AES/ RE/ 10-36  The root causes of stope slippage
            at Kidd Mine, Canada

06/ 10/ 2010  Pauline Resoort
Abstract

Kidd Mine has a production target of 2.5 million tonnes of ore per year in 2010. Seventy-five stopes are turned over to the next stope in order to achieve this annual production. Each turnover from stope to stope has an anticipated number of days based on the geomechanical relation between them. Due to the depth and size of the operation, it is crucial that this turnover takes place within the anticipated time to avoid delays in the mining sequence and cycle and set-backs in production. Currently delays in the stope turnover occur, this is called stope slippage. This thesis describes the occurrence and size of stope slippage in longhole mining, presents a system to identify and track the root causes of stope slippage and ranks the root causes of stope slippage at Kidd Mine. A flowchart was created to present the system of identifying and ranking root causes of stope slippage.
Acknowledgements

This thesis is part of the Master of Science program in Mining Engineering at Delft University of Technology in the Netherlands. Xstrata Copper’s Kidd Mine provided the subject for this thesis. This thesis intends to identify, track and rank the root causes of stope slippage at Kidd Mine. Previous analysis on the mining cycle has been done, Kidd Mine has concluded that a further analysis is needed to find opportunities to reduce the gap between the ideal situation and reality. This thesis intends to help Kidd Mine in understanding the reality, find opportunities and suggest paths that may lead to solutions.

I would like to thank Kidd Mine for providing this very interesting topic and facilitating the research and analysis. The underground supervisors were of tremendous help, their stories, inside information, explanations and honesty are invaluable. I would like to thank the superintendents for allowing me to go underground with their crews, for explaining their work and providing me all the information I needed. The mine-engineering department for teaching me all I needed to know about longhole stoping and hard-rock mining in general.

Special thanks goes to Arie Moerman, for all the help, guidance, encouragement and advice. Thank you for sharing a bit of your knowledge with me, for not being afraid to disagree and for believing in me, especially on those moments where my plans and ideas didn’t agree with yours. Your guidance and advice were inspiring and have been a great learning experience for me.

I would also like to thank Shannon Campbell for the inspiration you provided and the chances you gave me, Steve Black for keeping me on my toes, Gertjan Bekkers for many practical things.

Thank you to Ir. Hans de Ruiter, Prof. Charles Pelley and Dr.-Ing. Ludger Rattman for their feedback and support.

And last but not least a big thanks for all underground workers at Kidd Mine, for sharing their stories, speaking their mind, answering all my questions, helping me stay safe and for showing me what mining really is about.

Delft, October 2010
Pauline Resoort
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Introduction
This thesis intends to define, track and rank the root causes of stope slippage. A root cause describes the basic cause of a problem. A root cause can be distinguished from a general cause by the fact that a root cause can be changed; a solution to the problem can be developed, whereas the general cause cannot be changed since it is impacted by a deeper cause.

The approach and methods for stope slippage analysis as outlined in this thesis are applicable to longhole stoping operations in general and is applied to Kidd Mine to illustrate the practical application.

Kidd Mine divides the mining cycle into four steps: (1) mucking; (2) mucking to backfilling; (3) backfilling; (4) backfilling to mucking. Definitions of the processes in these steps can be found in appendix I. These four steps are the four key components of the mining cycle which must be well managed to produce the optimal mining cycle. This thesis deals only with the fourth component of the mining cycle, the backfilling to mucking lag. A lag is the time period between the end of one process and the start of the next process. A delay is defined as the difference between the planned number of days for a process and the actual work performance. Delays in this lag are poorly understood, but contribute significantly to the mining cycle. The backfilling to mucking lag is a complex lag that requires all preparation processes in the stope to be finished on time. Due to this complexity, analysis of this lag can reveal problems that influence more than just the backfilling to mucking lag. This thesis provides a better understanding of these problems.
Stope slippage occurs when the lag between backfilling and mucking exceeds the anticipated number of days. The ideal backfill to muck lag is 12 days as shown in figure 1 (Moerman, 2010). Since 2003 this number has dropped from 49 to 25. Although this shows significant improvement, the backfill to muck lag is still 13 days from the ideal situation. The root causes of this lag are unknown and need to be understood in order to find ways to decrease the backfill to muck lag.

