Developing Process Control Standards for Optimal Plant Performance at PanAust Limited
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ABSTRACT
This paper describes how Brisbane-based PanAust Limited develops process control strategies that are implemented at all operations and are used in functional descriptions for plant upgrades and new projects.

The process control strategies are determined by operating management philosophies designed to maximise returns from the company’s assets.

The approach is endorsed in the project planning and design phases to ensure facilities and equipment that form the major production assets are fit for purpose and capable of enabling the production managers and operators of the projects to maximise shareholder returns.

PanAust’s process control approach has been to develop sets of process control standards which focus on two key areas. The first area covers hardware requirements and architecture, software objectives, control models and individual loop tuning methods. The second area defines control room layout, graphic standards and the alarm philosophy. The application of these standards in a new plant or upgrade decreases the time required to achieve design capacity and optimal performance.

The PanAust process control strategy changes the operator’s role from one that controls a number of individual loops to one that sets the control objectives of the processing plant. To achieve optimal performance, all the process areas of the plant are analysed to identify opportunities to improve throughput, recovery and stability. Once a key opportunity is identified, a process control strategy is developed which defines the objective of the control, its functionality and how an operator will interact with it. After development of the control model the operators assist engineers to test and debug it. Once the model is robust, it can then be duplicated throughout the group and developed as a group process control standard.

INTRODUCTION
PanAust is a copper and gold producer with operations centred on Laos in South-East Asia and a portfolio of growth projects including the Inca de Oro project in Chile.

PanAust’s producing assets are the Phu Kham copper-gold operation and the Ban Houayxai gold-silver operation located in the company’s prospective 2600 km² Phu Bia contract area in Laos. The Phu Kham operation consists of a copper-gold mine and 18 Mt/a concentrator, while the Ban Houayxai operation consists of a gold-silver mine and a 4 Mt/a carbon-in-leach plant. Both operations utilise conventional shovel mining and truck haulage to the processing facilities.

In Chile, PanAust owns the Carmen deposit and holds a majority interest in the nearby Inca de Oro copper-gold project through an incorporated joint venture with Codelco. These assets provide the company with geographic diversity and a base for establishing a copper business in South America, which is the world’s most prolific copper producing region.

PanAust’s key growth activities in Laos include the Kham Tong Lai (KTL) (formerly Phonsavan) copper-gold project and exploration and resource development within the Phu Kham district.

PanAust has recognised the benefits of using process control across all facets of its operations in Laos in order to maximise capital efficiency and asset utilisation. Process control strategies, control method developments, and standards for production control and reporting are applied to existing sites and new projects. The improvement and development of process control has followed a bottom-up approach of getting the right equipment and basic control in place and operating reliably before increasing automation within and between production units. The development of operations strategies and control standards follows a top-down approach based on setting the business objectives and getting production...
management systems in place before designing plant and automating measurement and reporting.

Process control was identified as an operations improvement opportunity in early 2011, and an initial audit and review of plant process control was undertaken in the Phu Kham concentrator. The audit identified that the majority of the control loops were running in manual, and that much of the control and instrumentation design had not been commissioned or correctly installed. The few control loops that were running in automatic were generally tuned in a manner that did not suit process conditions. Historical data storage was both limited and difficult to access, making analysis of control performance inefficient.

The first phase of the bottom-up process control improvement was to enable single loop controllers to operate effectively. The premise was that regulatory, stabilising and advanced control can only be implemented if the instrumentation and basic control is functioning. Once the basic control was operating as required, enhancement with standard techniques such as feed forward, ratio control and dead time compensation became possible.

The second phase was to apply methods of stabilising and advanced control to improve the performance of key areas of the plant such as crushing and grinding, flotation and thickening. Improvements in architecture and data storage systems were also implemented which allowed detailed process analysis to be undertaken over long time periods. The application of advanced control and analysis has led to a reduction in variability in process outputs and disturbance to inputs to downstream units of the process. Where common processes exist between operating sites, the developed advanced control strategies have been utilised, regardless of differences in hardware and software platforms.

The successes of effectively applying improved automation have prompted PanAust to develop process control strategies and standards which will be used for all projects. The strategies are intended to be applied across all production and product logistics activities to integrate and control each link in the business chain to maximise productivity and minimise variability and cost.

**OPERATIONS MANAGEMENT PHILOSOPHY**

The operations management philosophy applied by PanAust is to develop a structured top-down approach to designing and operating production assets, and drive continuous improvement using measurement and analysis, automation, and control along the production chain.

