Economic benefits of improving precision

Trevor Bruce[a] and Michael Hidding[b]
[a]30 Christopher street, Boksburg East, 1459, South Africa, E-mail: Trevor.Bruce@FLSmidth.com
[b]Osborne Park, Perth WA 6916, Australia, E-mail: Michael.Hidding@FLSmidth.com

Better sampling, preparation, and analysis (SPA) can improve the precision of results for resource grades and commodity trading. What we are often asked by customers is how they might quantify these improvements in terms of economic benefits.
One way to do this is by applying the SPA precision of your results to the selling price of the resource. In this paper, a deeper look into resource pricing methodology for iron ore will be undertaken and how improved precision, on the quantification of the critical elements in this product, can affect the selling/purchase price of this commodity.
Using a real-world example, this paper will show the results of a basic business case study, investigating the return on investment (ROI) for a Sampling Improvement Project (SIP) including a well-designed sampling, sample transport, sampler preparation and analysis facility. The investigation will include the estimated total cost of the SIP, from the problem statement to implementation, together with an estimate on operational costs. This is then compared to the potential profit gains that the SIP could provide.
Primary focus will be on structures/methods used to determine commodity prices, how the measurement of the concentration of the critical elements link to pricing, and how variations in measured vs actual concentrations effect the final price. Also considered will be the economic benefits of faster more reliable data collection as well as improved quality moisture measurement.

Introduction

There is a lot of consideration within the sampling community around how better sampling, preparation, and analysis (SPA) improves the precision of results for resource grades. The debates, however, often fail to demonstrate how monetizing this improvement can be quantified. Some of these debates and discussions have been highlighted and discussed in the October 2021 edition of Spectroscopy Europe under the special section on Economic Arguments for Representative Sampling[1].

One way to attempt to quantify this monetary improvement is by applying the SPA precision of your results to the selling price of the resource and then balancing these differences in precision against the costs of improving precision.

The higher the price that resource companies can sell the resource for (with the same cost base) the more profit they can realize. On the same note, the lower the price that consumers (refineries etc.) can purchase the resources for (with the same quality), the more profits they can realize. Two obvious statements but points that tend to be overlooked when delving into the details of motivating for budget to install or upgrade sampling and sample preparation systems.

There is typically a large penalty payable by producers if they overstate the critical element content of their respective resources. It is, therefore, common for producers to understate measured content by the level of confidence or precision they have in their SPA results. The consequence of this is a larger discrepancy in the price they can sell their resource at, compared to what they could be selling it at. The further away from the actual value that the reported value is, the more the producer will lose if the content is understated.

Discussions below will show the results of an investigation into resource pricing methodology for iron ore, and how improved precision, on the quantification of the critical elements, in these products can affect the selling/purchase price.

The investigation will include the review of structures/methods used to determine the commodity price, how the measurement of the concentration of the critical elements drive this pricing and how variations in the concentrations effect the final price. It will also look into a few other economic benefits of a SIP, such as how improved turn-around-time on results, whilst still maintaining confidence in the results, can add to profits earned.

To understand the true ROI it is also important to know what the total cost of the SIP will be, not only the final project, but also the investigations required to establish that a SIP is required, and what systems will be needed to suitably fulfil these requirements. This all requires many man-hours and other resources, all of which have an associated price tag. In addition to this, the final installed system (sampling, sample transport and laboratory) often holds a large price tag that, and if not properly understood and explained to stakeholders, could already put a stop to a project before it has started. Estimations of these costs, based on real world projects, are discussed, and compared to potential gains as well as the cost of lost time whilst the project is underway (i.e., the cost of not having optimal results until the upgraded system is in place). The results of the comparison are used to illustrate what ROI can be expected based on a relatively large automated SIP.

Although this paper is focused on iron ore, the principles of the discussion are universal to all other commodities. Effectively, giving the seller or purchaser the tools to evaluate their product to the highest level of confidence possible will also

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enable them to assign the most suitable price tag to the commodity, whilst maintaining or reducing the risk of penalties from over/understating the commodity quality.

Cost benefits for an Iron Ore port facility

Before we look at the cost savings of a sampling improvement project it will be prudent to investigate the time and cost that is involved in initiating and implementing the project; it is important to establish an understanding of what to expect when approaching this matter. Sampling improvement projects (SIPs) are often shut down before they are started, often because of the perceived high capital cost required for these projects. It is important, therefore, to understand these expected costs from the start and ensure stakeholders are aware of what they should expect to pay for their improved profits that a well-executed SIP will bring them.

The time and costs do not start at order placement on a supplier for the manufacture and integration of a system, but instead they start quite a way back up stream of this. Time, and therefore costs, start already at the investigation stage where it is necessary to establish if there are any improvements possible in a given system. The question could be asked; "why spend time and money investigating a system that is producing as expected and has not shown any signs of concern?" As you will see later in the discussion, the longer an improvement takes to be defined and rectified, the larger the value of the net "un-known" profit loss will be. It is for this reason that regular investigations should be carried out with the intent of continually improving the process.

What will also be highlighted here is the criticality of installing the best possible sampling, preparation and analytical (SPA) system the first time around. This is, primarily, because the cost that will be incurred for the upgrade is far outweighed by the potential profit not realized during the time that it takes to establish the problem, specify a solution, engineer the solution, manufacture, and integrate the solution.

Scenario requiring a SIP

Although the figures used in the example below are based on actual projects of this nature, the author has chosen to represent these figures as a hypothetical project for the purposes of this paper.

Scenario: Here we consider an existing (brown fields) Iron Ore port facility where Iron Ore is blended from stockpiles to achieve a required product grade and transferred via conveyor into a ship hold at a design rate of 5000tph. This facility was initially designed and built with an appropriate SPA system for the nominated throughput, but over time the port increases its loading capacity to 10000tph (50MTPA), whilst failing to upgrade the SPA system accordingly.

