pracsys benchmarking 2012

Figure 21: FIFO Expenditure Assumptions

Average weekly spend/FIFO worker	$24
Convenience Expenditure Leakage Rate (select items)	70%

Source: ABS Census Data 2006, Pracsys benchmarking 2012

The following assumptions underpin population driven community services:

Figure 22: Community Driven Services – Population Thresholds

Unit	Population	Dwellings
Primary School		350
Secondary School		900
Doctors	800	
Police	650	

Source: Pracsys benchmarking 2012, The Department of Education and Training

For every 350 regional family dwellings, one primary school is required. For every 900 regional family dwellings, one secondary school is required. For a regional population of 800, one doctor is required. For a regional population of 650, one police officer is required.

5.0

5 RESULTS

5.1 DIRECT ECONOMIC IMPACT: EMPLOYMENT

The direct economic impact that may occur as a result of automating a mining operation is the net change in mining employment. The model has been constructed with a focus on the residential workforce and the town population. The direct employment affect due to automation is therefore centered on the Town A and Town B residential workforce. Four scenarios were modeled to depict the change in employment of the residential workforce.

Under Scenario 2: Smart Regions – town, and Scenario 4: Regions Fight Back – town, there is a positive net change in residential employment. Under the remaining scenarios, where the remote operations centre has been removed from the town, there is a negative net change in residential employment. The change in employment in each of the scenarios is a combination of first, second and third order jobs lost at each of the mines within a 75km radius of the selected town, due to automation.

The scenario that has the most significant positive impact on residential employment is Scenario 2: Smart Regions, with the remote operations centre located in town. The scenario that has the most significant negative impact on residential employment is Scenario 1: Brave New Mine.

Figure 23: Net Change in Employment

	Scenario 1: Brave New Mine – Perth	Scenario 2: Smart Regions - Town	Scenario 2: Smart Regions - Site	Scenario 3: Fly-Over-Economy – Perth	Scenario 4: Regions Fight Back - Town	Scenario 4: Regions Fight Back - Site
Town A	-226	151	-171	-113	75	-85
Town B	-136	183	-102	-68	92	-51
Level of Automation	100%	100%	100%	50%	50%	50%

Source: Pracsys Analysis 2011

5.2 INDIRECT ECONOMIC IMPACT: POPULATION

The indirect economic impact that occurs as a result of automating a mining operation is the net change in residential population and households. The direct employment affect due to automation has a flow through effect that leads to a change in the residential population and number of occupied residential households. The four scenarios that were modeled to depict the net change in residential employment also depict the net change in town population and households.

Figure 24: Net Change in Population

	Scenario 1: Brave New Mine – Perth	Scenario 2: Smart Regions - Town	Scenario 2: Smart Regions - Site	Scenario 3: Fly-Over-Economy – Perth	Scenario 4: Regions Fight Back - Town	Scenario 4: Regions Fight Back - Site
Town A	-682	454	-514	-341	227	-257
Town B	-404	546	-305	-202	273	-152
Level of Automation	100%	100%	100%	50%	50%	50%

Source: Pracsys Analysis 2011

The results show that under Scenario 2: Smart Regions – town, and Scenario 4: Regions Fight Back – town, there is a positive net change in residential population and the

Figure 25: Net Change in Households

	Scenario 1: Brave New Mine – Perth	Scenario 2: Smart Regions - Town	Scenario 2: Smart Regions - Site	Scenario 3: Fly-Over-Economy – Perth	Scenario 4: Regions Fight Back - Town	Scenario 4: Regions Fight Back - Site
Town A	-226	151	-171	-113	75	-85
Town B	-136	183	-102	-68	92	-51
Level of Automation	100%	100%	100%	50%	50%	50%

Source: Pracsys Analysis 2011

number of occupied households. This would be expected, as these are the scenarios that result in a positive net change in residential employment. The results show that the greater the change in employment, the greater the change in population. A loss/gain of one job in town does not result in a decrease/increase in town population by one. The model has been constructed to represent the household structure of Town A and Town B. Under the remaining scenarios, where the remote operations centre has been removed from the town, there is a negative net change in residential population and occupied households. The change in residential workforce results in a change in population of entire families as well as group households and lone persons.

5.3 INDUCED ECONOMIC IMPACT: EXPENDITURE & BUSINESSES

The induced economic impact that may result from the automation of mining operations has a localisation and urbanisation effect.