The objectives of the PanAust philosophy are:
- maximising asset utilisation and productivity
- improving reliability of assets and plans
- producing quality product through the supply chain from mining through to final concentrate
- minimising inventories and associated costs
- an emphasis on data collection, process control and production analysis leading to defect elimination and low cost continuous debottlenecking.

Operation of mining and processing production assets requires flexibility in control to balance unit inputs and outputs, for example using milling and crusher metrics to feedback information to mining fleet management systems to ensure blend and capacity targets are achieved. The flexibility must also allow for site-specific operating strategies, for example changing the mining plan over short time periods to improve materials handling or mineralogical issues affecting downstream processing performance and metal output.

The objective of the PanAust philosophy is to continuously optimise and reduce constraints experienced by any of the operating units that are impacting on productivity. If an operating unit becomes a bottleneck and cannot achieve its operating objectives, the control strategy of an upstream process may need to change. Each operating unit must have a flexible set of operating strategies which can easily be implemented. The best solution for the requirement of the day will be selected. Figure 1 shows how information must flow between operating units to enable all units of the operation to be aligned to operational objectives.

The operating strategies encompass not only automation and process control functions, but include all aspects of production management such as drill and blast designs, stockpile and rehandle minimisation, wet ore handling, and feed blending.
SYSTEM DESIGN

Each unit of the process has inputs and outputs clearly defined in measurable terms such as tonnes, rate, particle size, and grade which determine the level of instrumentation required. The strategies within each unit must also be flexible in order to suit the operation’s objectives. For example, the grinding circuit must achieve a specified grind size and can forsake throughput (recovery strategy), or it can maximise throughput at the expense of grind size (throughput strategy). The rougher flotation strategy can be set-up to achieve a specified mass recovery, or a specified concentrate grade. Before the control system is designed, the process objectives and the strategies for control must be defined. The defined control strategy then determines the physical measurements and location of instrumentation, on line sampling locations, frequency and size, assays, data retention, reporting and the control system required.

The same process applies to all functional units of the operation. Using the PanAust standards during design ensures that the appropriate equipment is selected and installed correctly, or that allowance is made for equipment to be retrofitted if site conditions justify it. The detailed requirements ensure the process control will be automated according to the design, and functioning as soon as commissioning has been completed. A number of the control strategies that have been developed contain PanAust intellectual property. To protect this, these strategies will be implemented by a PanAust engineer during commissioning.

Operational control design

The design of the operational control systems enables operations management and production objectives to be met. An example of operational design flow for processing facilities is illustrated in Figure 2. The control design commences following the development of process design criteria, process design, and process flow diagrams. Detailed control designs are then developed for meeting process design objectives, with PanAust-developed standards for control system architecture, software, hardware and reporting.

![Process control design flow chart.](image-url)
used to specify the equipment requirements, control system functional specifications and final design.

The same methodology applies for each production unit, with the control system architecture and software and hardware standards facilitating inter-unit communications.

Integrating all units together during the design phase of a project and using proven control methods to reduce variability in throughput helps to decrease required inter-unit surge capacity, which adds capital and operating costs to designs.

**Equipment**

The PanAust design standards include three broad groups of instrumentation and equipment:

- **Group A** – mandatory minimum equipment for all projects required to meet PanAust control standards
- **Group B** – process specific equipment which is mandatory for some processes but not others
- **Group C** – non-mandatory equipment which may be economically justifiable based on site-specific requirements or not required during early years and installed at a later date.

Group A and B mandatory equipment is included in design from preliminary project study stages. Group C equipment may not be defined or included in design unless it is justified by site-specific requirements. Each process control strategy specifies the instruments required to meet the process control objectives.

Examples of Group A mandatory equipment include fleet management systems and distributed control systems (DCS) or supervisory control and data acquisition (SCADA) systems, weightometers on crusher discharge and mill feed conveying, variable speed drives on pumping equipment, level transmitters on tanks and hoppers, flow and density transmitters on key streams, and metallurgical samplers.

Group B examples include process-specific mandatory equipment such as on-stream analysis for flotation, or on-stream cyanide concentration analysers for gold processing.

Group C non-mandatory examples include particle size analysers which may be justified for primary or regrind processes. The measure while drilling information from drill rigs in the pit provides ore hardness information which can be used to optimise drill patterns and the plants selected comminution strategy.