What could be wrong with the brownfields sampling system after the plant is upgraded to the higher loading rate?

This is a common problem that, I am sure, most operators have experienced at some point in their careers. Listed below are few possible problems that this facility could face until their sampling, preparation and analytical system is corrected (in no order of importance):

- With increased flow rate, and therefore likely increased belt speed, the primary sample cutter angle could be too shallow for the new flow (i.e., the cutters are no longer cutting through the stream at 90deg)
- With increased burden depth the cutter aperture may no longer accommodate the entire stream
- The flow rate of material could be causing the cutter spoon to fill up to quickly and therefore not all sample is collected in the cutter aperture as it passes through the stream (i.e., material could be steadily overflowing out of the cutter as it passes through the stream)
- It is possible that the drive to move the cutter through the stream is not strong enough for the new rate and therefore battles to move at a constant speed through the material stream
- Precious maintenance and inspection SOPs will no longer be suitable as there will now be a higher wear rate on the cutters, this could be resulting in worn cutters going unnoticed for longer than acceptable
- Because of the higher flow the primary sample will be larger (assuming the cutter was already moving through the stream at 0.6m/s and therefore could not be increased further), the secondary sampler and other downstream equipment (feeders, crushers, and the like) may also be undersized to handle the new sample mass
- With the faster loading rate and the required number of increments remaining the same, the time between primary cuts will be greatly reduced which could result in backlogs in the downstream sampling, sample preparation and analytical systems (leading to possible sample loss, sample mix-ups etc.). This often results in the plant reducing the number of increments which of course could be detrimental to the precision of the sample results due to the increase in sample variance (because of time variation of grade), especially if there is a high level of variability in the ore.
- With larger samples, manually transporting these to the laboratory could now be a concern (further delaying the sample from getting to the laboratory and also furthering the risk of sample degeneration before it reaches the laboratory)

All these problems will result in a number of sampling errors and likely sample preparation and analytical errors as well, if the laboratory is not set up to handle the new load of samples. The financial damage these errors can result in, even if a small error (i.e., resulting in even a 0.1% degradation on precision of results) can be catastrophic. What is even more alarming, is that these financial losses are almost never even detected - it is difficult to assign a value to a profit most organisations don't even know they are losing out on.

Analysis of the cost of the large upgrade project

Labour costs. It is often months or years before an alarm is raised that there could be an opportunity to gain additional profits from a SIP. Then from the date that this alarm is raised, as can be seen in the Table 1, it will typically take approximately 3 years to detail and implement an upgraded solution.

As seen in Table 1 and illustrated in Figure 1, between the project owner and their suppliers, approximately 30 000 man-hours are typically spent during this period for engineering (electrical, mechanical, software, etc.), process and sampling specialists, technicians, procurement, management etc. to develop these primary stages:

Table 1: SIP life-cycle stage duration

Sampling Improvement Project (SIP) life-cycle stages	Cumulative days	Total man-hours
Identification of problem/opportunity for better sampling	60 days	732.00
Consultation with industry on what is required	60 days	110.00
Testing to quantify what the current situation is and a simulation of what could be possible to quantify what improvement can be made	40 days	1340.00
Define what can be changed to be able to act on better sample information (i.e. what process can be changed/modified in reaction to the sample results to better improve profits)	60 days	410.00
Business case model of what the hidden costs of not improving sampling to analysis are	40 days	350.00
Prepare and issue specification documents for tender	80 days	700.00
Adjudicate tender responses	20 days	310.00
Order placement on successful bidder	20 days	10.00
Detailed design of sampling to analysis system	160 days	16352.00
Manufacturing of systems	100 days	2906.00
Delivery, installation, and commissioning of system	80 days	5160.00
Validation of installed system	40 days	1280.00
implementation of monitoring and maintenance program for sampling to analysis system	20 days	340.00
Total	**780 days**	**30000.00**

