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Operations Strategy Formulation:
Shifting from Grasberg Open-Pit Surface Mining to Underground Mining

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ABSTRACT

PT Freeport Indonesia has decided to alter its mining operations from open-pit mining to underground mining in Grasberg. A change of mining area focus directly affects its related departments, and even need new operations strategy to address the transition. Considering its long-term run of mining operations, its strategic issues are assessed by using Slack and Lewis operations strategy model, and decisions are made through the Quantitative Strategic Planning Matrix (QSPM) tool. Previously, the assessment of company's current business and corporate strategy was conducted by applying SWOT analysis and complemented with the Strategic Factors Analysis Summary (SFAS) as the point-of-reference of the operations strategy.

Mine Electrical Maintenance (or Mine Electrical) is a new department, under the Mine Maintenance Division, PT Freeport Indonesia (PTFI). It was a joint force of Grasberg and Underground Electrical sections. According to mine production forecast released in early 2011, the Grasberg open pit mine was planned to continue until 2017, due to very limited ore left to be mined from the surface that makes it uneconomical and to some extent: unsafe. The ore-body will then be mined from below through underground. It has brought challenge to Mine Maintenance that is responsible for all maintenance activities of equipments operating in both surface and underground mines, and mainly Mine Electrical the unit of analysis in the project, as it has to prepare resources to face the focus shifting properly.

The department has to formulate a strategy in order to face this transition smoothly, operational-wise and manpower-management-wise, because while adding people to the underground is a

must, support to surface mine production cannot be abandoned either at all the sudden. Balance is the keyword for successful transition as hiring too many employees to fill underground slots will create another problem when Grasberg eventually closes as there will an excessive workforce around than needed. There will be decision-making on how this manpower requirement can be fulfilled without causing other operation suffers; how to better managed all equipment-related works and service requests in a more advanced but easy-to-handle system that will ensure target-budget conformity and easy tracking for both customers and maintenance crews. There is also issue about the lack of proper Key Performance Indicator (KPI) to measure the service-based works, causing the departments difficult to improve that dimension of its tasks. Bottom line, Mine Electrical management has to set up a long-term operations strategy in order to make a smooth transition of its operations aligning it with PTFI management mission, objectives and the ever-dynamic circumstances of commodity market, while at the same time taking significant efforts to improve particular dimensions of its performance.

Operations strategy reconciles market requisition with operations resources in the form of decisions pattern that shape long-term capabilities of the operations (Slack and Lewis, 2008: 18). The aims of this project are to provide clear steps for Mine Electrical management before, during and after the transition period, to assess overall capacity required by operations and the way to fulfill it, to assess the condition of current work request management system and recommendation for improvement and to assess the issue regarding proper KPI to measure service-based works. In the following, after assessing PTFI current business and corporate strategy using strategic management model presented by Wheelen and Hunger (2008), operations strategy formulation started with business issue exploration and analysis to have better understanding and come up with alternative solutions. Using the pro-contra analysis and Quantitative Strategic Planning Matrix (QSPM), each alternative would then be assessed to find the best one that will serve as the operations strategy. It would be followed by detail implementation plans complete with estimated timeline and person in charge during the execution.

Company Profile

PTFI is a copper and gold mining company located in Papua, the easternmost province of Indonesia. It started operation in the country after signing Contract of Work (COW) with Government of Indonesia in 1967. PTFI is owned by Freeport-McMoRan Copper & Gold Inc. (FCX) which holds 81.28% of its shares, the GOI (9.36%) and PT Indocopper Investama (9.36%). FCX is the world's largest publicly traded copper company. Based in Phoenix, Arizona, United States, the company mines geographically diverse, long-lived reserves of copper, gold and molybdenum. It performs operations through some major affiliates: PTFI, Freeport-McMoRan Corporation and Atlantic Copper.

Right now, PTFI applies two mining techniques, open-pit (surface mine) and underground. Crushed ore from both areas is transported to the mill trough a series of conveyor and ore passes. Combined crushing techniques are used, including the use of Semi Autogenously Grinding (SAG) and Ball Mill to crush ore to become very fine grinded sand. Next, there is flotation process using reagent, an alcohol and lime-based chemical, to separate concentrate containing copper, gold and silver, where these minerals will float to the surface and then skimmed-off as final product. The remainder of the rocks that doesn't have economical value, the tailings, will settle at the bottom of the flotation cell as sediment, and will be released through river flow to the Modified Ajkwa Deposition Area (ModADA) in lowland area. As for the concentrate, it will flow from the mill to dewatering plant in Amamapare port through a 110-km-pipeline. It will then be stored and shipped to smelters around the world.

Although Grasberg open-pit mine is currently the biggest contributor to PTFI production output, it is expected to continue only until end 2017. Thus, the future of the company will lie on the underground mines. Other than DOZ and Big Gossan that's already in production phase, there are the GBC, Deep Mill Level Zone (DMLZ) and Kucing Liar that are currently in development. These mines are presented in Figure 1.

The unit of analysis in this project is Mine Electrical Maintenance, which has the responsibility to perform maintenance works on electrical equipment (or electrical-side of equipment) and provide service to various customers in the form of new/additional electrical installation, electrical wiring/function modification, moving/removing, part replacement, troubleshooting and engineering design/drawing. Major equipments under Mine Electrical is shown in Table 1

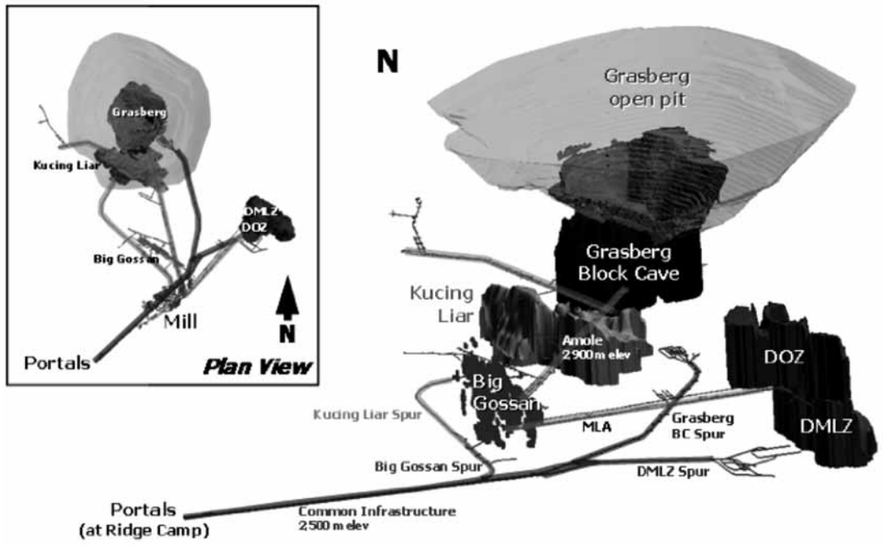


Figure 1. PTFI Mine Ore Bodies

Table 1. Mine Electrical Major Equipments Responsibility

Equipments	Area	Quantity
Shovel	GRS	12
Drill	GRS / UG	75
Gen Set/Compressor	GRS / UG	49
Over Head Crane	GRS / UG	64
Switchgear/Ring Main Unit (RMU)	GRS / UG	38
Substation/Load center/Transformer	GRS / UG	161
Loader	UG	144
Haul Truck	UG	271
Rock Breaker	UG	26
Ore Chute	UG	30
Ventilation Fan	UG	210

Equipment-based maintenance activities are raised according to routine schedule set in system called Ellipse and then trigged by a certain period or operating hours, inspections result or breakdown events. These kinds of activity mostly are preventive maintenance (PM) and reactive maintenance (breakdown). Service works are created based on user/customer requests or ongoing projects. In total number and duration, service work orders are almost equal to those equipment maintenance ones, with a ratio reaches 48:52. This characteristic has made Mine Electrical different from most of departments in Mine Maintenance division. For both surface and underground areas, the role of the department is critical to provide electric power and maintenance service to equipments, buildings, shops and lightings.

METHODS

The research method used is a combination between the strategic management model presented by Wheelen and Hunger (2008) and operations strategy model introduced by Slack and Lewis (2008). The desired final output is the operations strategy and implementation plan for Mine Electrical in response to the shifting of mining focus from Grasberg to underground mines. The strategic management model will be used to derive corporate strategy and business strategy which will serve as guidance and reference for the operations strategy developed later.

