MinRPIM – Mining Recommendation Priority Indicator Model

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1. Introduction

MinRPIM is being used at IMIU for all recommendations prepared by its engineers when conducting risk surveys at mining and mineral processing operations.

As the name of the model suggests it provides an indication of the priority for each recommendation that is included in Section 10 of the IMIU Risk Survey reprots. MinRPIM does this using a qualitative process that produces a single number indicating the relative priority of each recommendation.

Unlike most qualitative processes the IMIU priority model has several important distinctions:

- It considers the Life-of-Mine. Clearly a mine with a life of less than 5 years has a very different investment outlook than a mine with a life in excess of 25 years.
- It uses a forced log-scale for the three inputs. This produces a wide range of results – hence it clearly differentiates between those recommendations that should be adopted quickly, and those where the time horizon can be much longer.
- It considers the size of each operation, and also the size of the operations in the company's portfolio. What may be an important recommendation for a small operation or company may fade into insignificance for a larger operation.

The MinRPIM has been introduced for several reasons including:

- Mine managers have to make decisions on the order in which to implement recommendations. Often these require capital and providing an indication of the priority of the recommendation assists with the decisions on capital spending.
- Regional / divisional / national managers need to know which are the important recommendations affecting operations under their control, and without having to read through a collection of low priority recommendations.
- Insurance managers in corporations need to know which are the high and very high priority recommendations so that they can discuss progress on these when negotiating renewals and also internally within the corporation. Again this can be done without having to read through what maybe a very large collection of recommendations if there are 20 or more operations in their portfolio.

It is important to note that the MinRPIM only considers the priority from a commercial perspective only. Factors such as impact on health, safety, environment, legal or communities are not included – but if these are a consideration then the mine manager can add these to the commercial priority.

2. Aims of MinRPIM

The aims for the operation and conclusions of the MinRPIM are:

1. **Simple in Structure**. The three building blocks; Frequency Factor, Life-of-Mine Factor and Consequence Factor are all readily understood. The Frequency Factor x Life-of-Mine Factor becomes 'Likelihood' in the well known cost of risk equation:

   Cost of Risk = Likelihood x Consequence.

2. **Simple to Use**. It is not unusual to develop and present 10-12 recommendations at a site each year for several years, and at times there have been up to 35 recommendations in a single site in a single year. With this volume the process of providing priorities for the recommendations has to be rapid.
3. **Simple to Interpret**. Each recommendation will have a single number that indicates its priority relative to the others at the site, and also relative to others elsewhere.
4. **Clear Conclusions**. By using a forced log scale for the three building blocks; Frequency Factor, Life-of-Mine Factor and Consequence Factor; there is a wide spread of results from MinRPIM that resemble the relative significance of each recommendation and the hazard that it is addressing. Hence the relative significance of a recommendation is instantly recognisable by the magnitude of the RPI – Recommendation Priority Indicator.
5. **Robust and Repeatable**. The MinRPIM results do not vary significantly as various engineers use it at each location.
6. **Transparent.** The numerical value for each factor, and hence the development of the Recommendation Priority Indicator is included with each recommendation in the IMIU Risk Survey reports.

3. The Outcomes from MinRPIM

There are two outcomes for every recommendation presented by IMIU. These are:

1. A *Recommendation Priority Indicator (RPI)* which is a single number providing a *relative measure of the priority* that the recommendation should receive when compared with the other recommendations prepared for that mining operation.

2. A ranking of the priority as 'LOW', 'MEDIUM', 'HIGH' and 'VERY HIGH'. The ranking is based on the RPI and also the size of the operation as measured by the TIV (Total Insured Value).

4. The MinRPIM Process

As stated, the approach being used by IMIU is a qualitative risk assessment, i.e. there is still a significant reliance on experience and estimating to make the judgements on the probability side of the risk equation (Cost of Risk = Probability x Consequence) or more specifically:

Cost of Risk = Frequency x LOM x Consequence

This equation is at the heart of the MinRPIM.

The three building blocks used to provide the RPI are:

1. Frequency Factor FF
2. Life-of-Mine Factor LF
3. Consequence Factor CF

4.1 Frequency Factor (FF)

This is the most challenging of the factors to use and the guidelines for assigning the FF is shown below in Table 4.1.

Table 4.1: Selecting the Frequency Factor

The number chosen will be chosen on the description that best describes the likely frequency of the hazard actually occurring assuming reasonable effectiveness of the existing preventative controls.