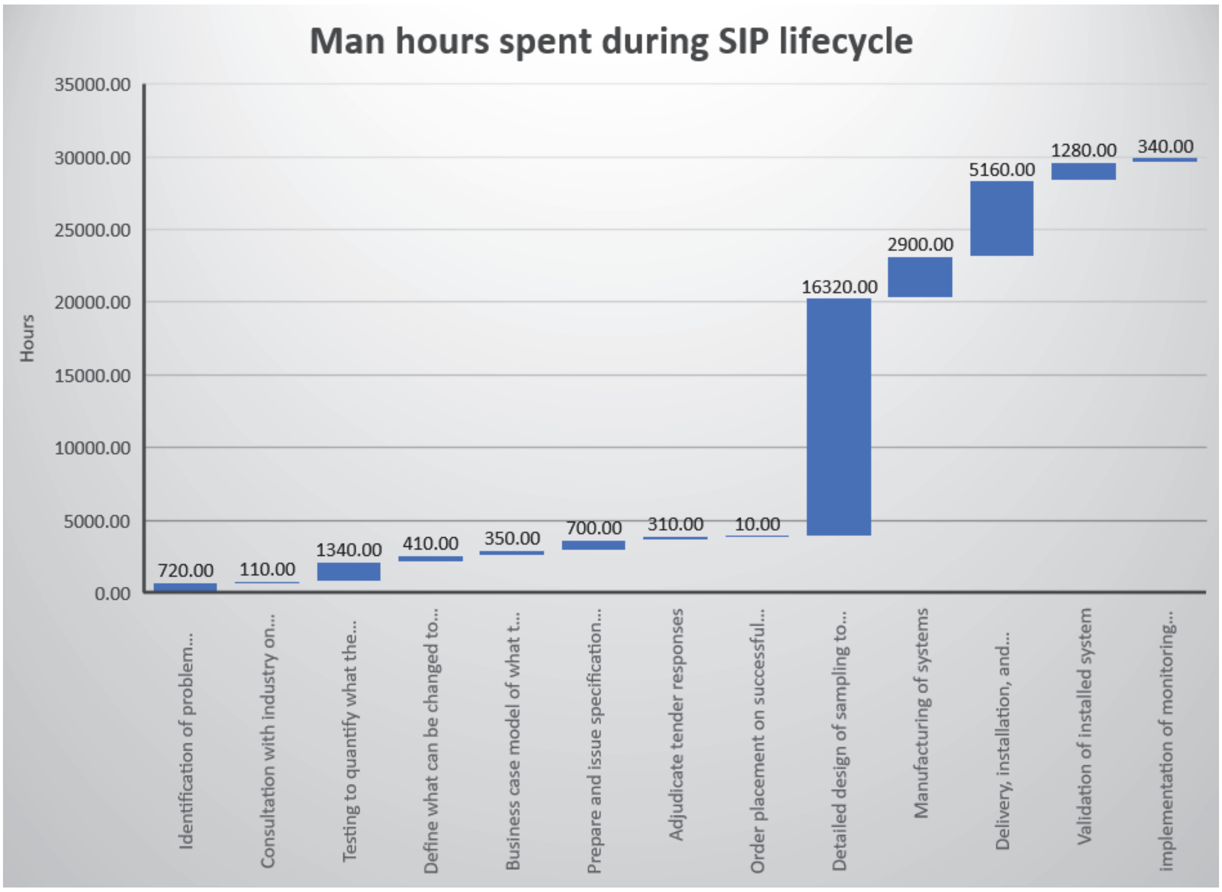

Figure 1: SIP lifecycle manhours spent

Capex and Opex. Based on past SPA industry solutions of a similar nature, for a +-50MTPA iron ore project a suitable (and often the only) solution to be able to sample, transport the sample and analyse the sample fast and precisely enough to allow for confident “real-time” changes to the blending and loading process, is an end to end fully automated sampling to analysis process. As these solutions are typically also the most capital-intensive options, the author has chosen to consider this type of fully automated system for the model. This will represent the highest cost option for comparing any ROI calculations.

Comparing past industry indicative prices, from various leading suppliers in these systems, for a port facility of 10000tph Iron ore (50MTPA capacity), a fully automated sampling, sample transport, sample preparation and analysis system will cost in the region of US$7.5M. The cost of a new building and services for this facility could add a further US$2.8M. Then, assuming US$120/hr as a combined rate for the resources required to carry out the tasks listed above (30000 man-hours), the cost of labour for the project will be US$3.6M.

The above total estimated project cost is around US$13.9M from the start of an investigation to the final installed and operational solution. If not already included in the project, any upstream process optimisation changes should also be carefully considered. While this may increase the final project cost, the longer-term benefits will also be greater.

Of course, there are a multitude of configurations that SPA systems could have to reduce initial capital expenditure, e.g. reducing the level of automation, but each concession should be carefully considered, along with the overall purpose of the upgrade, to ensure not to degrade KPI’s, such as throughput, cost of sample due to manual handling and precision degradation which are all required to achieve the maximum benefit of the upgrade.

Finally, a cost that must also be considered, is the cost to operate and maintain the facility itself. Although it will be included in the ROI calculations, it should be noted that this cost is not additional, as in the case of this brownfield project example (Scenario requiring a SIP), a SPA system in some form is assumed to be already in place and therefore these operational costs are already being incurred. A conservative estimate for inclusion of operational expenditure (maintenance and spare parts) is approximately US$1.8M/annum.

Analysis of economic benefits

Without the context of ROI these numbers may appear to be large, and again, this is where stakeholders struggle to see value, however now we will investigate the economic benefits of implementing best practice SPA. To calculate the ROI for the large capital expense and high operating costs of this application we can consider the primary contributing factors or “money makers/breakers”. The primary factor in this instance, is the potential profit loss due to selling the product below what it could be sold at, as a direct result of the level of sampling, preparation and analytical precision achieved during loading. The precision on chemical analysis will affect the price sold and the precision on the moisture analysis will affect the percentage of on-grade ore that is not billed for (i.e., overstating moisture level will result in less of the loaded mass being invoiced as ore).

In the case of the example noted above, because the upgrade will make it possible to analyse the samples in close to real-time, as the ship is being loaded, it is possible to optimize the grade of material being loaded, by blending the correct grades as it is loaded. This offers the opportunity to increase the total volume of ore available for sale with no other changes in production (i.e., ore that would have been considered low grade waste can now be blended in with higher grade ore and sold at the price of the higher-grade material).

Although smaller in comparison, other benefits of the fully automated system include the ability to process the samples faster and have the laboratory purged and cleaned between batches of material in a much-reduced time. This reduction in process and delay time between lots results in a shorter duration that the vessel needs to be sitting at port, saving on port costs and allows the supplier to issue certified results for invoicing in a shorter period.

Iron Ore price structure based on precision. Iron ore products are broken into several different classes/grades of ore. Each grade, however, is still a non-commutable commodity (each unit has unique qualities that add or subtract value) due to its variation in quality. There are many different methods used by large multinational corporations to calculate the purchase price of iron ore at any one time. These methods form the basis of negotiations of larger supply contracts, which can become very complicated. As a basis of discussion in this paper the author has selected one method of pricing, developed by an international price reporting agency (PRA); Metal Bulletin (Fastmarkets MB). This method involves an index of key price-affecting chemical components of Iron Ore, namely: iron, silica, alumina, and phosphorus. The indices are called the Value-In-Use (VIU) indices.

To better understand this method, and how it is applied to prove points noted above, it is good to have a slightly better understanding of the iron ore market. Below is a summary of this based on information referenced from an article in the MetalMarket Magazine, June 2018[2]

The article notes the following:

Different percentages of iron content reflect both the natural variation in iron ore grades found in mine deposits and the degree of processing (if any) employed to upgrade the ore for a certain use. In general, higher purity ores help increase hot metal yields in the blast furnace, and lower production cost by reducing the amount of coke required. For these reasons, the rule of thumb is “higher Fe grade, higher price.”