Analysis began with environmental scanning: external and internal environment. External environmental scanning was done using Porter's Five Forces and PEST analysis. Internal environment scanning tries to analyze organization's structure, culture and resources. The results of this scanning will be used as the base of SWOT analysis complemented with the use of Strategic Factors Analysis Summary (SFAS). Next, there will be review and assessment of company's current mission, vision, values and objectives. This stage is important to compare between target and resources because strategy is a comprehensive master plan that states how the corporation will achieve its mission and objective by effectively manage environmental opportunities and threats in light of corporate strengths and weaknesses (Wheelan and Hunger, 2008: 14 & G-9). Output of this stage is formulation of corporate strategy and business strategy. Beckman and Rosenfield (2008: 17) state that "corporate strategy identifies the industries and markets in which a firm will compete". It is usually categorized as growth, stability or retrenchment. "Business strategy is competitive and cooperative strategies that emphasize improvement of the competitive position of a corporations' products or services in a specific industry or market segment" (Wheelen and Hunger, 2008: G-1).

The next step will be formulating functional strategies, based on the corporate and business strategy. In this project, the scope is only operations strategy. As mentioned before, model developed by Slack and Lewis (2008) was used in this stage. This model is shown in Figure 2. Content of operations strategy is mainly about an interaction between operation's performance objectives and the decisions that need to be made regarding its resources, processes and capabilities. In this project performance objectives are determined by upper management target and influenced by the corporate goals and also from customer needs. Competition is non-existence neither does market positioning, since Mine Electrical is a department in a company. Performance objectives will refer to what the model offers: quality, speed, dependability, flexibility and cost. Operations decision areas are concerned with the capacity, process technology and development and organization.

After all problems in each decision areas were analyzed, several alternatives solution will be offered. All alternatives will then be elaborated and also analyzed to better understand the pros and cons of each. Decision will then be made using the Quantitative Strategic Planning Matrix (QSPM). "QSPM is a strategic tool which is used to evaluate alternative set of strategies. The QSPM

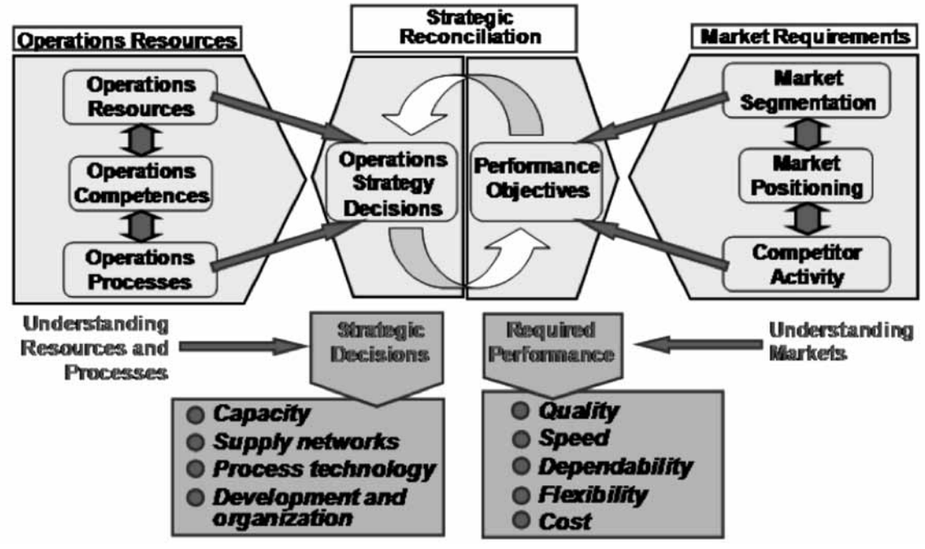


Figure 2. Operations Strategy Model by Slack and Lewis (2008)

combine the intuitive thinking of managers with the analytical process to decide the best strategy for the organization success." (www.mba-tutorials.com, 2009). Key factors used as comparison parameter were the performance objectives. The weight for each key factor was determined from historical data and discussion with several key team members. Then, each of the alternative solution was rated by its influence to the key factors, and an Attractiveness Score (AS) was given. The range for Attractiveness Score is 1 = not attractive, 2 = somewhat attractive, 3 = reasonably attractive, 4 = highly attractive. Total Attractiveness Score (TAS) is the product of weight and AS. After all examinations are done, the Sum Total Attractiveness Score (STAS) is calculated and alternatives solution with highest STAS is the one to be chosen.

RESULTS AND DISCUSSION

Business and Corporate Strategy

Assessment of PTFI current business and corporate strategy started with external and internal environmental scanning. PEST analysis and Porter's Five Forces were used to analyze external factors then combined with the internal situation analysis in the SWOT and SFAS. Summary of PEST analysis is shown in Table 2, while summary of Porter's Five Forces analysis is given in Figure 3. Important points include:

- Indonesia's volatile and unstable political situation provides risk to PTFI operations. Political instability might lead to company's property destruction and interruption of activities.
- Company's revenue is highly influenced by production output and commodity prices. Copper price averaging $3.42/lb during 2010, ranged from $2.76/lb to $4.42/lb. Gold reached $1,500/oz on third week of April.
- Copper has been benefited from the emergence of India and China as the next industrial countries.

Table 2. PEST Analysis PT Freeport Indonesia

Political -Legal	Economical
Uncertainties in Indonesia's political situation.	Fluctuative but increasing commodity prices
New Mining Law that might affect the current COW	High demand of copper from industrial countries, especially China
Constant protest and demonstration on PTFI existence in Papua	Instability of foreign currencies
Complex and evolving environmental law	Limited non-renewable energy sources
Regulation on greenhouse gas emission and climate change	Increasing inflation rate from end of 2010
	US debt condition
Social	**Technology**
Unrest among community after numeruous shooting since 2009	Not many breakthrough in mining techniques developed in last decade
Sporadic terror from separatist groups of Free Papua	
Illegal panners	Technological developed vastly for mining support activities such as remote control, automation, high capacity/capability equipments
Most of the local tribe in nearest area still illiterate	
High number of malaria and HIV/AIDS case in Papua	
Local and national media coverage of PTFI operations	

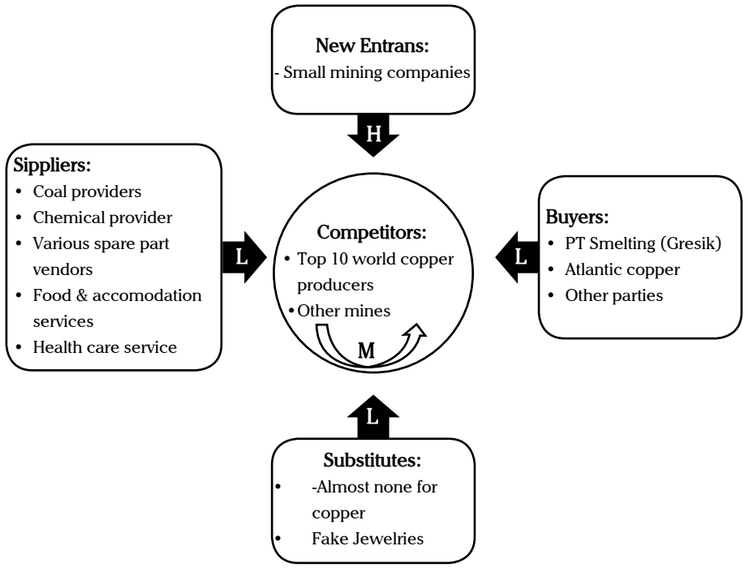


Figure 3. Porter's Five Forces Analysis for PTFI

Table 3. FCX Selected Financial Ratio

Financial Indicator	2010	2009
Current Ratio	2.62	2.48
Quick Ratio	1.64	1.49
Assets Turnover	65%	58%
Profit Margin	29%	23%
Return on Assets	19%	14%
Return on Equity	38%	33%
Dept Equity Ratio	1.02	1.42

- Since mid July 2009, there have been 12 shooting incidents inside PTFI COW area causing 5 casualties that has led to unrest within community.
- Mining techniques haven't gone far for the last decades, causing no significant breakthrough occurs and usually just small production improvement.
- Top 10 copper producers are comprised 50% of total worldwide copper production. FCX ranked second among these firms with 9% contribution.

Internal environmental scanning result highlights include:

- From FCX selected financial ratio shown in Table 3, it can be seen that 2010 has been an improvement year compared to 2009, especially due to the increase in copper and gold price.
- PTFI site is one of the safest mine in the world, supported strongly by its concern in safe production. In 2006 and 2010, PTFI succeed in maintaining the fatal rate to zero. One of the biggest challenges to this, workers factor aside, is operation locations, which are located in unusually difficult terrain in a very remote area.
- On the deposit side, PTFI has huge ore reserve that can be mined until the end of the Contract of Work, including the two 10-year extensions. The deposit represents opportunities to stay among the top players of copper and gold industries in the world for years to come.
- PTFI is equipped with high-skilled and experienced employees, combined with strong motivated freshmen as the next generation of the mine operations. It provides broad range of development programs for its employees, complemented with offsite training programs whenever required.
- PTFI has several key Corporate Social Responsibility (CSR) programs as stated in FCX 2010 Form 10-K (2010: 28):
- job training programs
- basic education programs
- public health programs (including malaria control)
- agricultural assistance programs
- small and medium enterprise development programs
- cultural preservation programs, and many others.
- PTFI also participated in Partnership Fund, where it provide one percent of its annual revenue for development programs aimed at local people. PTFI contributed $64 million in 2010, $59 million in 2009 and $34 million in 2008.
- Some less supporting facts about the operations and area including: only one land road available from lowland to highland and from highland to mine area. Any disruption to part of the road will lead to halt of material and employee transportation and even the halt of operations. Underground mine manpower requirement ramp-up also means that proper and adequate accommodation available for all employees and contractors, which currently still significantly lack of capacity.