The ideal cycle for Kidd Mine is based on a normalized stope tonnage of 34000 tonnes. The production target of Kidd Mine for 2010 is 2.5 Million tonnes hoisted per year (Kidd Mine, 2010). With a normalized stope size of 34000 tonnes, 74 stopes need to be mined annually to achieve the production target. It can be understood that a delay in every stope, will lead to a set-back in production: equipment, manpower and worksites will be tied up in processes that were not anticipated in the schedule. For example, a one-day delay in every stope could lead to a loss of 74 production days. The idealized stope cycle is 63 days, therefore a 74 days delay equals an approximate production set-back of 39900 tonnes or 1.6% of the annual production target. With an average delay of 13 days in the backfill to muck lag, this can rise to a set-back of 21% of the annual production.

Understanding of the root causes of delays in the fill to muck lag will help reduce these delays.
Figure 1: Stope Cycle Time 2003-2010 at Kidd Mine

(Moerman, 2010)

<table>
<thead>
<tr>
<th></th>
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<th>M-BF Lag</th>
<th>Fill</th>
<th>BF-M Lag</th>
</tr>
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<td>Idealized</td>
<td>41</td>
<td>3</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 1: Average number of days for all steps in the mining cycle at Kidd Mine

(Moerman, 2010)

The problem statement of this thesis is formulated as: “The root causes of the backfill to muck lag are unknown. These causes need to be defined and ranked in order to be able to find solutions for the problems that drive the stope slippage.” This leads to the main question: “What are the root causes for stope slippage and how does each root cause contribute to this slippage?”
The objectives of this thesis are

1. To define the reasons for stope slippage based on the delays recorded by the mine.
2. To track the slippage by comparing planned work and data extracted from SIMS.
3. To carry out an analysis which ranks these causes based on their contribution to the overall stope slippage.

Chapter one provides information on the theoretical background of Kidd Mine, the mining cycle and scheduling. Definitions on processes and stope slippage are given in this chapter. In chapter two the analysis method is outlined and the dataset for the analysis is introduced. In the third chapter, the results of the analysis are presented. Trends in stope slippage are identified, the root causes are listed and ranked. A flowchart shows the application of this analysis to other mining operations. Chapter four contains the conclusion and recommendations. The complete dataset and analysis can be found in the appendix.
1. Theoretical background

1.1. **Kidd Mine**

Kidd Mine is an underground base metal mine in Northern Ontario, Canada, located 22 km north of Timmins. The mine produces copper and zinc ore, with byproduct silver. Originally started as an open pit mine in 1966, the mine evolved into an underground mine which progressed deeper over time.

The underground mine was built in different stages: Mine 1, Mine 2, Mine 3 and D Mine. 1 Mine runs from surface to 2800 level; 2 Mine from 2800 level to 4600 level; 3 Mine from 4600 level to 68 level and Mine D from 68 level to 95 level. Each level is named after its depth: 2800 level is 2800 feet below surface, 68 level is 6800 level below surface. D Mine is divided into four blocks, each consisting of 4 to 6 levels. The blocks are grouped in two stages: Stage 1 containing blocks 1, 2 and 3. Stage 2 contains blocks 4 and 5, of which only the mining of Block 4 has been approved.