Market conditions drive the preferences for the various ore types, and the differentials between the different iron ore indices are dynamic. Profit margin, defined by the price of the final product less the cost of raw materials, that steelmakers are achieving, is considered to be one of the largest drivers of these market conditions.

Because Blast furnaces cannot easily be switched on and off, to optimize their operating rates in varying market conditions, steelmakers need to be astute in purchasing of iron ore.

To maximize blast furnace yields, when margins are high, steelmakers prefer high-purity ores to optimize the profits from each tonne they produce, however, Low-grade ores are turned to by steelmakers when margins fall away, to minimize their production rates and reduce costs.

More recently, at least in China, environmental policy has become a key driver of prices across the iron-ore grade spectrum. Typically, lower-grade ores with higher fractions of deleterious elements such as silica and alumina require increased consumption of coke, which can raise emissions of controlled gases and particulates.

Also quoted directly from this article:

"Though Metal Bulletin published indices for several grades of iron ore, the real-life variability is such that virtually all ores differ in some respect to the base specification of the index they settle against. Where actual iron ore grades do not match the index specifications exactly, counterparties typically agree premiums or discounts based either on bilateral negotiation or using the VIU indices published by PRAs. Metal Bulletin's VIU indices, calculated and published monthly, help companies agree upon appropriate price adjustments based on the iron, silica, alumina and phosphorus content of their specific products." [2]

Price calculation using VI. With the Value-in-use indices, each of the key elements are considered separately and compared to the base value of the specific grade of iron ore. Although each element is looked at in isolation their VIU adjustment[3] is applied additively for the difference in each chemical content from the index base specifications. Considering a 62% Fe fines ore, the price formula is as follows:

Price=index+[(actual Fe - 62)×Fe_VIU]+[(actual Si - 4)×Si_VIU]+[(actual Al - 2.3)×Al_VIU]+[(actual P - 0.1)×P_VIU×100]

Precision (2σ) on chemical results of critical elements. For the purposes of discussion, it is noted that the actual accurate value of ore being loaded is perfectly as per the base values for this commodity type, i.e., Fe=62%, Si = 4%, Al = 2.3% and P = 0.1% with moisture of 8%. It is then considered that, to avoid harsh penalties for overstating the quality of the ore, the supplier will degrade/understate their analytical results based on the SPA precision achieved (i.e., with a 0.35% precision on Fe, the supplier will degrade the product value by 0.109% when calculating the final price of the product as-loaded).

Although some automated port laboratories in South Africa and Australia have managed to reduce their total precision for Fe to just below 0.16%, as a baseline in this calculation the author has chosen to consider the overall precision specified in table 1 of the ISO 3082 specification for Iron ore[4] (+210kt lot as per figure 2), as the value that the upgraded sampling to analysis project should aim for. These levels of precision will be applied to the critical elements and considered scenario 1 (results after upgraded SPA system)

Table 1 — Overall precision, β_{SPM} (values as absolute percentages)

Quality characteristics		Approximate overall precision β_{SPM} Mass of lot t								
		Over 270 000	210 000 to 270 000	150 000 to 210 000	100 000 to 150 000	70 000 to 100 000	45 000 to 70 000	30 000 to 45 000	15 000 to 30 000	Less than 15 000
Iron content		0,34	0,35	0,37	0,38	0,40	0,42	0,45	0,49	0,55
Silica content		0,34	0,35	0,37	0,38	0,40	0,42	0,45	0,49	0,55
Alumina content		0,11	0,12	0,12	0,13	0,14	0,15	0,16	0,18	0,20
Phosphorus content		0,003 4	0,003 5	0,003 6	0,003 7	0,003 8	0,004 0	0,004 2	0,004 5	0,004 8
Moisture content		0,34	0,35	0,37	0,38	0,40	0,42	0,45	0,49	0,55
Size – 200 mm ore	– 10 mm fraction mean 20 %	3,4	3,5	3,6	3,7	3,9	4,0	4,2	4,4	5,0
Size – 50 mm ore										
Size – 31,5 + 6,3 mm ore	– 6,3 mm fraction mean 10 %									
Size – Sinter feed	+ 6,3 mm fraction mean 10 %	1,7	1,75	1,8	1,85	1,95	2,0	2,1	2,2	2,5
Size – Pellet feed	– 45 µm fraction mean 70 %									
Size – Pellets	– 6,3 mm fraction mean 5 %	0,68	0,70	0,72	0,74	0,78	0,80	0,84	0,88	1,00
NOTE The values of β_{SPM} for silica, alumina and phosphorus content are indicative and subject to confirmation through international testwork.										

NOTE The overall precision for other physical characteristics and metallurgical properties is not specified in this International Standard, because they are used to qualitatively compare the behaviour of iron ores during handling and reduction processes.

Figure 2: Table 1 from the ISO 3082[4]

Of course, it must be noted that no amount of downstream treatment can resolve large sampling error noted in the sampling problems above, and that in this example (Scenario requiring a SIP), trying to quantify the accuracy and precision of the samples taken, compared to the actual grade of the lot is nonsensical and not possible. But, again for the purpose of the discussion it is conservatively assumed that even with all the problems of the system noted in the example (Scenario requiring a SIP), before the SIP upgrade, the precision achieved for this grade of product is as follows: Fe precision = 1%, Si precision = 1%, Al precision = 2% and P precision = 0.35% with moisture of 15.35%. In manually operated sampling and sample preparation labs it is not uncommon to see precision values well in excess of 5% for Fe, so it should be noted that the estimate here is conservative. These levels of precision will be applied to the critical elements and considered scenario 2 (results before upgraded SPA system).