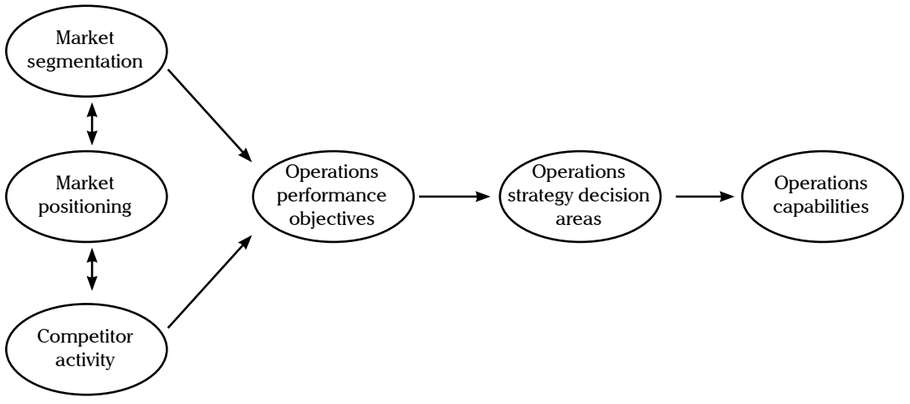


Figure 4. The Allignment of Operations Resources with Market Requirements

The SWOT-SFAS analysis of PTFI is shown in Appendix 1. Assessing mission, vision (IR Guidebook, 2009: vii – viii) and objectives of the company and comparing them to the SWOT-SFAS result, showed that they are still in line with the situation in which the organization is presently facing, external and internal. So, there's no requirement to revise them to adapt to the current environment.

Recalling PTFI mission and vision about being "the lowest-cost" copper producer, indicates the company's intend to choose lower cost as its competitive advantage. Also, since copper is a common commodity and PTFI sells to numerous smelting facilities, the competitive scope is broad. Thus, the business strategy that suits the company best is cost leadership.

While for corporate strategy the most logical directional corporate strategy that PTFI will choose is Growth. There are huge opportunities to produce higher revenue due to market condition. Combining this momentum with PTFI internal strong resources, organizational capabilities and especially ore deposits, there's big probability that the plan will go on successfully. According to Wheelen and Hunger (2008: 169), "a company can grow horizontally through internal development or externally through acquisition or strategic alliances with other firms in the same industry". For PTFI, horizontal growth means developing its internal resources, in this case the ore deposits, by investing capital to improve the capabilities of the productive mines and perform development projects in the future underground mines (DMLZ, GBC, Kucing Liar).

Operations Strategy

Every operations has objective to align market requirement and operations capability. This alignment is called "fit", or approximate balance between required market performance and actual operations performance (Slack and Lewis, 2008: 228). The alignment can be approached in two ways, first by identifying current market requirements and then align the internal operations resources; second by understanding resources and processes and identify core capabilities and then seek market opportunities that align with those capabilities. The flow as discussed by Slack and Lewis (2008: 232) is presented in Figure 4. Note that it is only for the first approach that will be used in this project.

The Slack and Lewis model derives market requirements from market segmentation (customer needs), market positioning and competitor's actions. In Mine Electrical case, market positioning

and competitor's actions are not applicable. Customer needs defined as all items required by the customers which are performance target from the upper management set to the department and all dimensions of customers' requests. List of customers with their needs is shown in Table 4. As for Mine Electrical, the performance is measured by certain parameter targets which are availability, Mean Time between Failure (MTBF), KPIs (five of them) and also target of other department that it supports. All of these targets are shown in Table 5. In terms of supporting production targets of Surface Mine and Underground Mine division, as mentioned before, Mine Electrical has vital role in providing power to equipments, buildings and workshops, also in performing maintenance work on the equipments. For example, to achieve 154,000 tpd target in surface mine, the department, in this case surface power distribution section, plays important part in ensuring that electric power available through transmission lines from switchgears, to substations, from substations to electric shovels. The section also responsible to connect and disconnect trailing cable from substation to shovels whenever they plan to move or relocate, to maintain the switchgears and substations and to repair/ perform service to trailing cables. The electric shovel section is responsible to the availability of the shovels by doing routine maintenance and troubleshooting. Dispatch system maintenance technicians are responsible to the smooth operation of the dispatch system components: the display, the communication network, etc. It is a complex work and involves different sections in Mine Electrical and also different departments in Mine Maintenance, to accomplish the preset target.

Analysis of current operations resources capabilities:

- Experienced workforce, 51% of employees have more than 10 years, 41% of those have 15 years or more of service.
- Excellent process know-how especially for old equipments and tasks. Years-of-experience in performing similar projects and maintenance on same equipments has developed in-depth knowledge and skill required and the team has improved the learning curve. There's challenge though to upgrade the knowledge and skill especially to new and updated systems and equipments through training and hands-on experience.
- Close relationship to customers.

Table 4. Mine Electrical Main Customers' Needs

Main Customers	Needs
Mine Maintenance Management	Availability, MTBF, KPI
Surface Mine Division	Production target, regular requests, safety
Underground Mine Division	Production target, regular requests, safety
Loading and Support Mtc Dept.	Availability, regular requests, safety
Haulage, Welding & Tire Service Dept.	Availability, regular requests, safety
Underground Mechanical Mtc Dept.	Availability, KPI, regular requests, safety
Concentrating Division	Production target, availability
Human Resources and Industrial Relations Dept.	Regular requests, safety
Management Information System (MIS) Dept.	Regular requests, safety
PT Redpath Indonesia	Production target, regular requests, safety
Central Service Division	Project target, regular requests, safety
Quality Management Services Departement	Regular requests, safety
Supply Chain Management Division	Regular requests, safety

Table 5. Availability, KPI and Customers' Target for 2011

Availability/KPI/Department	Target
Electric Shovels availability	88%
GRS Electric Drills availability	80%
Switchgear/Substation/Load Center availability*	98%
Service Tram #1 availability	92%
Service Tram #2 availability	95%
UG Electric drills availability	83%
UG Remote Loaders availability	80%
Rock Breakers and Loading Points ava	85%
Ventilation Fans availability	85%
KPI #1 - Scheduled Work Order Compliance*	80%
KPI #2 - PM Schedule Compliance	90%
KPI #3 - Planned Work Order Raised*	60%
KPI #4 - PM Effectiveness*	85%
KPI #5 - Actual Man Hours for Planned Work*	60%
Surface mine	154,000 tpd
UG - DOZ Mine	80,000 tdp
UG - Big Gossan Mine	2,500 tdp
UG - DMLZ Mine	1334 m/month

- Strong support from vendors and manufacturers. PTFI is considered as major customer by vendors and manufacturers due to its buying power and purchase volume. Mine Electrical has advantage of this condition because suppliers tend to give more serious attention on the department needs and requirements.
- Adequate operational budget. Annually, in total, there's adequate operational budget available to be used for maintenance process: for the equipments and for the crews.
- Support of proper tools. PTFI provides a wide range of tools ready to be ordered by each department requires from the warehouses. In case a special tool is needed, they can be acquired through direct charge process from suppliers.
- Access to new technology updates and information. Frequent updates of what is happening in the industry, is required to keep the team well-informed and make adjustments as necessary.
- Ability to adjust schedule and resource requirement. One of the challenges of performing PM is the ability to execute it on schedule. Operational priority often gets in the way to accomplish this. Team ability to adjust to the issue and appropriately re-assign crews and resource to other location and task.
- Good reputation among customers. Beside the fact that the department is the sole service provider of all electrical-related work orders in the mine, it is also known for consistently delivering good results and service to the customers. This information is gathered from feedback of customers through emails or supervisors.

The performance objectives demanded from

Mine Electrical by customers in priority order are speed, quality (including reliability), dependability, flexibility and cost. On the other hand, management sees quality as the higher priority. Speed and quality are the most important things especially when dealing with the production groups, because they always going for the production target, which is the ore. This fact revealed based on the feedback from customers and interview with Mine Electrical Manager, Agung Hariyadi, on 10th March 2011 as quoted below:

> "One of the disadvantages in carrying out our duty is the fact that our task still considered as non-core business although in reality our role is inseparable to the production chain. The core is ore. So it's a bit hard to be professional in terms of bringing the best quality to our work. Our clients opt for speed and flexibility, while our management asks for reliability (quality and dependability)… Cost is not a big concern at this point. As long as you can justify each of the expenditure, the money is there to spend. Also, so far, customers almost never complain about the cost they have to spend to buy materials and spare parts or to fund their projects."