Mine 2 is completely mined out, salvage mining in Mine 1 is conducted at low rate in order to control the movement of a 60 million tonnes wedge in the open pit. Mine 3 is getting towards the end of mining as 88% of the reserves are mined out (Kidd Mine, 2010). D Mine Stage 1 is slowly maturing while most of Stage 2 is still under development, the first stopes in block 4 have been mined, which slowly brings Stage 2 on line. The study of block 5 will be finished by the end of September 2010. Figure 2 shows the different blocks and stages in the mine.
Figure 2: Longsection of Kidd Mine

(Kidd Mine, 2010)
Kidd Mine applies longhole stoping, also known as sublevel open stoping to all stopes in Mine 3 and D mine. Sub-level retreat is applied to the remaining stopes in Mine 1. Longhole stoping involves an overcut drift from which production holes are drilled, using a fanned drill pattern. For the slot, the first opening of the stope, parallel drill holes can be used. At the bottom of the designed stope an undercut drift is driven from which the blasted material is extracted. Both drill patterns are shown in figures 3 and 4. Figure 5 illustrates the typical stope layout.

Figure 3: Sublevel stoping - parallel drillholes

(Hamrin, 1982)
Figure 4: Sublevel stoping - ring drilling
(Hamrin, 1982)

Figure 5: Typical Layout of a stope at Kidd Mine
(Kidd Mine, 2010)
Kidd Mine is a large organization, the mine employs approximately 700 people, another 400 contractors work on site. Due to the size of the operation, many people are involved in every process. To fully understand the design and decision processes and the problems that can result from that, a good understanding of the organizational structure is needed.

The organizational structure of Kidd Mine is shown in figures 6 and 7.

![Organizational Chart Kidd Mine - Management](image)
Figure 7: Organizational chart Kidd Mine - Operations & Engineering
Five managers and five superintendents report directly to the General Manager, who has the highest level of responsibility over the mining operation. The Manager Mine Operations and Engineering is responsible for all mine engineering work and mine operations: development, drilling, blasting, backfilling. All processes involved with mine production and capital development fall under responsibility of the Manager Mine Production, Maintenance and Mine D Expansion. As shown in figure 7, areas of responsibility are organized by process as opposed to organization by area. Each type of organization has its advantages and disadvantages. The advantage of organization by process is that supervisors are knowledgeable for the specific process; a disadvantage is that strict coordination between processes is required. An advantage of organization by area is that a supervisor can coordinate all processes in his area, but the supervisor may lack the right level of knowledge about all processes, making processes run less than optimal.

According to Canadian Law, every engineering print and technical drawing has to be signed and approved by a competent person, who can identify hazards and has authority to take measures to eliminate these hazards. At Kidd Mine, the first step in the design of a stope is the design and approval of a block plan. The block plan is a detailed drawing of the stope, giving a description of the entry to the stope, the ground support required, the drill layout, the blast sequence and the backfill requirements. The block plan is drawn by the Mine Design group, and approved by the Long Term Group, Ground Control group, Production Engineering group, Drilling/blast superintendent, Paste Fill engineer, Geology group and the Senior Design Engineer.

When the block plan is approved, the design group issues a print for the development of new drifts. The ground control group ensures prints for the installation of ground support and if necessary enhanced support are available. All prints need to be signed and approved by the senior engineer of the group who issues the drawing, as well as the senior engineers and superintendents who are involved in the execution. Prints for raiseboring, drilling and blasting are also drawn and issued by the design group.
Scheduling of all development, rehab, construction, drilling, blasting and mucking activities is done by the production engineering group under responsibility of Senior Planning & Scheduling Supervisor. The production schedules are intended to follow the Intermediate Term Plan, which is based on the Life of Mine Strategy. The interaction between the Intermediate Term Plan, the Life of Mine Strategy and the Short Term Plan are described in section 1.3. There is a continuous exchange of information between the Production Engineering Group and the superintendents and supervisors of the different processes.

Due to the continuous feed of updated information, the weekly and daily schedules may be updated up to multiple times a day.

The work rates used by the production engineering group to schedule the processes is mostly based on experience and may vary based on availability of equipment and worksites. More information on the work rates can be found in section 1.3.4.
1.2. **Mining Cycle**

The mining cycle is described as a series of processes that will cover rock breakage and materials handling. These processes are traditionally defined as ‘drill, blast, load, haul and hoist’ (Hartman, 2002). For each mining method, the actual processes may vary. Kidd Mine applies longhole stoping, a variation of sublevel stoping where multiple levels are utilized to bring a stope into production. For stoping methods, the mining cycle is completed by backfilling of the stope to provide stability support to the surrounding rock.