If the index price of 62% Fe fines is as per the values taken from the MBIOI (Fastmarkets MB Iron Ore Indices) index from the 8th September 2021 (code MBIOI-62), the selling price of scenario 1 and 2 can be calculated:

- 62% Fe fines = $132.19
- Fe-VIU =2.55
- Si-VIU = -4.97
- Al-VIU = -5.99
- P-VIU -0.7

Scenario 1 (results after upgraded SPA system):

Price=$132.19+(61.892-62)×2.55+(4.007-4)×-4.97+(2.301-2.3)×-5.99+(0.1-0.1)×-0.7×100=$131.87

Scenario 2 (results before upgraded SPA system):

Price=$132.19+(61.69-62)×2.55+(4.02-4)×-4.97+(2.323-2.3)×-5.99+(0.100185-0.1)×-0.7×100=$131.15

From this example, it is seen that if no upgrade project is carried out the supplier could be losing at least US$0.72/tonne of ore that is sold. If this facility is selling 50MTPA this would be worth up to US$36 000 000/annum in lost profits.

The charts below (Figure 3 and Figure 4) illustrate the resultant profit degradation as the total precision deteriorates.

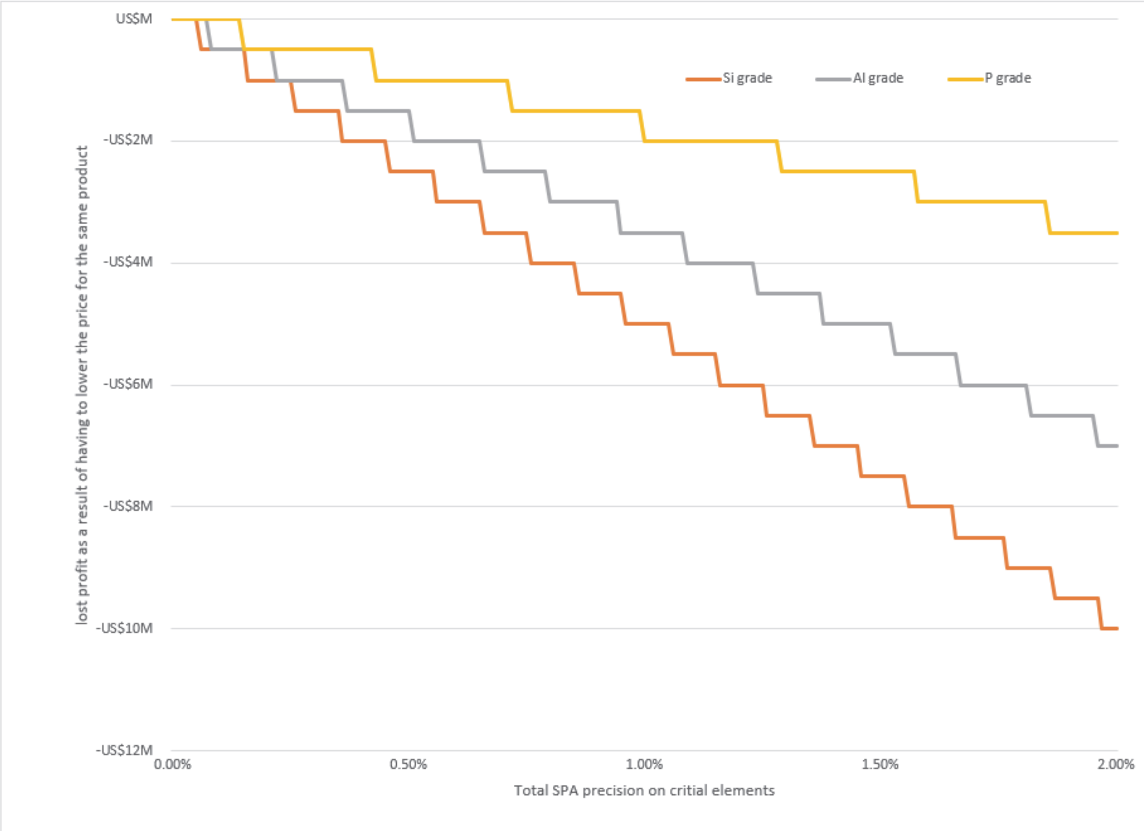

Figure 3: Profit degradation with deterioration of precision on deleterious elements for a 50MTPA iron ore port facility