Aspects to be considered from each performance objective are:

- Quality: the specification conformance between planned/requested and actual delivered, the conformance to standard/reference, and the reliability of work result.
- Speed: the time required for PM on equipment to be executed, the total time required to repair equipment/installation and the total time to complete a project or work request.
- Dependability: the difference between promised completion time of work given to customers and the actual completion time.
- Flexibility: the ability to change the variety of product and services, the level of the operation's aggregated output, and planned or assumed delivery dates.
- Cost: any financial input to the operation that enables it to produce its products and services: operating expenditure, capital expenditure and working capital (Slack and Lewis, 2008: 41).

Capacity Strategy

Capacity strategy is defined as "the set of decisions concerned with how operations configure and change their overall capacity in order to achieve a particular level of output potential" (Slack and Lewis, 2008: 69 – 70). Main focus would be the decision on overall level of operations capacity, because the number and size of sites, the location of sites and capacity change were either not a significant issue or already predetermine by the department. Overall capacity is analogized as the total manpower required running the operations, because Mine Electrical is in the business to provide services. The number then will be distributed based on the how many manpower required for each equipment in each area.

As reference, this project will use data forecast of equipment requirement in both surface and underground mines. Each component of the forecast has certain ratio that can be used to convert equipment number to manpower number. For baseline calculation, the number and ratio used for year 2011 will be used as comparison. As Grasberg open-pit mine will last until 2017, calculation will cover manpower requirement up to that year. Manpower distribution will also refer to the current organization chart added with necessary adjustment for each year. Number of equipments forecast and men/machine ratio for each equipment are shown in Table 6. The number of manpower required for non-equipment factors is dynamic, subject to mine development or activity decrease in the respective areas, but as comparison, 2011 figures will be used. Current ratio used is shown in Table 7. Actual manpower requirement for each of the non-equipment category was assessed by calculating type and number of job per day, manpower required per job and duration needed to perform each job. End result was the proper manpower number per shift. Assumption used was that the work roster

Table 6. Equipment Forecast and Men/Machine Ratio

Equipment	Man/Machine Ratio	2011	2011	2013	2014	2015	2016	2017
		Units	Units	Units	Units	Units	Units	Units
Axera 5	0.5	1	0	0	0	0	0	0
Axera 7	0.5	28	31	30	29	30	30	30
Axera T08-290	0.5	6	5	5	5	5	5	4
Axera T08-360	0.5	5	6	7	7	7	7	5
Cubex	0.5	8	8	8	8	4	4	8
Robolter 5	0.5	3	7	5	4	4	4	4
Cabolter 7	0.5	5	5	5	5	5	5	5
Solo 7-15	0.2	3	5	5	9	13	14	14
Compressor	0.2	12	14	16	20	20	20	20
Main Fans	0.1	22	22	22	24	24	24	24
Auxiliary Fans	0.03	188	188	200	200	240	240	240
Welding Machine	0.05	45	60	60	60	60	60	60
Hi-Vac	0.2	1	2	2	2	2	2	2
Lighting Plants	0.2	2	2	2	2	2	2	2
Fixed Crane	0.1	28	31	34	38	38	38	38
Rockbreakers	0.3	26	26	28	32	32	34	38
Ore Chutes	0.2	30	30	32	34	34	42	46
Remote Control Loaders	0.5	10	10	12	12	12	12	12
36 Ton Locomotive	1.5	6	6	10	10	10	10	12
43 Ton Locomotive	1.5	1	1	1	6	8	10	12
Battery Locomotives	1.5	0	0	0	0	0	0	4
Battery Stations	2	0	0	0	0	0	0	1
Surface Substation Mtce	0.25	17	17	17	17	17	17	17
SHvl Electrical	2.45	11	11	8	8	4	3	0

would be managed as three shifts per day, consists of four crews (each day, one crew will be on day off schedule). Per shift, effective work hours are seven hours, considering meal break and travel time on early and end of shifts. When required, a steady day personnel could be established to maintain the work better, especially for area where most projects are likely to be executed in during daylight. For groups where troubleshooting are part of their job description, an extra man hours to troubleshoot, 10% of subtotal man hours, is added to the equation. Samples of calculation are given to better explain how the process went, from describing the responsibility of the group, area/equipment of responsibility, average men and duration required for each task to finally come up with the ideal men/shift ratio number.

HV and LV Power Distribution – Maintenance. This group has responsibility to maintain and perform power expansion projects in DOZ. Due to their similarity in working process, the HV and LV power distribution and maintenance groups can be considered as one team. So, there will be 7 crews available per shift. The job description includes:

- Pull and install cable, distribution panel to development areas where electric drills need to operate and other areas where sections of the Underground division works and need electrical power;
- Install, move, relocate, remove, maintain the jumbo box, the drill control panel, that follow the drill everywhere it goes;
- Perform maintenance on the load centers, transformers, switchgears, ring main units (RMU), vacuum circuit breakers (VCB) located in DOZ, Big Gossan, DMLZ, GBC and Kucing Liar on monthly and yearly basis including to handle trouble on this equipments.

Table 7. Manpower Requirement Ratio for Non-Equipment (Current)

Non-Equipment/Area	Required
HV Power Distribution - Maintenance	3 /shift
LV Power Distribution - Maintenance	4 /shift
Fixed Plant - Shops & Lamp Room	2 /shift
Tram, Hoist & Paste Plant	6 /shift
Dispatch, Communications & Instrumentation	6 /shift
Big Gossan Power Distribution	2 /shift
DMLZ Power Distribution	2 /shift
GBC Power Distribution	2 /shift
Expansion Mines Construction	2 /shift
Power lines	6 /shift
Cable Repair	2 /shift
Fixed Facility Mtce	3 /shift
Dispatch technician	2 /shift
Rotation	4 /shift
Planners	5%
Supply Chain Management Division	4%

In average, there are six equipments per day scheduled for monthly preventive maintenance where three persons are required to perform the task in about two hours. Jumbo box related jobs in this area are about six per day, requiring two crews to work in a task that takes averagely three hours (including travel time). Four power expansion projects that take about five hours per job usually handled by three crews. Detail calculation shown below in Table 8. In one day, a total of 146 man hours are required. It is equivalent to 6.9 men per shift (calculated from 146 / 3 shifts / 7 hours). Rounding up to 7 men per shift, it can be seen that the ratio still matched of what the upper management uses.

For the moment, the ratio of 3/shift and 4/shift are adequate for the group. But, considering the ramping up of DOZ production in 2015 to cover open-pit production stop in 2017, there has to be an adjustment prior to that year in term of the ratio. DOZ development activities which require more HV power installation, make it sensible to increase the ratio to 4/shift starting 2015 for HV power distribution – maintenance. The result of this calculation through year 2017 is presented in Table 9.

Tram, Hoist and Paste Plant. The main responsibility is to perform preventive and reactive maintenance on each of these plants. Service Tram #1 and #2, at GBT area, have routine PM schedule each week which in average need eight hours and required four personnel to perform. One crew also needed performs shift inspection for about two

Table 8. Required Man Hours for HV and LV Power Distribution

Job	Qty	Crew	Duration	Man Hours
PM	6	3	2	36
Jumbo box	6	2	3	36
Expansion	4	3	5	60
		Subtotal		132
		Troubleshooting		14
		Total		146

Table 9. Manpower Requirement Forecast – HV and LV Power Distribution

Non-Equipment/ Area	2011	2011	2013	2014	2015	2016	2017
	N/S	N/S	N/S	N/S	N/S	N/S	N/S
HV Power Distribution - Maintenance	12	16	16	16	20	20	20
HV Power Distribution - Maintenance	16	16	16	16	16	16	16

Table 10. Required Man Hours for Tram, Hoist and Paste Plant

Job	Qty	Crew	Duration	Man Hours
Tram PM	0.14	4	8	5
Hoist PM	0.05	5	10	3
Tram Inspection	3	2	2	12
Hoist Inspection	3	2	3	18
Paste Plant	1	8	7	56
Projects	1	3	7	21
		Subtotal		115
		Troubleshooting		12
		Total		127

hours. The Big Gossan Hoist is scheduled for PM every three weeks, performed by five crews for ten hours. Similar to the trams, shift inspection by one crew is also performed for two hours. In both areas, electricians also perform building and shops electrical installation inspection and maintenance duty. Paste plant on the other hand is still under construction and will be commissioned in mid of May 2011. Separate study shows that as many as 2 crews per shift added with 2 persons in day shift will be adequate for the paste plant. The calculation is presented in Table 10. The result shows that 6 men/ shift is required for a group.