The processes that make up the mining cycle for Kidd Mine are shown in figure 8. In an optimal mining cycle, the lags between processes are kept to a minimum. A lag is the number of days between the end of one process and the start of the next process. The steps in figure 8 represent the four steps as defined by Kidd Mine and discussed in the introduction of this thesis.

![Diagram](image.png)

**Figure 8:** The optimal stope cycle showing all processes in a Gantt Chart.
1.2.1. Processes

1.2.1.1. Development
The first step in stope preparation is the development of crosscuts and drifts to provide access to the ore. The headings are driven and standard ground support is applied. The ground support in drifts can get damaged by production blasts of other stopes or by rockbursts and seismic events. After these events, rehabilitation takes place in the damaged drifts to bring the ground support back to the required level. Enhanced support is installed to mitigate potential damage from seismic activity. Enhanced support is mostly installed in access drifts instead of the actual stopes.

1.2.1.2. Cable bolting
Cable bolts are installed to provide extra ground support. This will prevent the back of the stope from caving in after the production blasts. Cablebolting is not required for every stope. The ground control department decides on the installation of cablebolts based on geological and geomechanical information. Major intersections of drifts are also supported with cablebolts.

1.2.1.3. Raiseboring
A raise is drilled to create adequate void for the blast. In stopes with no overcut, two upward raises are drilled to provide the void required for the blast.

1.2.1.4. Drilling
The goal of production drilling is to drill enough holes to create a distribution of explosives that will break the rock to the desired size distribution. The drillholes are located in a set pattern around the raise, based on the diameter of the raise. The blasting sequence is established in the first design phase for each stope. This sequence is based on both the void that is available for the blast, the position of the raise and the drill-layout. The number of blasts for each stope is limited due to costs, operations planning, the availability of resources and to limit damage to surrounding rock.
1.2.1.5. Mucking
After the blast, the broken rock is transported to an ore-pass by use of scooptrams. Each level has access to an ore-pass, except for the levels below 88 level, where the capital development is not yet completed. The ore-pass is in place but no loading pocket is currently available; therefore the material from these levels is currently hauled by truck to the ore-pass on 84 level and transferred on 88 level.

1.2.1.6. Backfilling
Kidd Mine uses two kinds of backfill: unconsolidated rockfill and pastefill. The rockfill is the waste material from all parts of the mine that is dumped in the open stope by a truck. The pastefill is a mixture of tailings, esker sand and cement which is mixed together on surface in the pastefill-plant. The pastefill is then distributed throughout the mine by a system of boreholes and pipes. Pastefill makes up 95% of the total backfilling.
1.2.2. Stope Slippage

Stope slippage occurs when the turnover lag between two stopes exceeds the anticipated number of days. For this thesis, the turnover lag is defined as the lag between the end of filling of stope 1 and the start of mucking of stope 2. Based on the mining sequence and geomechanical concerns, there is a relation between stopes. The anticipated number of days for the turnover lag is based on the type of relation between two stopes. The different types of relation between stopes is explained in section 1.3.2.

In the ideal situation, the mucking starts directly after the end of filling of the previous stope. This will lead to a continuous flow from stope to stope, from filling directly to mucking. When the turnover lag is larger than anticipated, the end of filling will not connect to the start of mucking of the next stope, but will connect to a earlier process such as raiseboring or drilling. In this case a turnover lag exists.
It is decided that the root cause of stope slippage can be determined by identifying which processes and lags contribute to the turnover lag. By definition, stope slippage only occurs when there is a delay in the turnover lag. It is decided that this delay has to occur in the processes in the critical path. Delays outside the critical path will tie up resources, but do not contribute to stope slippage in the scope of this thesis. Only those processes in the critical path will contribute. The lags between processes are used to determine whether a process is in the critical path. For each process and lag in the critical path, the contribution to the turnover lag is based on the delay in the particular process or lag. The delay has been defined as the difference between the planned workdays and the actual workdays.