**Reliability**

A common failing recognised during control standards development, and recorded during the 2011 Phu Kham audit, is that field instrumentation for process control is often not considered critical, and receives a low maintenance priority because it doesn’t actually stop the process. The result of degrading field instrumentation is increasing operator input and a movement toward manual control which increases process variability.

The accuracy, availability and consequence of failure for each measurement and instrument necessary for control must be specified during design according to the impact on controlled outputs of rate and quality. This will determine the types of instruments installed, whether built-in redundancy is required, and maintenance criticality.

Reliability and performance is achieved by selecting fit-for-purpose and high quality equipment, and then correctly installing, calibrating and maintaining it. Control models are designed with instrument failure considerations in place. If an instrument fails, the control model should adapt to the loss of a measurement and not respond with inappropriate vigour. Difficult to maintain equipment such as semi-autogenous grinding (SAG) mill load cells can be backed up with bearing oil pressure transmitters to ensure control is maintained, otherwise redundant equipment may be justified to keep critical control functions operating.

**Control rooms**

PanAust operations were initially controlled by local plant control rooms. The main control rooms were located at a central position near the grinding circuit, and operators were an integral part of the process control system by walking the plant. At Phu Kham the crushing and flotation circuits were controlled from small control huts, with operators spending time out in the field and coming back to make control adjustments. The disadvantages of local control are that each production unit is run independently with minimal interaction with other production units, even within the process plant. The frequent changes to ore blends were often a surprise, and control was reactive. Benchmarking of other operations showed that significant advantages were achieved with a common central control room. Both Phu Kham and Ban Houayxai now run central control rooms with mining and processing controlled from a central room where the mining fleet management system and processing plant control systems are located. The centralised control facilities are designed to enhance communication between business units and enable holistic operations control and reporting. Figure 3 shows the Phu Kham centralised control room, located within the administration building providing access to all production units and allowing direct interaction between mining and processing operators and supervisors. At future operations, the use of remote control rooms is being considered to avoid the costs of transporting and accommodating operators.

All operator interfaces are being re-designed in accordance with abnormal situation management guidelines (Bullemer et al, 2009). The guidelines use very few colours in the operator interface and bright colours are reserved for abnormal conditions only.

The PanAust process control standards specify the layout of a control room, the extent of control from the control room, the manner in which human machine interface (HMI) graphics will be implemented and the level of plant observation via closed circuit television and the reports required.

**FIG 3** – Phu Kham central control room.
Proving the top-down approach
During the increased recovery project at Phu Kham (Bennett, Crnkovic and Walker, 2012), the PanAust process control design standard was applied. The control functional description supplied during project engineering and procurement was modified to describe the specific functionality required of the control system. This was used to design the program and provide specifications for selection, required location and installation of all instrumentation. The specific functionality description was then used as the basis for the control systems factory acceptance testing.

This was the first PanAust project where all the control functionality was designed, commissioned, tuned and functioning by the time project commissioning was completed in April 2013.

OPERATIONAL SYSTEMS OVERVIEW
Data collection, storage, and reporting were identified as an operations improvement opportunity in 2010 during the Phu Kham 16 Mt/a upgrade project, when it was found that accessing historical operating data to develop the project design was cumbersome. To drive continuous improvement, key operating information must be readily available to all levels of personnel within the operation, enabling performance analysis, and effective planning and management control.

Operation data and information
All essential sensors must be in place at the most fundamental level to gather data about mining and process plant equipment. This data is then used to control the plant and individual pieces of equipment. The data from the equipment will be used to control the process and the information from the various processes will be used for planning within the operation. Finally, the information from the operation will be used by the business for its planning needs, as shown in Figure 4 which is based on the international standard IEC 62264 for enterprise-control system integration. Improvements since 2011 include implementation of a standard operations historian system which allowed improvement in metallurgical accounting and process analysis, and downtime analysis and maintenance systems.

This hierarchy relies on suitably selected instrumentation, analysers, sensors and actuators installed in the field. It also relies on effective communication links between the equipment in the field at Level 1 through to the business systems used in Level 4. Only relevant data is passed to the next level. The fewer the number of communication links and protocols in place, the easier the system is to implement and maintain. A reputable data historian has a large number of interfaces available and will efficiently store large volumes of data which is critical for the link between Level 2 and Level 3. The single repository of data simplifies the task of performing cross-functional analysis between various business units of the operation.