Table 11. Manpower Requirement Forecast – Tram, Hoist and Paste Plant

Non-Equipment/ Area	2011	2011	2013	2014	2015	2016	2017
Tram, Hoist & Paste Plant	32	32	32	32	32	32	32

Table 12. Number of Work Requests in Selected Period

Periode	Jan-Nov 2010	Jan-Apr 2011	2015e
Total number of work request	25,000	9,000	43,000
Average per day	77	78	118
Average per shift	26	26	39

Forecast through 2017 is shown in Table 11. In the forecast, other than six crews per shift, eight personnel have been added to the equation to represent the need of steady day crews in paste plant and trams. Because although Table 2-19 shows plenty of time still remain in each day (12 man hours), the fact that these plants are located separately (trams at GBT, hoist and paste plant in Big Gossan) makes it difficult for the team to switch area quickly or move to other site to provide support when problem occurred. With additional steady day crews, it is hoped that projects can be executed during day shift, so shift crews can focus on maintenance duty. These plants are planned to still be operating under the same condition as today by 2017. There will be no changes in the functionality or major modifications on the system that will require additional manpower. Thus, from 2011 to 2017 the total manpower will be flat at 32 personnel. Calculation summary of manpower requirement for equipment and non-equipment category is presented in Appendix 2.

Process Technology Strategy

The issue that is closely related to the increased volume of jobs in underground mine areas and in need of the touch of technology is handling of the abundant work requests in both surface and underground mines. Based on historical data, during the year of 2010 (up to 17th November), Mine Electrical planners have processed about 25,000 work orders, equivalent to 78 work orders per day or 26 per shift. During January to April 2011, the number still range at average 77-78 work orders (total 9300). It is estimated that with DOZ mine development and production, Big Gossan mine development and production, DMLZ and GBC development occurs simultaneously in 2011 to 2014, and will be added with DMLZ production kick-off starting 2015, total number requests per day that has to be managed will increase significantly by about 50% in 2015. It equals about 120 work requests per day, 40 per shift, or double the capacity one planner can handle. These numbers presented in Table 12. By April, work requests from underground area make about 56% of total request received during 2011.

Without the overload situation, the current system already has several flaws:

- high involvement of manual data input (by user, planner, engineering, action team)
- high redundancy (same email has to be forwarded several times)
- lost of information still occurred due to no feedback from action team after work has been done, planner forget to update status etc.,

causing incompliance or severe delay
- high possibility of double record and double work order raised from the same email information

What the current system tries to achieve basically is the uniformity of customers' request through one door, which is the planner, to prevent back-and-forth communication between users and field supervisors, the lost or lack of information due to each party's dependence on the others to maintain those information, the delay in execution due to wrong-directed information and to ensure that all requests are stored, maintained, reminded, updated and reported regularly. User will submit request using standard form, fill in the mandatory field and send the form back to planners. Planners will then verify the data, record in the database and raise work order. All fields in the database have to be filled in manually by planners with correct corresponding information, thus opening more possibility of fault or mistyping leading to the incompliance or delay.

Currently, the task of raising daily work order is handled by the shift planners, one person per shift, that have average ability to process about 15 to 20 work orders, subject to the complexity of each work orders, because some might need spare parts to be completed while others might need no parts; some might located in hazardous area where pre-work communication with area owner is required while others might located in nearby shops. For the moment, shift planners only available for underground area. For surface mine, due to very limited resources, all planners are on steady day basis, manage PM, inspection and corrective maintenance work orders, also manage the part inventory.

Development and Organization Strategy

To make good improvement actions, an organization needs to have indicators to measure its performance properly and accurately. At the moment, there are five KPIs used in Mine Maintenance division to measure each department's performance. The current KPIs are on equipment fleet vs. owner base, a condition where all equipments are mapped to a certain owner, and it is the assigned-departments' responsibility to achieve the target.

These KPIs can't recognize other sections' contribution, although in reality most of the equipments successful maintenance programs are result of collaborative acts of several departments. The worst disadvantage for Mine Electrical happens in underground. Underground electrical KPIs are calculated only for equipments they "owned": switchgears, load centers, RMUs, VCBs, and transformers, while their work and dedication in performing maintenance for rock breakers, loading points, electric drills, ventilation fans, compressors, over head cranes, service trams, hoists and many others will not be recorded as their achievement, but rather it will contribute positively to the owner of those equipments. For example, every time a drill is on PM schedule, mechanic and electrician work together on the machine. Automatically, out of whatever KPI achievement is, 50% contributed by the electrical group. The similar thing applied for KPI Actual Man Hours for Planned Work. Say, PM work orders contribute about 60% of the total work order of the drills. Then for the manpower works on PM activities alone, electrical group contributed about 20% – 30% of the KPI achievement. Unfortunately, for this issue it is impossible to be repair, because system (Ellipse) limitation, where for one equipment, there can only be one reference for each of the KPI. Modification has suggested, to change the KPI from equipment-based to work-group-based, to have a system better and fairer in describing a department's true performance.

The most important thing to be addressed is Mine Electrical service works performance indicator. As far as the Mine Electrical management concern, five KPIs implemented has failed to measure most of the department's service-nature duties, because the object has different characteristic from other equipments that are maintained by the rest of maintenance departments. There is a KPI to measure Scheduled WO Compliance (was Backlog Compliance), that suppose to describe how many of the scheduled works within period X that are completed also during period X. To be considered as "planned work", a work order must be raised before period X starts, maximum at 18:00 on X – 1 day. The time frame is shown in Figure 5.

This is where the weakness of the logic lies, because any work order raised within period X to be executed during the same period (and comply), will be considered as unplanned, thus will not be counted in this KPI. In fact, this event will decrease department achievement on KPI Planned Work Order Raised. But actually the case is, when discussing about service work, the important thing is not whether it is planned or not, but more like the service level or service quality, such as: responsiveness, reliability, assurance that reflected in customer's satisfaction. In reality, a customer might ask for a service early in the morning to be done in the evening or in the next day or even in the next month. System limitation that strictly differ planned and unplanned work due to KPI parameter requirement may be unable to accommodate new KPI in service works. Not only that the creation of new KPI will enable the fairer and better judgment of Mine Electrical performance, it will also increase the moral of the crew, because they will feel that their hard work in the field is appreciated in a more appropriate way and it will encourage them to do better in the future.

MANAGERIAL IMPLICATIONS

Proposed Solutions

The overall capacity of Mine Electrical operations is determined by the number of equipment and the size of area that require their services. There are gaps, first in the current fulfillment between the approved manpower requirement and actual in the field, and the second in the increase of underground area manpower and the decrease of surface area manpower. Manpower number is very important to ensure that adequate resources available for all the teams to be able to achieve their targets. First option to be considered is to fill the gap with new hires and do lay-off as necessary; Second option will be to fill the gap with local contractor/regular employee provider; Third option will be to fill gap with professional/skilled contractors; Fourth option is to relocate manpower from Grasberg open-pit area to underground mines area as per manpower requirement.

The decision of work request management system is important because good strategy at this point of time will influence the performance of the whole group during the transition period. Because half of the department's working load is the service-type jobs where success factors include: information quality, responsiveness, dependability and the service quality itself. With the high level of manual handling in the current system, a vision of process technology usage on the issue should be considered. To improve performance in the long run, there are three alternatives that can be selected: As-is condition, using the conventional system

Figure 5. Time Frame of KPI Data Acquisition

using standard form in spreadsheet and email as main communication channel; Collaborate with Management Information System (MIS) department to develop online call center/work request management system; Develop new web-based and database system by internal resources using existing tools.

The presence of proper performance indicator will enable an organization's performance to be described and measured fairer and better. This point of time is critical to make the decision, because proper KPI will also help management of Mine Electrical and also Mine Maintenance to have better view of the performance and determine work requirements in the future. First solution to consider is to maintain the as-is condition, using only the five KPIs and measure only for jobs related to equipments. Second solution is to modify the logic in the current KPIs to accommodate service-based works. Third, new KPI created with parameters derived from a known standard to measure service level or service quality or other common standard for service organization.

In the QSPM, weights for each performance objective were determined from data and discussion with key members, resulting with the following: quality (30%), speed (25%), dependability (20%), cost (15%), and flexibility (10%). There was also risk of loss sales opportunity cost that should be considered, derived from one draw point inability to produce in a day ($64,123 – note: there are 125 active draw points) and one shovel failure to operate in a day ($788,199 – note: there are 20 shovels). Results of analysis are shown in Table 13.