Given the conditions seen onsite, the potential loss:	**Frequency Factor (FF)**
Could be incurred in the next year – i.e. immediate threat	10
Could be incurred in the next 2 years	3
Could be incurred in the next 5 years	1
Could be incurred in the next 10 years	0.3
Could be incurred in the next 20-30 years	0.1
For a system failure This consequence has not occurred in the industry in the previous 50 years *For a natural peril* The ARI for an event of this strength/magnitude is >=100 years	0.03

Apart from events that fall into the lowest category with a FF = 0.03, a useful starting point is to use a FF = 1 and then to consider the local factors that are being used onsite to push the FF higher or lower.

Example 1: 'Improve the use of Hot Risk Permits'.

If only minor breaches or imperfections of a sound Hot Work Permit system are observed then the FF may move to 0.3 or 0.1. However, if there was no Hot Work Permit at the work location and good practices were not being used then the FF would move to 3 or 10.

Example 2: 'Install sprinklers over the ball mill lubrication system'.

If the conditions in the ball mill lubrication room were exemplary then the FF would move to 0.1 and if there were only minor imperfections such as small oil leaks then it may move to 0.3. However, if there was a large accumulation of oil and housekeeping was poor and there was a fine oil spray from a high pressure joint, then the FF would move to 10. The sprinklers will not affect the likelihood of the fire, but they will affect the likelihood of a major loss from the fire. Naturally if there were poor conditions in the lubrication room then there would be other recommendations addressing these issues.

In general, when considering recommendations for operational perils it is unlikely that the FF will be as low as 0.03 unless the prevention measures are exceptional. In practice these are the static risk reduction measures such as using blast walls between transformers or purchasing a complete spare girth gear.

In the last 20 years the mining industry has seen two draglines go over banks, autoclave explosions, winders fail, haulage shafts severely damaged, longwall collapse, filter presses burnt, oil systems burnt, elution heater fires, mines filled to the shaft collar with water etc. Hence the industry has seen them all! The only operational peril where human intervention is still important that might warrant a FF of 0.03 is boiler explosion. Mercifully, due to large range of inbuilt safety devices and rigid control procedures these are very rare.

4.2 Life-of-Mine Factor (LF)

This is the easiest of the three factors to use and the guidelines are presented in Table 4.2 below. In essence, the longer an operation exists the more likely that a hazard will cause a loss event.

There is an important exception with the Life-of-Mine factor. This is:

- LF =3 (i.e. maximum value) whenever the recommendation is for a 'good practice'. This includes practices such as Hot Work Permits, smoking controls, mill inspections, fire system inspections, etc. These should be adopted even if the operation has a life of only 3 years.

At IMIU we take an optimistic view of the LOM – we have seen many mines that have a 5 year mine life still operating after 15 years!

Table 4.2: Selecting the LOM Factor

Anticipated LOM	**LOM Factor (LF)**
LOM <5 years	0.1
5 years < LOM < 10 years	0.3
10 years < LOM < 25 years	1
LOM > 25 years ***OR*** Good practice recommendation	3

4.3 Consequence Factor (CF)

This is also a relatively easy factor to use mainly because the ranges are broad and therefore there is not a high level of accuracy required in the estimates

The guidelines for the selection of the Consequence Factors are shown in Table 4.3 below.

The Consequence Factor chosen is the estimated cost of the loss from the most severe consequence associated with the hazard, assuming reasonable effectiveness of ***existing*** AND ***tested*** mitigating controls.

Table 4.3: Selecting the Consequence Factor (CF)

PD + BI Consequence – USD	**Consequence Factor**
>USD 1 Billion	1,000
USD 100 Million – USD 1 Billion	300
USD 10 Million – USD 100 Million	100
USD 1 Million – USD 10 Million	30
< USD 1 Million	10

It is anticipated that very few consequences will score CF = 1,000 because there are likely to be devices of reasonable effectiveness to control the loss e.g. flood levees, pressure safety valves, spare girth gears, fire protection in a substation. However, there may not be and the 1,000 level will be invoked at a large operation with high insured BI values.

With the use of large scale machines in mining and mineral processing CF = 1,000 are becoming more common.

4.4 Risk Indicators (RI_B and RI_A)

The Risk Indicators are calculated before and after the recommendation is applied in the standard equation for cost of risk:

$RI_B = (FF \times LF \times CF)_{BEFORE}$ and

$RI_A = (FF \times LF \times CF)_{AFTER}$

4.5 Recommendation Priority Indicator (RPI)

The Recommendation Priority Indicator (RPI) is the final calculation in the MinRPIM and is simply the difference between the before and after Risk Indicators.

$$\mathbf{RPI = RI_B - RI_A}$$

The RPI is a particularly useful tool for setting priorities because it provides a wide range of values, which tend to approximate the relative importance of the recommendations. However, further simplification of the relative importance of the recommendations is provided by ranking the priority of the recommendations as LOW, MEDIUM, HIGH or VERY HIGH. This is the final step in the MinRPIM.