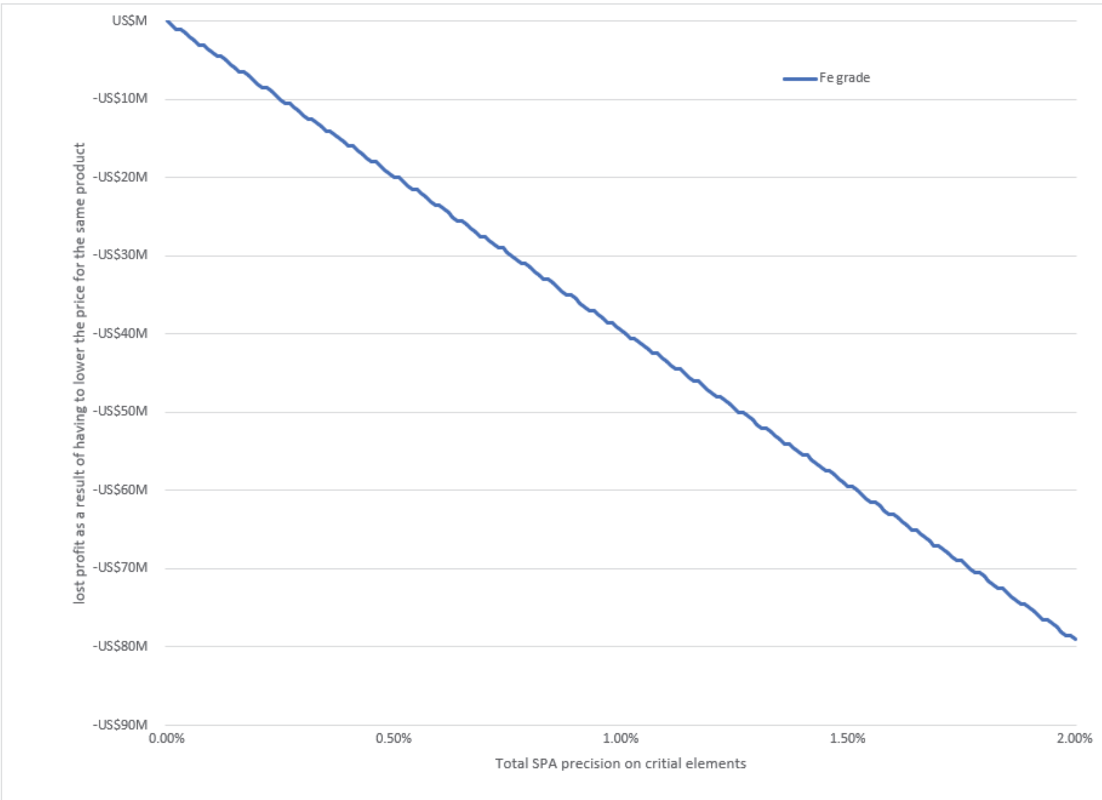

Figure 4: Profit degradation with deterioration of precision on Fe for a 50MTPA iron ore port facility

Precision on Moisture. If we then consider the effect precision of the moisture value has on the effective price (using the index price of 62% Fe fines with a moisture base of 8% as per the values taken from the MBIOI Fastmarkets MB Iron Ore Indices[3]) then scenario 1 (0.35% total precision, 2 σ, on moisture) would be charging for 0.014% less product than actual (0.0035/2 x 8), and scenario 2 (15.35% total precision, 2 σ, on moisture) would be charging for 0.614% less product than actual (0.1535/2 x 8). So, by upgrading the facility (assuming the upgraded facility could achieve a 0.35% precision on the stated moisture), the supplier will be able to sell 0.6% more ore with no other process change requirements. This equates to 300 000 tonnes of ore on a 50MTPA facility or US$39 657 000/annum additional profits at the iron ore price noted above for the 62% Fe fines.

The chart below (figure 5) illustrates the resultant profit degradation as the total precision on moisture deteriorates.

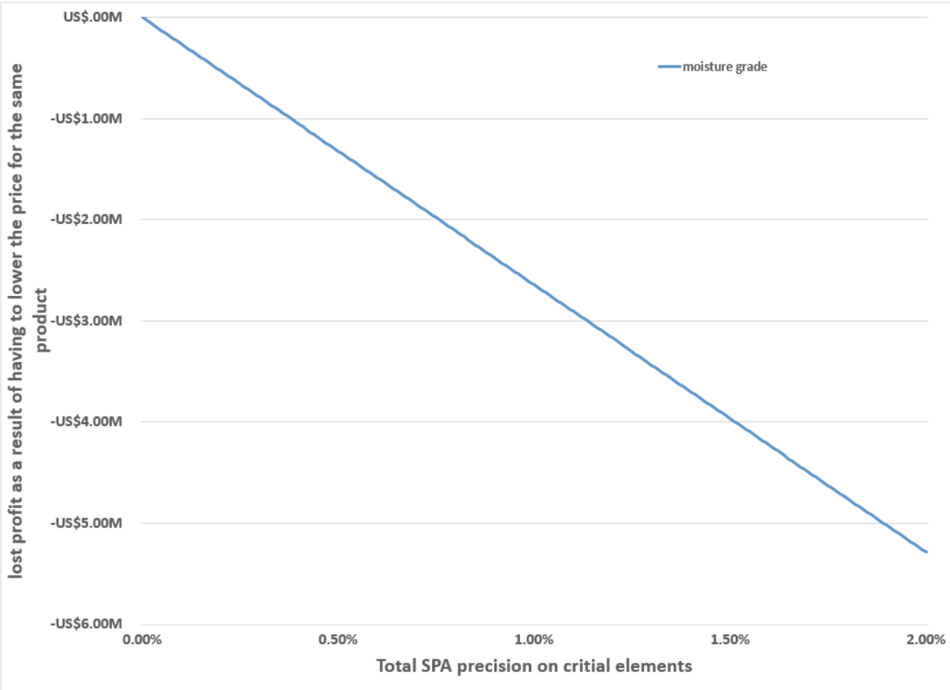

Figure 5: Profit degradation with deterioration of precision on Moisture for a 50MTPA iron ore port facility

Faster turn-around time. It is even possible for a producer to realise savings that they did not expect to achieve with a SIP. An example of this is experienced by an Iron ore port facility that realized that by being able to invoice their client over two days earlier for every shipment resulted in them getting their "money in the bank" faster and benefiting from the interest earned for these additional days. Assuming an interest rate of 5%pa on invoiced costs, a Fe price of $132.19/DMTU and a lot size of 200kt, this was worth around US$7243/200000t vessel loaded, the overall yearly value, of which, equated to over US$1 810 821.92/annum additional profit.

Opportunity to carry out "in-ship" blending of ore. As noted earlier, if the port facility has the required infrastructure to react quickly enough to change using the near real time data, with the level of confidence needed in the data, low grade ore can be blended in with higher grade ore as the vessel is being loaded. This optimizes the use of both high- and low-grade ore reserves. For a 50MTPA port facility this could mean selling at least 0.1% additional ore that would have previously been assigned as waste product. At the above price of US$132.19/t of 62% Fe fines (as above) this would equate to an additional US$6 609 500/annum additional profit previously not possible.

ROI for a large SIP – 50MTPA Iron Ore port sampling to analysis facility

The above scenarios provide a good understanding of what can be expected in regard to the cost of implementing a SIP as well as what the possible economic benefits are. The larger scale of the operation, the more there is to win or lose. Let's now consider the comparison between expected CAPEX and possible profits achievable after the sampling improvement project has been completed.