In this project, the decision taken is to combine alternatives 3 and 4 into one integrated strategy, which is by using the skilled contractors to fill in the current manpower shortage, and subject to contractor's performance, also for the upcoming years while manpower relocation will be more used to cover the dynamic decrease and increase of manpower requirement in surface mine and underground respectively. Having analyzed the department's objectives and situation, they are in line with contracting goals, presented by Levitt in The Handbook of Maintenance Management (2009: 121), which are to get maintenance work executed at higher quality, faster, safer or at lower cost than it would be possible with own resources; allows organization to maintain profit margins during downturns as contractor's people can be sent home without severance or adverse publicity; and to concentrate talent, energy, resources into core competencies area.

Dependability, speed and quality are very important factors of the online call center. With the system implemented, data lost can be minimized or even eliminated, thus ensuring that all customers requests, especially ones related to panels, draw points, draw bells and tunnels development, are completed as per required with no significant delays, minimizing also the loss opportunity incurred. Delays in three to five draw points per day can cause loss opportunity of $128,000 to $192,000.

The decision on this issue is mainly focused for the long-run operations of the department. Most users might be satisfied for how Mine Electrical provide service to them, but such acknowledgement is very hard to quantify if it's based only on person-to-person communication between supervisors in the field and it's also hard to present it as evidence of performance without the proper system to accommodate it. So, the decision to create new KPI should be welcomed by the team, because it will give them a target and reference on how to provide service in the future to the customers. All results were then mapped to the operations strategy matrix presented in Appendix 3.

In the capacity strategy, hiring skilled contractors will increase the quality and speed of the workforce significantly because this decision enable department to cut the time required on people development. The effect to the first two performance objectives is similar from the

decision to relocate manpower from Grasberg to underground, because most of the manpower that will be sent to underground will mostly have more than five years experience thus giving them a good base to broaden the knowledge in underground area. Combined total manpower will provide department with resources as forecasted, making dependability and flexibility easier to achieve. The trade-off is on cost, because skilled contractors require very high fee compared to other alternatives. This fact fortunately is counterbalanced by option 4, where almost no cost will be incurred. Overall, this decision should able to improve performance in the future.

In the process technology strategy, the use of more advanced information technology (IT) for work request management system in the form of online

Table 13. Pros-Cons Overall Capacity Alternative Solutions

No	Alternatives	Prerequisite	Pros	Cons
1	New Hires and Lay-Offs	External manpower resources pool	fres and strong motivated new employees	Extended cost and time for hiring especially for training
		Good mutual agreement terms	manpower requirement independence on each area	Cost of Compensation
				Complaints from the fired employees
				Hard to find skilled freshmen
2	Local Contractor	Reliable manpower providers	Averagely lower cost	Low skill and experience
			Provider usually have many manpower resources ready to work	Training required for safety, area-specific tools and equipments, trade
			Providers already have had contracts with PTFI	Most of the contractors asked to be transfered to PTFI
				User still have to deal with employment-related matters
3	Skilled Contractors	Proven and qualififed manpower contractor	Qualified and experience workforce	Higher fee
		Long-term contract to ensure the supply of manpower	No more training time required except for safety-related	
			Users only deal with job assignment; employment deal by contractor management	
			Unlikely to ask for PTFI employee status	
4	Manpower Relocation	Comprehensive area specific work training to prepare manpower from Grasberg	Employees already accustomed to department's culture and environment	Not all employee willing to be relocated to underground
			No so many training needed	Lack of motivation due to saturated feeling in long-serving employees
			No extended cost for hiring/ firing	

Table 14. QSPM of Alternative Solutions for Overall Capacity Strategy

Criterion	Weight	Alternative I		Alternative II		Alternative III		Alternative IV	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS
Quality	0.30	2	0.6	1	0.3	4	1.2	3	0.9
Speed	0.25	2	0.5	2	0.5	4	1	3	0.75
Dependability	0.20	1	0.2	2	0.4	3	0.6	3	0.6
Cost	0.15	2	0.3	4	0.6	1	0.15	4	0.6
Flexibility	0.10	3	0.3	2	0.2	2	0.2	3	0.3
STAS			1.90		2.00		**3.15**		**3.15**

Table 15. Pros-Cons Work Request Management Alternative Solutions

No	Alternatives	Prerequisite	Pros	Cons
1	As-Is Condition	Not needed	Internal team and users are familiar with the system	Too many manual handling of information
			No extended cost needed	Events of information lost
			No development time required	Unnecessary data flow redundancy
				Different dara handling/treatment
				Back-and-forth question from user
2	Collaboration with MIS	Approval of MIS and Mine Maintenance management	Proven system in order departments	Additional time and cost for development
		Feasibility study of the current condition	Many features for future development	Socialization phase internally and to users
			User can check status by their own	Development time depend on other department's resources
			Infrastructure is available	
			Standard process flow	
			Minimal human intervention regarding data input	
			Most users already familiar with similar call centers by other departments	
3	Develop system internally	Comprehensive skill and knowledge in IT	Customized to the needs of the department	Hard to estimate development time as internal resources don't have proper skill and experience
			No need to depend on other department's resources	More time needed to repair the bug
				Users still need time to accustom to the new system
				Socialization phase internally and to users

Table 16. QSPM of Alternative Solutions for Work Request Management

Criterion	Weight	Alternative I		Alternative II		Alternative III		Alternative IV	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS
Quality	0.30	2	0.6	1	0.3	4	1.2	3	0.9
Speed	0.25	2	0.5	2	0.5	4	1	3	0.75
Dependability	0.20	1	0.2	2	0.4	3	0.6	3	0.6
Cost	0.15	2	0.3	4	0.6	1	0.15	4	0.6
Flexibility	0.10	3	0.3	2	0.2	2	0.2	3	0.3
STAS			1.90		2.00		**3.15**		**3.15**

Table 17. Pros-Cons KPI Alternative Solutions

No	Alternatives	Prerequisite	Pros	Cons
1	As-Is Condition	Not needed	No time and cost required for new KPI development	Inability to represent service-based works
				Inability to measure true performance
2	Modification of current KPI	Discussion of responsible parties to find opprtunities for logic modification to accommodate service-based works	Some parts of the service-based works might be covered	Due to modification of existing system, not all the required parameter can be covered
			System ready to be used	
			Almost all people alread familiar with current KPIs	Modified calculation logic might impact to other department's KPI translation
3	Create new KPI	Approval from Mine Maintenance management	Represent true performance	KPI Development and perfecting requires time
		Task force to handle project or give responsibility to OpEx team	Cover all aspects required to measure service organization performance	Socialization to all team involved
		Comprehensive study/ understanding of some standard in the world	Act as reference for future decision making	

Table 18. QSPM of Alternative Solutions for KPI

Criterion	Weight	Alternative I		Alternative II		Alternative III	
		AS	TAS	AS	TAS	AS	TAS
Quality	0,30	2	0,6	2	0,6	4	1,2
Speed	0,25	2	0,5	2	0,5	3	0,75
Dependability	0,20	1	0,2	2	0,4	3	0,6
Cost	0,15	4	0,6	3	0,45	2	0,3
Flexibiity	0,10	1	0,1	2	0,2	1	0,1
STAS			2		2,15		2,95

web-base call center will have positive effect on quality (better service quality; complete information leads to higher conformance of request), speed (user-friendly menu makes it easier for user to submit request; simple process and approval flow with minimal data redundancy makes it easier for planners to process the request), and dependability (complete request data including user-proposed required date enable planner and action team to estimate job duration better and when required, update that information to reschedule work under users approval).

For KPI, it is important as the first step toward improvement process. Continuous improvement based on the weekly KPI will impact mainly to quality, speed and dependability. All those will be traded-off with cost for KPI creation and development. No definite impact on the flexibility.

Implementation Plan

Detail implementation plan is given in Appendix 4. Resources required during this phase are:

- Cost to hire skilled contractors is very high, but it is expected that they can provide high quality works. From two company references available, Mine Electrical has to pay between $901,047 to $1,414,217 in a year to fulfill about 43 current vacant positions. These contractors will be given the task in power distribution in both areas that requires skilled, tough and speedy crews to cope with the high expectation from customers.
- Manpower relocation from Grasberg to underground requires minimum cost. Cost incurred will be for underground-specific PPE (caplamp, Savox, respirator). A small team of staff planners is needed to manage the relocation.
- Collaboration with MIS to develop Mine Electrical Online Call Center requires assigned person from department and a technical expert, as the contact persons to MIS. Internal resources will be needed then, to run the system (call center officer), train the people and conduct socialization. An estimated cost of $6,000 will incur as the cost to MIS department.
- Development of new KPI for service works requires a formation of task force, with assigned person from Mine Electrical involve in it, together with OpEx team and Maintenance Engineering staff. No cost will incur because OpEx have their contract PTFI paid as a package. An estimated $6,000 will be required for MIS to merge with existing online KPI.