4.6 Ranking of the Priorities for the Recommendations

It quickly became apparent when IMIU was developing the MinRPIM that ranking of the priorities was dependent on the size of the operation, in effect it is the ratio of potential loss as expressed in the CF as part of the TIV that is important. From observations and experience the boundaries between the ranks for the various TIV ranges shown in Table 4.4 were developed.

Table 4.4: Priority Categories for Recommendations

Priority Category	**Recommendation Priority Indicators (RPI)**		
	Low TIV (<USD500M)	**Medium TIV**	**HIGH TIV (>USD2,000M)**
LOW	1 < RPI < 15	1 < RPI < 27	1 < RPI < 80
MEDIUM	16 < RPI < 80	28 < RPI < 140	81 < RPI < 450
HIGH	81 < RPI < 170	141 < RPI < 280	451 < RPI < 850
VERY HIGH	RPI > 171	RPI > 281	RPI > 851

Large mining companies often have separate mining operations of widely varying sizes and commodities, and hence the insured TIV's have a wide variation. It is not unusual for the some of the larger companies to have operations with TIV's that are in all three TIV ranges listed above.

Hence, what may be a VERY HIGH priority for an operation with a low TIV would only rank as MEDIUM when viewed from a corporate perspective. Hence for mining operations that are part of a mining company with widely varying TIV's there are two ranks provided the priorities for the recommendations.

The first rank is from the operational perspective and is there to provide guidance to the local mine manager when making decisions about the recommendations in the IMIU Risk Survey report.

The second rank is from the corporate perspective and provides guidance to Regional / Divisional / National Managers about the relative importance of recommendations from a wider perspective. He/she may elect to only be concerned with HIGH and VERY HIGH ranking recommendations from a corporate perspective. Similarly the Insurance Managers of these corporations may elect to be concerned with recommendations of the higher ranks.

5. MinRPIM in Action

Shown below is a typical recommendation and MinRPIM work table that is seen in IMIU Risk Survey reports.

XX 14/06 **Install a deluge sprinkler system at roof level to cover the full area of the Larox filter room.**

The Larox filter is a critical machine in the concentrator and without it all production of concentrate would cease. If a fire occurs in the filter that is not controlled manually in its incipient stages then the filter will almost certainly be destroyed. All production would cease for at least six months, and probably longer due to the time required to replace a machine of this size.

Factor	Freq.	Life	Cons.	Risk Ind.	Rec. PI	XX Priority	Co. Priority
Before	0.3	1	300	90	90	MEDIUM	MEDIUM
After	0.03	1	10	0.3			

Comment: The low frequency factor after the installation of sprinklers was used in this example because at this particular location the testing of the sprinkler systems used elsewhere at this location were 'top of the class'.

YY 13/08 **Test the fire pumps and mains to AS1851-2012.**

AS1851-2012 requests that Flow vs Head tests be done for the fire pumps annually. At the fire pumps at YY there is a return water line to the fire water tank which enables the testing of the pumps to be done without spillage of any water. However, there is no flow meter in the return line which makes it difficult to use this line for the Flow vs Head tests. Installing a flow meter in this line makes it considerably easier and does not require hydrants to be opened and discharging large quantities of water onto the ground.

Factor	Freq.	Life	Cons.	Risk Ind.	Rec. PI	YY Priority	Co. Priority
Before	0.3	3	100	90	87	HIGH	MEDIUM
After	0.1	3	10	3			

Comment: The frequency of fire pumps being ineffective will fall if testing is done properly and hence there is a reduction in the FF. Even though this mine only has a 10 year mine life the LF = 3 because the recommendation is for a good procedure that is independent of the projected life of mine. The consequence factor is also reduced because if the fire pumps are working properly the consequences of a fire will probably be reduced because the ER Team will have adequate water supplies and pressures for fire fighting.

The priorities are different because this operation has only a low TIV, but the others in the corporate portfolio fit into the medium TIV range.

6. Conclusions

IMIU developed MinRPIM in response to the needs amongst our clients to have guidance on the priorities for recommendations that are presented by IMIU in its Risk Survey reports.

It is a coherent model that uses the skills and experience of the IMIU engineers and clients' personnel to assist with the decision making on spending for the adoption of recommendations to improve the risk profile of the mining operations.