From the sections above (summarized in table 2), the estimated CAPEX for the world class SIP considered is US$13 900 000 with an ongoing operational cost of around US$1 800 000. In comparison, the potential profits to be realized because of this SIP are as follows and as per figure 6 below:

- Profits from enabling a higher price to be charged for the same ore, US$36 000 000
- Profits from being able to charge for more ore (less water) for the same product, US$39 657 000
- Potential additional profits resulting from the ability to process the samples faster, US$8 420 321

Offsetting these gains to the capital and operation costs a Pay-back period of less than 3 months is possible as can be seen in figure 7.

Table 2: Breakdown of ROI input values

Item description	Expense (labour and CAPEX)	Operational costs/year	Potential profit gains after SIP (/year)
Cost of man hours from owner and supplier	US$ 3.60M		
Automated sampling, transport and laboratory	US$ 7.50M		
Building and services	US$ 2.80M		
Total capital cost	US$ 13.90M		
OPEX/year		US$ 1.80M	
Value of faster loading rate (invoice 2 days earlier)			US$ 1.81M
Ability to charge more due to improved precision			US$ 36.00M
Ability to optimize grade by blending in ship (improvement of 0.1% additional on grade ore)			US$ 6.61M
Moisture result precision (Improvement from 15.35% to 0.35%)			US$ .40M

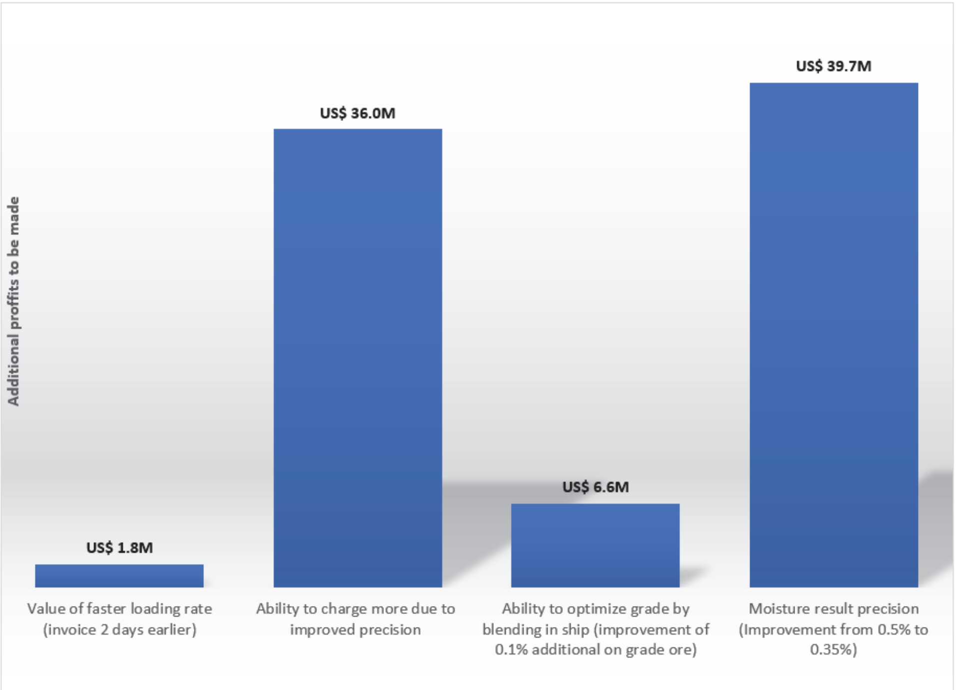

Figure 6: Potential profits that can be realized after a SIP

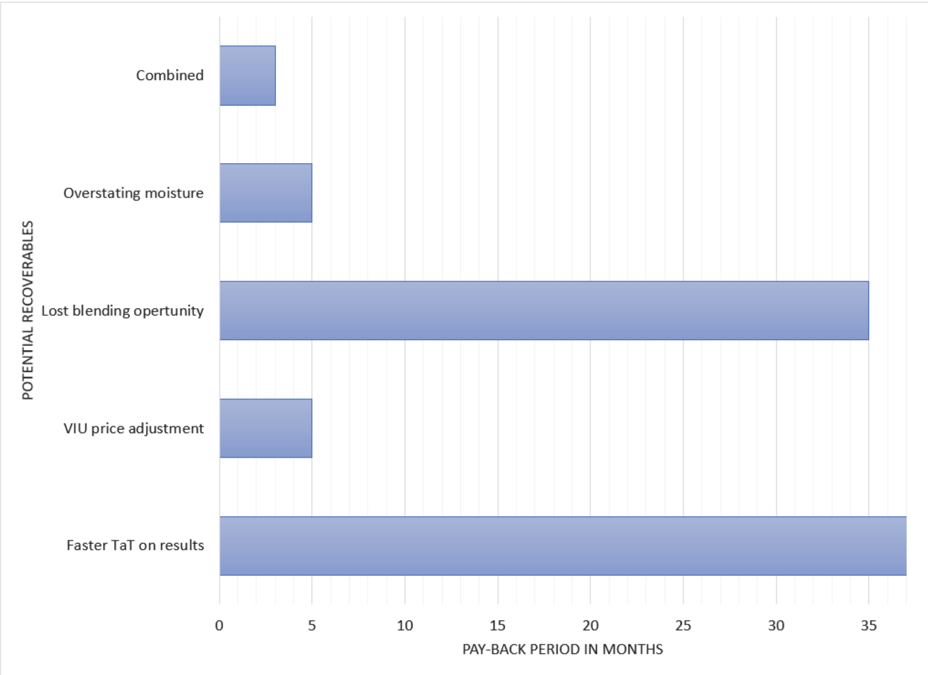

Figure 7: Possible ROI

Consider on 20% of possible profits. It could be argued that these are only a best case potential profits, so this ROI could be unreasonable. But even if it is considered that only 20% of these additional earnings are possible, as per the chart below (Figure 8), a combined pay-back period of less than 11 months is still possible.