CONCLUSION

In this paper, strategy formulation of Mine Electrical department was performed using operations strategy model of Slack and Lewis (2008). The need of new strategy itself was trigged by shifting of mine focus from Grasberg open-pit centered to underground mines. Business issue exploration confirmed the three issues surfaced needed to be taking care of due to their impact to long-term operations. The availability of adequate manpower based on requirement forecast is important as the main resource to perform daily tasks and achieve performance target. While for work request management, a reliable, trusted and user-friendly system is required to improve quality, speed and dependability of the works requested by customers. Minimum error and processing time can also increase job completion and avoid delay that might lead to loss sales opportunity at PTFI level. The existence of proper performance indicator is mandatory for an organization to benchmark its performance to a certain standard that in the end will make ways for improvement actions based on the KPI result.

The project though still has room for further study, for example for skilled contractor's database. More than two samples will increase the competition and with appropriate bid process, Mine Electrical might get a better price offer. The paper limited the scope of decision on KPI only to whether creating new one or not. There's opportunity in the future to assess options of what reference or standard that can be used. In the future, during the transition period, when there's need of another strategy change, there's possibility that supply network (out of scope in this paper) become an important decision area, especially regarding to the availability of the Top 50 and Top 100 critical part in Mine Electrical. ■

REFERENCES

Beckman, S., & Rosenfield, D. (2008). *Operations Strategy: Competing in the 21st Century.* New York: McGraw-Hill/Irwin.

Boric, J. (2011). *Investing in Copper – A Bullish Scenario for Copper.* Retrieved on 30 March 2011 from http://dailyreckoning.com/investing-in-copper/

Freeport McMoRan Copper & Gold Inc. (2011). *2010 Annual Report Form 10-K.*

Hariyadi, A. (2011). Personal interview by Rafiq Sulistyo, Tembagapura: 10 March 2011.

International Labor Organization (ILO), n.d., Act of the Republic of Indonesia Number 13 Year 2003 Concerning Manpower. Retrieved on 11 May 2011 from http://www.ilo.org/dyn/natlex/docs/SERIAL/64764/56412/F861503702/idn64764.PDF

Levitt, J. (2009). *Handbook of Maintenance Management.* New York: Industrial Press.

MBA Tutorials. (2009). *Quantitative Strategic Planning Matrix (QSPM).* Retrieved on 11 May 2011 from http://www.mba-tutorials.com/strategy/230-quantitative-strategic-planning-matrix-qspm.html

PT Freeport Indonesia. (2009). *Collective Labor Agreement 2009-2011.*

PT Freeport Indonesia. (2009). *Industrial Relations Guidebook 2009-2011.*

PT Freeport Indonesia. (2008). *Tour Companion 2009.*

PT Freeport Indonesia (n.d.). *Sekilas Tentang PT Freeport Indonesia*, Retrieved on 3 March 2011 from http://www.ptfi.co.id/about/default.asp.

Slack, N. & Lewis, M. (2008). *Operations Strategy.* New Jersey: Prentice Hall.

Tradingstocks.me (5 January 2011). *World Copper Consumption Supply and Demand in 2011.* Retrieved on 30 March 2011 from http://tradingstocks.me/world-copper-consumption-supply-and-demand-in-2011/

US Inflation Calculator (n.d.). *The Inflation Calculator*, Retrieved on 30 March 2011 from http://usinflationcalculator.com.

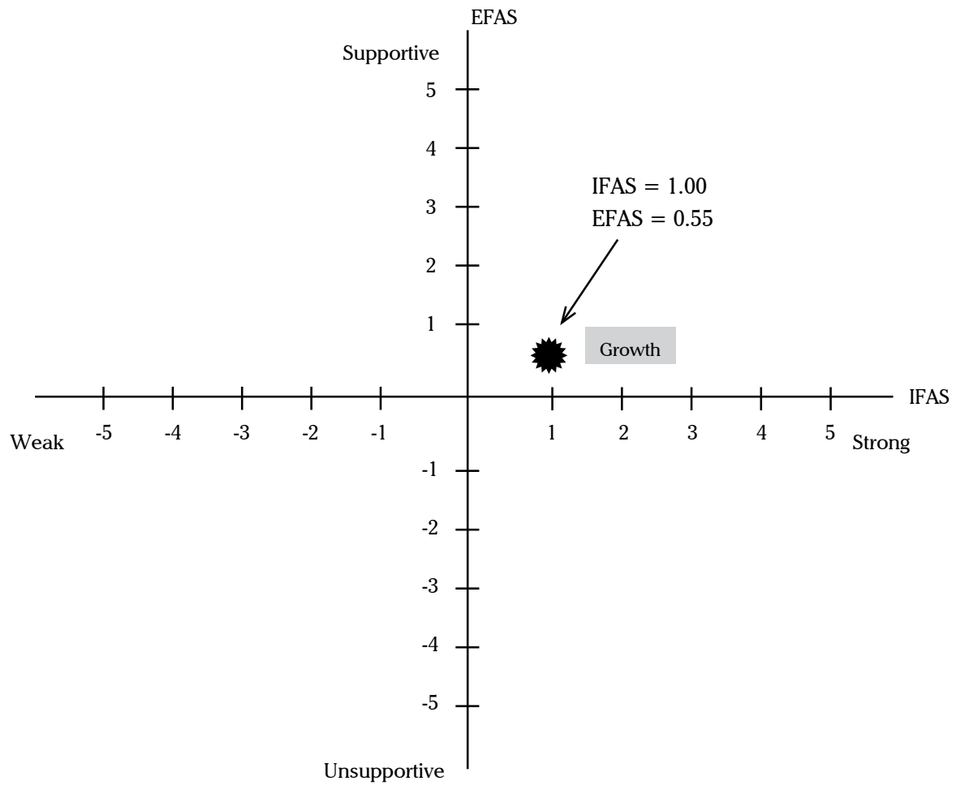
Wheelen, T.L., and Hunger, J.D. (2008). *Strategic Management and Business Policy.* New Jersey: Prentice Hall.

Appendix 1. Strategic Factors Analysis Summary

No.	IFAS	Weight	Rating	Value
	Strength			
1	Strong organization culture: safe production	0,1	4	0,4
2	Huge ore deposits and second-ranked producer in the world	0,2	5	1
3	Lower production cost among similar producer	0,15	4	0,6
4	Skilled employees through competency-based development	0,1	3	0,3
5	Thorough and complete Corporate Social Responsibility programs	0,05	4	0,2
	Weakness			
1	Only one access road available from lowland to mine	0,05	3	0,15
2	Extreme weather condition and remote mining area	0,1	4	0,4
3	Only have maximum until 2041 to conduct production activities	0,1	4	0,4
4	Limited availability of accommodation for new employees	0,05	3	0,15
5	Conditions and obligations in the Contract of Work	0,1	4	0,4
	Total	**1**		**1,00**

No.	EFAS	Weight	Rating	Value
	Opportunity			
1	High commodity prices (steady increase since 2009)	0,15	5	0,75
2	High demand of copper especially from China, US and India	0,15	5	0,75
3	Estimated shortfall of copper supplies in 2011 and 2012	0,1	4	0,4
4	Looming inflation rate	0,1	3	0,3
5	Technology breakthrough in mining support activities and equipments	0,05	3	0,15
	Threat			
1	Indonesia's political, economical and social uncertainties	0,1	4	0,4
2	Sporadic shootings terror to employees since July 2009	0,1	4	0,4
3	Fluctuated commodity prices highly influential to financial results	0,05	4	0,2
4	Environmental issues	0,1	4	0,4
5	Major risks that affect operation directly including natural disasters, accidents, unusual weather conditions, interruption of energy supply, wall failures, rock slides or structural collapse in mines	0,1	4	0,4
	Total	1		**0,55**