To establish whether all processes were pushed out by one process, the critical path of the processes has been determined. Assumptions have been made on the anticipated time for lags. These assumptions have been explained in section 1.3.2.

In general, there are three scenarios which can lead to a turnover lag:

1) Delay in a process: the actual workdays exceed the planned number of days.
2) The actual lag time is larger than the anticipated lag time.
3) The first process in the mining cycle pushes out all the other processes. This first process can be development or rehab.

These different scenarios are illustrated in figure 10.
In order to establish how each process or lag in the critical path contributed to the turnover lag, the compliance with the schedule has been reviewed by calculating the delay that occurred in each process. To calculate the delay, the number of days that were scheduled for a process has been compared to the number of days that were actually worked on this process. The information on the scheduled number of dates is provided by the Intermediate term plan and the Short term schedules. The data on actual work days have been extracted from the Supervisory Information Management System (SIMS). This will be discussed in detail in section 2.4.
Between the different processes a lag exists. This lag is a certain number of days between the end of one process and the start of the next process. The preparation of the worksite for the next process takes place in this lag. The anticipated number of days for a certain lag depends on the processes between which this lag exists. Different processes require different preparation. The difference between an anticipated lag and an extended lag is shown in figure 12. The anticipated lag times in days as established in this thesis are presented in table 2. For example, the anticipated time from Development to Raiseboring is three days. The anticipated lag from raiseboring to drilling is zero days, it is anticipated that drilling can start the same day as the raisebore process has ended.

Figure 11: Lags - anticipated vs extended

<table>
<thead>
<tr>
<th>From</th>
<th>Development</th>
<th>Cablebolting</th>
<th>Raiseboring</th>
<th>Drilling</th>
<th>Loading</th>
<th>Blasting</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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<tr>
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<tr>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: The anticipated lags between processes
1.3. Scheduling

Scheduling is the planning of mining processes in a way that the strategic goals are reflected in the day to day operations. To achieve this, an Intermediate Term Plan is extracted from the Life of Mine Plan. In its turn, the Intermediate Term Plan provides the strategic outline for the Short Term Plan. This line of scheduling ensures that a mining operation can reach optimal results over the Life of Mine. By using an accurate schedule, the mining operation will be able to have sufficient resources available to achieve the production targets.

The sequence in which stopes will be mined has a strong influence on the scheduling since the sequence forces restrictions on the order and timing of open holes. The mining sequence is an important part of all scheduling.

1.3.1. LOM

The Life of Mine Strategy is a strategic plan that describes the planning for the entire life of the mining operation. It includes all activities from the beginning of the project until the end, from exploration to decommissioning (Risbey, 2009). As the operation progresses and new information becomes available, the Life of Mine Strategy is updated to match the new situation.

The Life of Mine Strategy for Kidd Mine progressed as the mine matured. Originally started as an open pit mine in 1966, the mine evolved into an underground mine which progressed deeper over time. This downward way of expanding the mine has a significant impact on the Life of Mine Strategy. Each block contains 4 to 6 levels, the dimensions of each block are determined by the grade of the ore, the reserves and practical concerns such as loading pockets. Each block contains approximately 1 Million Tonnes of ore per level. Figure 11 shows the current status of the mine, the reserves and resources as well as the percentage mined out of each part of the mine. The downward expansion can be seen in this figure.
Figure 12: Long section of Kidd Mine showing ore reserves

(Kidd Mine, 2010)
Since the mine was developed from the top downward, the upper blocks are more mature than the lower blocks. The best scenario from a mine-closure perspective is to finish mining in all blocks at approximately the same time. Besides that, the costs for development in the lower blocks are to be financially supported by mining of upper blocks so no external cash was needed for the deepening of the mine. These two reasons lead to the need of a higher production level in the lower blocks, so these blocks can reach the same maturity level as the upper blocks.