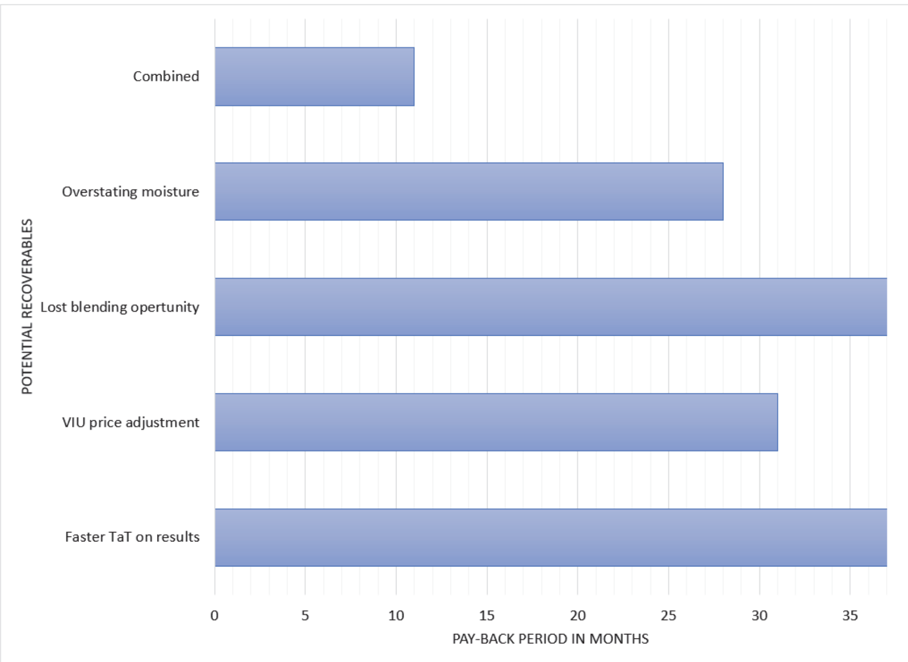

Figure 8: Pay-back period based on 20% of the potential gains

Cost of installing an under designed or unfit for purpose sampling to analysis system

As per table 1 above, it can take well over 3 years to take a sampling improvement project from the problem statement to implementation, especially for a brownfields (existing) facility. Based on the figures above the potential profits not realized in those 3 years could amount to anywhere between US$55 000 000 to US$250 000 000. If the full system, from sampling to analysis, had been better considered at the start of the complete port facility (i.e. when the facility was first installed), and all future upgrades could have been included in these early designs, it could have been possible to bank these additional profits.

Discussion

Pricing methodologies and contractual agreements for Iron Ore and other commodities can come in many forms and are often very complicated. What remains constant, however, is that if the analysis of the grade or product is not accurate and precise the calculated price for this material will be incorrect. In the above example this has been proven using the difference in price between what a poor sampling, sample preparation and analysis system can provide, compared to a well-designed complete end-to-end solution. If, in this case, the supplier/purchaser contract pricing method used was different and perhaps could have been a more traditional contract, with a fixed price for a set grade of ore, then potential profit could still be calculated based on the precision of the results. That is to say, it could be assumed that the supplier sets the grade of the product higher based on the level of precision and confidence that they have in the results. This has a direct impact on the amount of ore that can be sold as “on-grade” and how much “good” ore is lost because it is considered waste when it could have been sold as high grade.

This concept does not only apply to final load out product and could be considered throughout the process chain, from exploration through to final refined product. If each step in the production process can be monitored with a high level of precision, especially if it possible to get these results in real time, this can reduce costs by allow for better control of use of additives, recognise trends resulting in maintenance predictions, finely adjust process parameters in accordance with the results to optimize the overall process, etc. all of which result in better profits.

As seen in the example above (in the section labelled; Scenario requiring a SIP), it is highly critical to consider possible future expansions of the plant when designing the sampling system. If this is not done then either the SPA system will throttle the ability of the plant to produce more or (as in this same example) the plant is expanded without upgrading the sampling system which also has massive “unseen” costs to the facility (a possible US$250 000 000, excluding the time that this problem went un-noticed). It should also be noted that, before a budget is assigned to a sampling improvement project (SIP), by various stakeholders, it is key for these stakeholders to ensure that a suitable business case study is carried out to understand what the potential cost of a “cheaper” system could be on the long-term profitability of the plant. Specifications and KPI’s for the SIP should be based on this study and every compromise to the specified “ideal” system should be well considered against these KPI’s, i.e., if the system is downgraded from the “ideal” how will this affect the KPI’s and will this system still achieve what is expected from it.

Management and executive members often only see sampling and laboratories systems as something to have in place only to satisfy contractual requirements for sale of the product, and therefore assign little thought (and budget) to them. By looking at historic data, looking at where better quality results could have been used to realize additional profits, consider how these better results can be achieved through sampling improvement projects and presenting this in a financial model or business case, there may just be a shift in how these systems are perceived throughout the organization.

Conclusion

It is possible to define the economic benefits of being able to improve precision of results through sampling improvement projects (SIPs). This can be done by comparing the price of product if the precision is high and if it is low. In the real-world example discussed in this paper, a pay-back period of less than 11 months is calculated on a US$13.9M SIP investment (this is considering only 20% of the possible gains are realized). In basic terms, on a 50MTPA operation the revenue received is US$6.6B/annum (based on the Fe price in the example above), the total potential additional earnings, while only 2.4% of this, can add up to over US$84M/annum.

It is also concluded that all systems should be continually monitored and investigations into improvements should be carried out a regular basis. This is critical to ensure that the least possible time is spent operating a system that is not making as much profit as it could be.

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