The urbanisation effect is the result of a change in household structure. The loss/gain of residential workers leads to a change in the residential population and household structure. This in turn has an effect on household expenditure. A decrease in residential households means that there is a loss in household expenditure captured by the town. This in turn may lead to a decrease in economic activity and expenditure captured in town by local business and industries. The loss of expenditure captured in town (if great enough) may result in the loss of business. An increase in residential households may result in a gain of household expenditure captured by the town. This in turn may lead to an increase in economic activity and expenditure captured in town by local business and industries. The additional gain of expenditure captured in town (if great enough) may result in the growth of existing businesses or the opening of new businesses in town.

Figure 26: Net Change in Town Average Annual Expenditure

	Scenario 1: Brave New Mine – Perth	Scenario 2: Smart Regions - Town	Scenario 2: Smart Regions - Site	Scenario 3: Fly-Over-Economy – Perth	Scenario 4: Regions Fight Back - Town	Scenario 4: Regions Fight Back - Site
Town A Residents	-$2,793,210	$1,862,263	-$2,105,510	-$1,396,605	$931,132	-$1,052,775
Town B Residents	-$1,675,926	$2,263,320	-$1,263,330	-$837,963	$1,131,660	-$631,665
Town A FIFO	-$715,664	$249,051	-$268,803	-$357,832	$124,525	-$134,402
Town B FIFO	-$429,398	$386,899	-$161,282	-$214,699	$193,449	-$80,641
Level of Automation	100%	100%	100%	50%	50%	50%

Source: Pracsys Analysis 2011

The localisation effect that results from automating a mining operation is concerned with the change in local industry. The direct input to mine operations such as truck management and maintenance contracts may be replaced with specialised FIFO maintenance teams. The location of the control centre may also affect the local industry in terms of the number of residents employed and the type and quality of employment.

The results show that under Scenario 2: Smart Regions – town, and Scenario 4: Regions Fight Back – town, there is a positive net change in residential and FIFO expenditure captured in the town. This would be expected, as these are the scenarios that result in a positive net change in residential employment and an increase in the town population. Under all remaining scenarios and options modeled there is a negative net change in convenience retail expenditure captured in town. The less expenditure leaked from town, the greater the chance of town business survival.

A population change due to a change in the workforce structure may impact upon the population driven community services in the town.

Figure 27: Town A Population Driven Services Demand

Town A	Current Supply	Brave New Mine	Smart Regions (Town)	Smart Regions (site)	Fly-Over-Economy	Regions Fight Back (Town)	Regions Fight Back (Site)
Primary Schools	2	1	2	1	1	2	1
Secondary Schools	1	0	1	0	0	1	0
Police	7	3	4	3	3	4	3
Doctors	3	2	3	2	2	3	2

Source: Pracsys Analysis 2011

Figure 28: Town B Population Driven Services Demand

Town B	Current Supply	Brave New Mine	Smart Regions (Town)	Smart Regions (site)	Fly-Over-Economy	Regions Fight Back (Town)	Regions Fight Back (Site)
Primary Schools	1	1	1	1	1	1	1
Secondary Schools	0	0	0	0	0	0	0
Police	2	1	3	2	2	2	2
Doctors	1	1	2	1	1	2	1

Source: Pracsys Analysis 2011

The current supply of population driven community services may be affected by the automation of key mining operations. School education is the second largest industry of employment in both Town A and Town B. The introduction of automation may not only constrict or expand the mining workforce, it may also impact upon the employment profile of school education and other population driven services.

Under Scenario 2: Smart Regions – town, and Scenario 4: Regions Fight Back – town, there is a positive net change in the demand for population driven services. Under the remaining scenarios, where the remote operations centre has been removed from the town, there is a negative net change in the demand for population driven services.

The closure of schools and a reduced demand for doctors and police officers may result in a further contraction of residential employment and have economic and social impacts on the community. The opening of new schools and an increased demand for doctors and police officers may result in a further expansion of residential employment and have positive economic and social impacts on the community.

6.0

6 CONCLUSIONS

6.1 KEY FINDINGS

The modeling of economic impacts due to automation and remote operation of haul trucks was based on an exemplar open-cut iron ore mine configuration provided by CSRM. This mine site was for a generic ethnic workforce composition, thus the direct and indirect economic and social impacts as a result of automation were unable to specify the effects on indigenous employment.