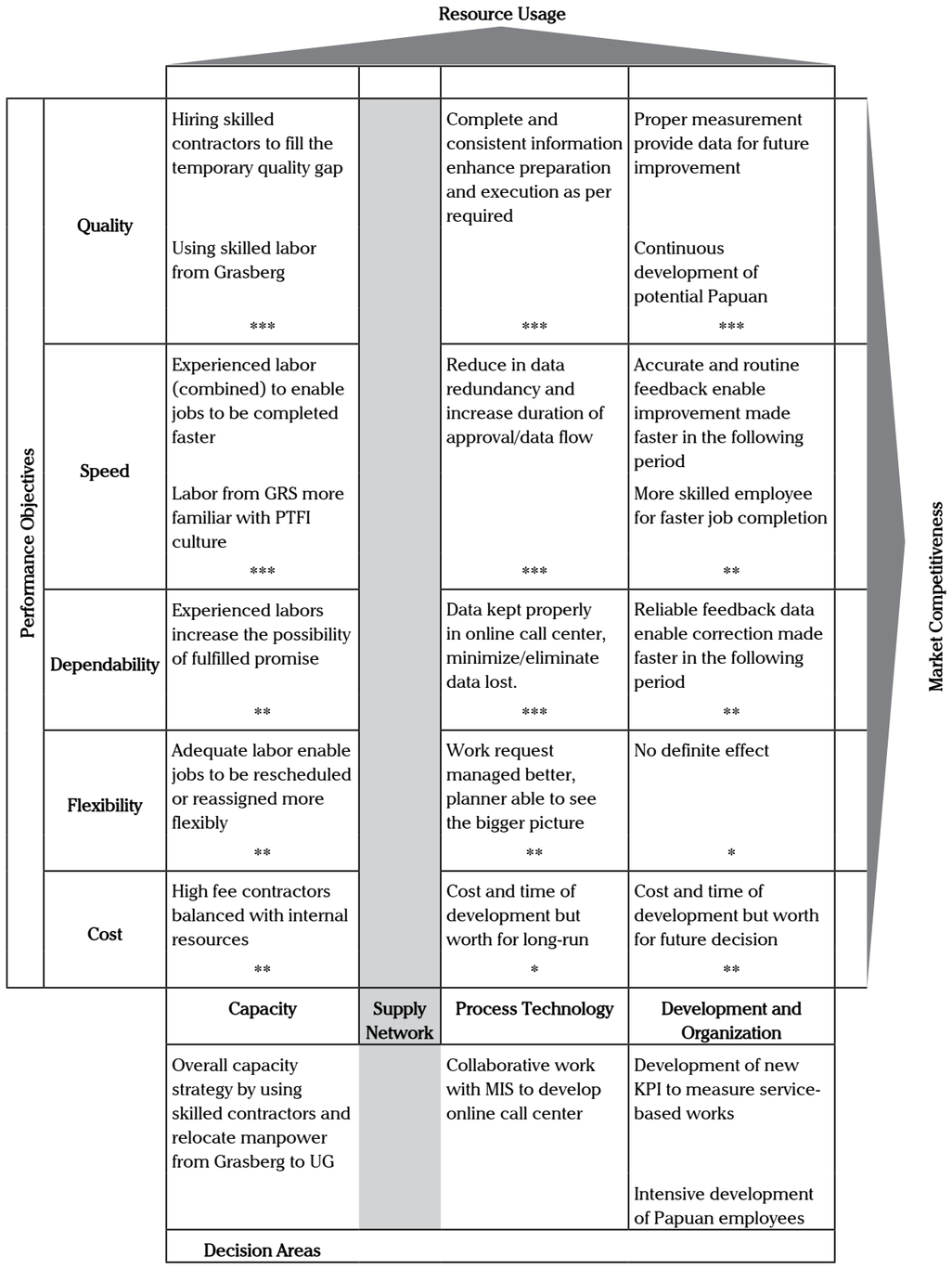
Matrix for Appendix 1



Appendix 2. Mine Electrical Manpower Forecast

Equipment/Group	2011 (actual)	2011 (ideal)	2012e	2013e	2014e	2015e	2016e	2017e
	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
UNDERGROUND ELECTRICAL								
HV Power Distribution - Maintenance	12	12	16	16	16	20	20	20
LV Power Distribution - Maintenance	16	16	16	16	16	16	16	16
Fixed Plant - Shops & Lamp Room	8	8	8	8	8	8	10	10
Tram, Hoist & Paste Plant	28	32	32	32	32	32	32	32
Dispatch, Communications & Instrumentation	27	28	28	28	28	30	30	30
Big Gossan Power Distribution	8	8	8	8	8	8	8	8
DMLZ Power Distribution	8	8	8	8	8	12	12	12
GBC Power Distribution	8	8	8	8	8	12	12	12
Expansion Mines Construction	8	8	8	12	12	12	12	12
Axera 5	1	1	0	0	0	0	0	0
Axera 7	14	14	16	15	15	15	15	15
Axera T08-290	3	3	3	3	3	3	3	2
Axera T08-360	3	3	3	4	4	4	4	3
Cubex	4	4	4	4	4	2	2	4
Robolter 5	2	2	4	3	2	2	2	2
Cabolter 7	3	3	3	3	3	3	3	3
Solo 7-15	2	2	3	3	5	7	7	7
Compressor	3	3	3	4	4	4	4	4
Main Fans	3	3	3	3	3	3	3	3
Auxiliary Fans	6	6	6	6	6	8	8	8
Welding Machine	3	3	3	3	3	3	3	3
Hi-Vac	1	1	1	1	1	1	1	1
Lighting Plants	1	1	1	1	1	1	1	1
Fixed Crane	3	3	4	4	4	4	4	4
Rockbreakers	8	8	8	9	10	10	11	12
Ore Chutes	6	6	6	7	7	7	9	10
Remote Control Loaders	5	5	5	6	6	6	6	6
MineGem Control Room	2	2	2	2	2	2	2	2
Trolley Maintenance	4	4	6	8	12	12	12	12
36 Ton Locomotive	9	9	9	15	15	15	15	18
43 Ton ore Locomotive	2	2	2	2	9	12	15	18
Battery Locomotives	0	0	0	0	0	0	0	6
Battery Stations	0	0	0	0	0	0	0	2
Planners	4	11	12	13	13	14	15	15
Parts Runners	12	8	8	9	9	10	10	11
VAT	30	36	38	40	42	45	47	49
Subtotal Underground	**257**	**271**	**285**	**304**	**319**	**343**	**354**	**373**
SURFACE ELECTRICAL								
Power lines	24	24	22	18	16	12	6	6
Cable Repair	6	8	6	4	4	2	2	2
Surface Substation Mtce	4	4	4	4	4	4	4	4
Fixed Facility Mtce	9	12	9	9	6	6	6	6
Dispatch technician	7	8	8	6	5	3	2	2
Rotation	14	16	12	12	8	8	6	6
Planners	5	5	5	4	4	3	2	2
Shvl Electrical	27	32	32	25	25	15	13	5
Parts Runner/ Facility Mtce	4	4	4	4	3	3	2	2
VAT	14	17	16	13	12	9	7	6
Subtotal Grasberg	**114**	**130**	**118**	**99**	**87**	**65**	**50**	**41**
Total Mine Electrical	371	401	403	403	406	408	404	414
Total Actual Non Staff	328							
Shortage	43							
Delta from previous year - UG			14	19	15	24	11	19
Delta from previous year - GRS			12	19	12	22	15	9

Appendix 3. Operations Strategy Matrix for Mine Electrical



Appendix 4. Detail Implementation Plan

ID	Task Name	Duration (days)	Person in Charge
1	**Hire Skilled Contractors**	**57**	**Agung H.**
2	Search available skilled labor providers	20	Ferry E.
3	Review bids/proposals and determine winner	5	Nano, Dadang, Basuki, Rafiq
4	Create contracts	15	Contracts Dept.
5	Prepare work documents & PPE	5	Rafiq, Andy, Rudi
6	Mobilize contractors to jobsite	2	Andy, Rudi
7	Conduct mandatory safety induction and trainings	10	Andy, Rudi, QMS
8	**Relocate Manpower from GRS to U/G**	**27**	**Rafiq S.**
9	Prepare list of manpower	15	Rafiq, Basuki, Sijabat, Rudi
10	Cross-check data and determine "to" locations	10	Rafiq, Dadang, Jarmanto, Andy
11	Prepare administrative data	5	Andy, Rudi
12	Send men to trainings	10	Andy, QMS
13	Prepare PPE	5	Sudjarwo, Andy
14	Start mobilization	2	Irpan, Sudjarwo, Siswanto, Mulyadin
15	**Collaborate with MIS to Develope Online Call Center**	**67**	**Rafiq S; Gary S.**
16	Gain approfal from Mine Maintenance and MIS Management	3	Agung, Gary
17	Kick-off meeting	1	Rafiq MIS
18	Analyze business process, work group, task catagory, approval flow	20	Rafiq, Gary
19	Review analysis and fine tune all process	20	MIS
20	Program the application and conduct test run	23	MIS
21	Pilot test for limited users	10	Rafiq, Andy, Rudi
22	Conduct internal socialization and training	10	Andy, Rudi
23	Conduct external socialization	10	Rafiq, Gary
24	Launch the Mine Electrical Online Call Center	2	
25	**Develop New KPI for Service Works**	**91**	**Opex Team**
26	Discussion and presentation to upper management	10	Agung
27	gain approval from Mine Maintenance management	3	Agung, OpEx
28	Form task force	3	OpEx, Rafiq, Rizal
29	Further study of available standard for reference	10	Task force
30	Start working on the proposed KPI	20	Task force
31	Socialize to Mine Electrical team	5	Task force, Rafiq
32	Conduct trial	15	Task force, Rizal
33	Integrate new KPI to online KPI calculation	25	Task force, MIS