**FIG 4** – Operational data flow.
Currently at PanAust the mining and laboratory information is stored in separate databases and the Ban Houayxai and Phu Kham processing plant information is stored in the operations historian. Downtime and production reporting third-party applications are used to summarise the operational data, converting it into meaningful information to be used as a single point of truth by various departments within the operation and by the business. Spreadsheets are used to run one-off analyses that are not required for routine reporting or on a continuous basis. Figure 5 indicates the actual simplified data flow diagram for PanAust operations.

**PLANT PROCESS CONTROL DEVELOPMENT**

The 2011 process control internal audit at Phu Kham identified that most control loops installed during the original plant DCS programming were being run in manual, and that only a few of the loops that were running in automatic provided the intended process control performance. The main reason for loops being in manual was the poor performance of installed instrumentation and control elements; in particular flow metres and control valves.

The bottom-up approach to process control improvement was adopted, because without the measurement devices in place and functioning correctly, process control is not possible to implement. This is demonstrated in Figure 6 where the bottom of the pyramid represents field instrumentation which measures process parameters (such as flow, level and density) and control elements (such as valves and variable speed drives) which are used to manipulate process variables. If the base elements have any shortcomings in performance and reliability, this will flow up the hierarchy preventing higher levels from functioning as intended.

The stabilising and regulatory layer covers single loop controllers such as level or flow loops. In some cases these loops are enhanced by using techniques like feed-forward and dead time compensation. The advanced control combines a number of single loop controllers into a control model, which controls a complex operating unit such as a SAG mill. The advanced control level normally makes use of model based, model predictive, rule based or fuzzy logic control. Holistic control is an extension of advanced control; it combines a number of units together such as fleet management and crushing, or grinding and flotation, and determines each unit operating objectives to optimise production outcomes for the operation.

This approach was applied in each area of the processing plant, starting with the crusher. The rationale being that by reducing variability at the beginning of the process, performance of the downstream units will be improved. In some areas the single control loops and regulatory control loops provide adequate process control, while in others holistic control is required.

The success of this approach prompted the development of PanAust’s process control strategy, which uses integrated holistic control to manage the overall performance of all processes from the mine to the final product. The operator sets the daily operating objectives determined by business objectives and current operational constraints.

Prior to 2011, the control room operator would be given a set of regulatory loop set points or ranges as a guide to achieve the plant’s shift objectives or targets. The operator would continually re-evaluate the set points to ensure the plant performance was within the required range, as well as monitor the performance of the regulatory loops. In effect, the operator was an integral part of the process control system, which leads to considerable control variability both within and across shifts as operators are distracted and change.

By lifting the level of automated control through reliable data acquisition and control of the process, the operator is removed as an input to regulatory control decisions and is only required to monitor the performance of the advanced controllers, thereby ensuring they are not constrained. Elevating the role of the operator requires the processing plant to be effectively and reliably automated, and the operator interface designed to increase the operator’s situational awareness of the plant.

Starting an operation with the best control methodologies develops a culture that accepts and uses automation and control. Introducing advanced control methods during
an operation’s life cycle requires waiting for windows of opportunity, and a high level of change management input and operator training to avoid operator ‘pushback’ in adopting the new methods. All of these steps increase the time necessary to achieve control benefits, and without significant resources applied to bedding in the advanced control, the operation will quickly return to the former state.

**PROCESS CONTROL EXAMPLES BY PRODUCTION UNIT**

Since 2011, PanAust has developed a number of advanced control models for operational units and processes. These models are continuing to evolve and grow to advanced control. This section briefly describes PanAust’s current implemented control models.

**Fleet control and reporting**

A fleet management system is deployed at the mine to monitor individual pieces of equipment and optimise asset utilisation. All major pieces of mining equipment are monitored and controlled by the fleet management control system located in the central control room. The fleet management system is integrated with the processing plant for ensuring crushing plant is not waiting for ore, and ore characteristics are fed forward to the concentrator in real time.

**Crushing**

The objective of the crusher control strategy is to move the ore through the crusher to the coarse ore stockpile as quickly as possible, without overloading any piece of equipment, whilst achieving the particle size distribution required by the grinding circuit.

The crusher can be set-up to achieve the required particle size distribution and forsake throughput by closing the closed side setting or maximise throughput by opening the closed side setting.