A more detailed economic and social profile of the indigenous workforce may be modeled once more information becomes available.

A large portion of the semi-skilled workforce (including haul truck drivers) is made up of indigenous people. As truck driving skills may not be transferable to remote operations, a large portion of the indigenous workforce may become unemployed.

6.2 IMPLICATIONS

Automation and remote control mining operations result in direct and indirect economic and employment impacts due to an overall change in the workforce structure.

The creation of remote control operations centres normally transfers jobs from the mine site to other locations. If control centres are portable (requiring minimal technology such as a laptop and high speed internet), there is the possibility that these centres will be located overseas, in order to reduce costs. This may further reduce opportunities for the residential and Australian workforce. It is recommended that at the very least, negotiations are carried out with mining companies to ensure the control centres are located in Australia.

Based on historical evidence (Rio Tinto Mines for the Future), the remote control centre for automated mining operations will be based in capital cities (Perth). The removal of the operations centre from the region has the greatest social and economic impact on the residential workforce and town community.

A reduced workforce in the mining industry due to the automation of key operations may not only impact on the residential workers, it may also affect population driven services and the local industry. Research conducted by CSRM suggests that approximately 34% of the overall workforce of a typical mine may be subject to reconfiguration, of which, 50% will be in pit roles. This may have a flow through effect on other industries of employment in mining towns, leading to employment, economic and social impacts.

6.3 REQUIREMENT FOR FOLLOW UP WORK

Due to the extent of data available, it was difficult to determine the level of site supervision and truck maintenance that would be required for the operation of remote controlled vehicles. As data becomes more readily available, it is suggested that CSRM continue to develop and refine the model to better reflect employment opportunities in these areas. The level of data available in this area also made it difficult to model the level and effects that automation has on the indigenous workforce. As more data comes to light, Pracsys recommends that an indigenous workforce component be modeled on the FIFO and residential mine site personnel.

A more detailed study would be required into the transferability of skills from truck driver to remote vehicle operator. This study would coincide with a feasibility study for the retraining of the indigenous workforce to fill these new roles.

7.0

7 RECOMMENDATIONS

7.1 A CHANGE IN WORKFORCE STRUCTURE DUE TO AUTOMATION

The automation of key mining operation may result in a significant change to the workforce structure. In order to reduce the economic impact on employment in mining towns, it is recommended that the remote control operations centre be located in the nearest mining town. Although there is still a reduction in the workforce due to the nature of replacement technology, this option will have the smallest population effect, and consequently economic effect.

Other recommendations that may reduce the impacts of automation include:

- Re-training haul truck drivers for either maintenance or supervision roles or other semi-skilled roles
- Re-training truck drivers to become remote operations controllers
- Re-training truck drivers to become education, safety and training instructors
- Re-habilitate a portion of residential workforce with related skill-set in other employment areas

7.2 CONTRACTION/EXPANSION OF LOCAL INDUSTRY & SERVICING CAPABILITY

The introduction of automation into the mining industry may see a change in the local industry and servicing capability. Mechanics and other local contractors may lose business, as they no longer have the skills or technology required to service the new fleet of automated haul trucks. In order to reduce the impact on the local industry, it is recommended that service providers for the new automated mining technology be set up in mining towns. Maintenance and repairs will remain close at hand to the mine sites and maintain business operation in town.

If remote control operations centres are set up in town, there is the possibility of increasing the local supply chain due to requirement of specific technologies, industries and labour associated with automation.

7.3 IMPACT ON ECONOMIC ACTIVITY DUE TO A CHANGE IN WORKFORCE STRUCTURE

There is a potential for the contraction of economic activity in town due to the nature of the new workforce structure. This may affect the operation of businesses in town. It is recommended that all businesses operate at optimum levels of production and increase efficiency in order to stay in business.

7.4 IMPACT ON DEMAND FOR LOCAL POPULATION-DRIVEN SERVICES

The introduction of automation for key mining operations may have indirect economic, employment and social effects that may impact the local population driven services. The change in residential workforce due to automation may lead to a change in the town profile. Without the population and households to support education, police and healthcare provisions, the town may no longer be able to support these services. School education is the second largest industry of employment in Town A and Town B. In order to reduce the employment and economic

effects of automation, it is recommended that education and training programs associated with automation and automated technology operate out of the mining town. This may lead to the creation of new jobs in town, thus increasing town population. The increase in population may in turn be enough to retain a level of population driven services.