The Life of Mine Strategy aims to:
- Optimize mining schedule for the end of mine life: completion of every block within a small time frame.
- Balance production in terms of tonnes and grade
- Balance mucking for efficient hoisting
- Respect the mining sequence

The Life of Mine Strategy forms the philosophy on which the Intermediate Term Plan is based. The Intermediate Term Plan embodies the Life of Mine Strategy into numbers and relevant information for scheduling purposes. This information then flows into the Short Term Plan or 3-month plan, and eventually down to the Weekly Schedule.
1.3.2. Sequence

The mining sequence dictates in which order and with what relative timing stopes have to be mined in order to keep some level of control over the rock stress. The restrictions the sequence places on open stopes dictates the scheduling in the intermediate term plan and short term plan.

For each block, Kidd Mine applies a chevron/pyramid pattern to its mining sequence. This chevron/pyramid pattern is schematically shown in figure 12. Mining starts in the centre of the lowest level, proceeds upwards and out towards the abutment in order to push the stresses out and around the orebody. In each block, the leading panel will be the first to break through in the level above. Due to geomechanical concerns the leading panel preferably is in the centre of gravity of the particular level. Another consideration for the choice of the lead panel is the sequence in the block above and how the lead panel can be tied into that.

At Kidd Mine, each block is divided into three fronts: North, Main orebody and the South-Lense / GreyWacke front. In D-Mine, four blocks are in production; 3-Mine is approaching the end of mine life with 88% mined out, at the moment the sill stopes are mined out. To achieve the annual budget of 2.5 million tonnes per year production for 2010, at any given time there should be 10 stopes actively mined with an optimal mining cycle. An optimal mining cycle means that there is no delay between the end of filling of one stope and the start of mucking of the next stope. To allow for less than optimal conditions in the mining cycle, the intermediate term plan schedules for 11 active stopes at any given time.

It is shown that due to the impact of the sequence on the production from the mine, disturbance of the sequence timing will have a significant effect on the production from the mine. A delay in the turnover lag can result in slippage of a complete sequence, which can unbalance the mine in terms of production, stresses and closure dates. Slippage of one sequence needs to be compensated by other sequences in terms of production, while at the same time a high production rate in a sequence may lead to
high stress levels and early completion of sequences may lead to complications in the mine closure process. The completion of sequences needs to be carefully balanced as the development of the lower blocks in D-Mine is financially supported by the production in 3-Mine and the upper blocks in D-Mine. Unbalanced completion of the sequences in the different blocks may lead to an early end of development in the lower blocks in D-Mine, which will reduce the total tonnage produced from those blocks and will shorten the Life of Mine.

![Figure 13: Mining sequence - Primary and Secondary stopes](image)

(Kidd Mine, 2010)
Each stope has links to other stopes, the status of each stope influences the ground conditions and stress levels in other stopes. There are different types of links between stopes, based on sequence, rock stress and operational concerns. These different types of links are important factors in the turnover from one stope to the next. Kidd Mine anticipates a certain number of days for each type of link as a lag between the end of filling to the start of mucking.

The three different types of links between stopes as established by Kidd Mine are:

1) Pyramid link: the stope predecessor is part of the pyramid shape that is created in the sequencing of the stopes to shed the rock stress around the orebody. Kidd Mine aims for a retreat from hanging wall to foot wall and in special cases, where the hanging-wall to foot-wall span does not allow for a slender, failing pillar for a secondary panel, a pillarless front on the abutment is formed. The predecessor is located on a different level than the stope in question and in an adjacent panel. In most cases, the development can only take place after the predecessor has been filled. To allow enough time for all necessary activities, a 42-day turnover lag is anticipated. When a turnover lag of more than 42 days is recorded, stope slippage has occurred. In figure 13, pyramid links are represented by the black arrow.