The crushed ore vault for gyratory crushers must have a reliable level sensor, and the crushed ore conveyor must be fitted with a weighmeter that is located as close as mechanically possible to the crusher feed or discharge apron feeder. The crushed ore weight controller will make use of dead time compensation. At Phu Kham, the controller is used to control the loading rate onto the overland conveyor to ensure the maximum rate is maintained but the belt is not overloaded, which has improved conveyor availability through reduced spillage and belt damage.

The mining fleet management system will receive information from the crusher indicating the current throughput and status of the crusher including bin levels. This information is used to assist decision-making for the mining fleet.

**Grinding control**

The PanAust grinding circuit control strategy is to maximise throughput, while achieving target product density and particle size into the rougher flotation banks. Achieving one of the grinding circuit’s objectives often comes at the expense of other objectives. The operator must be able to select the objectives required.

PanAust operations are SAG and ball mill (SAB) circuits. The PanAust SAG mill control model will vary the SAG mill feed rate and speed to maintain the required mill weight set point. The optimal mill weight is set according to mill volume, with compensation made for liner wear.

The SAG mill feed-rate is used as a feed-forward signal to the first rougher cells level controller.

The 13 MW Phu Kham SAG mill is used in a standard SAG and ball mill configuration as described by Crnkovic et al (2009), with the SAG mill pebbles recirculating to SAG mill feed. Initially the only automatic loops installed were SAG mill tonnes feed rate and water addition. The operator would continually adjust the feed rate set point, mill speed, and SAG mill density to control the SAG mill weight. The feed...
rate controller did not provide a stable output, and would oscillate if the operator changed the set point or the speed ratio between the two feeders located under the coarse ore stockpile.

The key criterion to achieve good SAG mill control is to have stable and fast acting control of the feed rate. During initial model development, the weightometer output was found to have a 60 second lag filter. This was removed, the feeder ratio control logic changed, and dead time compensators included, resulting in a fast acting, stable feed rate controller.

The SAG mill weight control model is designed to hold the mill weight at a set point input by the operator by controlling the SAG mill feed rate and mill speed. The dynamics of the SAG mill were identified by using the methods defined by Zhu (2001), where the behaviour of the process is used to identify dynamic response, rather than derivation from first principles. The analysis used historical data from all set point changes the operators had made over a six month period. The behaviour of the mill in response to changes in mill speed, feed rate and mill density variables under different conditions was analysed to develop the control model for the SAG mill. The control model was implemented in January 2012, and only required minor tuning changes before gaining operator confidence. The utilisation of the model was tracked by the DCS and recorded in the historian to ensure the reasons for turning off the control model could be reviewed with the operator responsible.

An analysis of the performance of the Phu Kham SAG mill control strategies was performed by comparing two 24-hour periods before (November 2011) and after (February 2012) the control model was implemented, with data being logged every five seconds. Due to changes in ore characteristics over short periods at Phu Kham, the measure of performance used was coefficient of variance, which is the standard deviation value as a percentage of the mean value.

Prior to implementation of the control model, the SAG mill weight tended to drift across a broad range as shown in the Figure 7 frequency histogram. The average mill weight changed from 348 t to 420 t, while the standard deviation from the average weight reduced from 32 t (9.2 per cent coefficient of variance) to 11 t (2.6 per cent coefficient of variance), indicating a significant improvement in control.

The SAG mill power shown in the Figure 8 frequency histogram demonstrates the improved power draw control with reduced deviation from the mean. Prior to implementation of model control, the mean power was 8010 kW with a standard deviation of 600 kW (7.5 per cent coefficient of variance). Afterwards, SAG mill mean power draw was 11 861 kW with a standard deviation of 300 kW (2.5 per cent coefficient of variance). The reduced standard deviation was again an indication of improved SAG mill control.

The SAG mill control system throughput performance review indicated that the throughput average of 1750 t/h with a standard deviation of 207 t/h (11.8 per cent coefficient of variance) was achieved prior to implementation of the model based control as presented in the feed rate frequency histogram in Figure 9. The feed rate increased to 1888 t/h with a standard deviation of 124 t/h (6.6 per cent coefficient of variance) afterwards.

**Flotation**

The specific objective of any part of a flotation circuit is to maximise recovery at a specified grade. The controlling variables can change according to the type of ore being treated, so the control model must provide allowance for both variation of inputs and variability of inputs. On-stream analysis (OSA) and flow and level instrumentation form a critical part of automating a flotation circuit. The design must ensure that slurry samplers are located appropriately, mounted in a position suitable for the type of sampler used to get a representative sample, and be easily accessible for maintenance. Flow and level transmitters must be fit-for purpose, reliable, and routinely calibrated and maintained.

Froth velocity control in roughing is by cell level, and froth velocity control in cleaning is by air injection.

**Rougher flotation control**

Immediately following commissioning of the Phu Kham increased recovery project (IRP) which expanded the regrind
and cleaning capacity of the plant, as described by Bennett, Crnkovic and Walker (2012), the PanAust rougher control model was developed. The IRP converted the flotation circuit from selective roughing, 38 micron regrind of rougher concentrate, and selective cleaning to a low selectivity, high mass recovery roughing, 20 micron regrind, and selective cleaning strategy. The control model objective was to maximise rougher copper recovery through maximising and stabilising rougher mass recovery up to the limit of regrind and cleaner circuit capacity.

Initially the instrumentation on the roughers was rectified as air flow metres and level sensors were incorrectly calibrated, and a number of level control dart valves were not functioning correctly. The rougher circuit control was stabilised by splitting the range of the two dart valves, applying feed forward control between cells, and improving pH control following improvement methodology adopted at Telfer as described in Baas, Hille and Karageorgos (2007).

The multi-input, multi-output (MIMO) rougher control model makes use of the correlations between froth velocity and mass and water recovery, such as described by Runge et al (2007). OSA readings, froth depth and air injection rate variables are also used to control the mass recovered by the roughers. Volume recovery is used in the control model as a proxy for mass recovery. The operator enters the required froth velocity and air injection profiles through the rougher banks, minimum cell froth depths, and the volume of rougher concentrate set point. The control model then determines the optimum froth depth and air injection rate for each cell to achieve the required rougher concentrate volume.

With the improved rougher circuit stability the impact frother has on the circuit became apparent. A correlation between frother, froth velocity, froth depth, air injection rates and copper recovery was identified which is used to control the amount of frother added to the first cells of each rougher bank.

An analysis of the performance of the Phu Kham rougher circuit was conducted by comparing a five day period from July 2013 (before implementation) and March 2014 (after froth velocity control was implementation) and finally May 2014 (after frother addition control was implementation). Data was logged every five minutes.

Prior to implementation of the control model, the volume recovered by the roughers tended to drift across a broad range as shown in Figure 10. The average volume recovered by the roughers was 1317 m$^3$/h with a standard deviation of 253 m$^3$/h (19.2 per cent coefficient of variance). This was increased to 1415 m$^3$/h with a standard deviation of 157 m$^3$/h (11.1 per cent coefficient of variance). An indicator of the success of the control model was the reduction in spillage in downstream regrind and cleaning stages, with amount of time the regrind cyclone hopper level overfl owed reduced from 3.8 per cent to 0.3 per cent of operating time.

The rougher control model review also indicated that the metallurgical performance of rougher flotation had improved. Prior to implementation of the model, an average rougher tailings grade of 0.13 per cent copper with a standard deviation of 0.03 per cent copper. This was reduced after model implementation to an average rougher tailings grade of 0.10 per cent copper with a standard deviation of 0.02 per cent copper, as shown in Figure 11.

By automating the frother addition and limiting the amount of copper tonnes fed into the circuit to below 14 t/h the rougher tails grade was further reduced to 0.08 per cent copper with a standard deviation of 0.013 per cent copper, as shown in Figure 12.

CONCLUSION

PanAust has identified that process control across all facets of its operations is able to maximise capital efficiency, production, and asset utilisation.

Process control strategies, control method developments, and standards for production control and reporting are applied to existing sites and new projects, regardless of process and site-specific differences in control hardware and software. The development of operations strategies and control standards is following a top-down approach based on setting the business objectives and getting production management systems in place before designing plant
and automating measurement and reporting. Developing standard process control strategies and specification of the equipment and instrumentation required for control during design has proven to realise production benefits almost as soon as commissioning has been completed.

The improvement and development of process control has followed a bottom-up approach of getting the right equipment and basic control in place and operating reliably, before increasing automation within and between production units. By effectively applying advanced control models to individual units of a plant, the variability in their measurable outputs has been reduced. This allows each unit to maximise productivity and run consistently to the physical and quality constraints of the production units. The reduced variability in each processing unit has been demonstrated to improve the performance of all downstream units.

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