2) Void link: this link type indicates that two adjacent stopes cannot be open holes at the same time. If this occurs there will be stability issues so it is a requirement that the stope predecessor is filled before a new open hole is created. The fill will provide support to the surrounding rock to prevent instability. A void link solely depends on the presence of material, no cure time is necessary. The anticipated turnover lag is zero days. In figure 13, the void links are represented by the orange dotted arrow.
3) Up link: the stope predecessor is directly below the following stope. The overcut of the stope predecessor becomes the undercut of the next stope. Every pre-mucking activity can take place before filling of the predecessor is completed. The anticipated turnover lag for an “up” link is 3 days to allow for a minimal cure of the fill. In figure 13, the up links are shown by the green dotted arrow.

Figure 13 shows the different stope links, the grey stopes are filled or in the process of being filled.

Figure 14: Link types

(Moerman, 2010)
1.3.3. Long Term Budget and Intermediate Plan

The Long Term Budget is a more detailed version of the Life of Mine plan and covers the planning of production for a period of multiple years (Kidd Mine, 2010). The Long Term Budget provides a strategic guideline for the Intermediate Term Plan and is crucial for the transition from Life of Mine Planning to Short Term Planning. The Long Term Budget ensures a balanced production from the mine in terms of grade and tonnage and enforces the mining sequence on the scheduling. At Kidd Mine the Long Term Budget covers a period of minimal 3 years.

The present Intermediate Plan of Kidd Mine covers the detailed planning of production from the current date to mid-2012. The intermediate term plan ensures a balanced production as well as a careful consideration of muck levels and backfill schedule. Scheduling requirements related to stope sequence are also taken into account. The Intermediate Plan forms a bridge between the Long Term Plan and the Short Term planning done by the production engineering group. All the information in the long term plan is captured in over 100 data points. Most of these data points are fixed data concerning tonnage, stope sequence and ore handling, other data is calculated based on fixed point. It was decided to use the data points from the Intermediate Term Plan to calculate the delays, so that possible problems with scheduling would show up in the root cause analysis. The data points that are used in this thesis, will be explained below.
Stope name

The stope name identifies the stope. The stope name is a composition of the mucking level, the panel number and the stope number in the panel.

Front

The mining front indicates the sequence the particular stope is part of. Each mining block contains separate sequences. Most blocks specify a sequence for the South Lense and/or Greywacke stopes, a sequence for the North abutment and a sequence for the Main orebody.

Number in sequence

“Sequence” describes the number of the stope in the order of the sequence. The higher the number, the more mature the sequence, the more this sequence is mined out. In mature sequences, the capital development will be done, as well as most of the production development. The ground support will be in place and the ventilation is set in the definite design. In younger sequences, development is still in progress, as well as the installation of ground support. Ventilation can vary, due to the availability of ventilation raises. All these processes will raise challenges in scheduling. Clear and strict prioritizing is required to prevent conflicts in processes.

Predecessors: Stope names

The predecessors are the three stopes most critical stope links, the stopes that are required to be mined before the stope in question can be mined. The stope links are determined by the stope sequences, geo-mechanical concerns and mucking constraints.

Link Type

The link type will identify for each stope link what the relationship is to the particular stope. The link type determines the minimum number of days required for preparation of the stope, calculated from the end of filling of the predecessor.
Scheduled Tonnes
Indicates the number of tonnes of material a stope is expected to produce. The scheduled tonnes are used to balance the feed to the mill, manage the mucking activity on each level and predict the length of the mining cycle for the stope.

Development Start date
The development start date is calculated based on the meters of development required for the stope as well as the number of levels on which this development has to take place. For stopes in more mature sequences, the development might be already in place.

Development End date
The development end date is based on the raisebore start date. A 63 day lead time between the development end and the raisebore start will allow time for the installation of cablebolts and necessary services in the stope, for example water, air and electricity.

R/B start date
The raise bore start date is calculated based on the muck start date. A 21 day lead time is included to allow for production drilling. For raiseboring, a rate of 4.3 meters per day is scheduled. With an approximate raise length of 35 meters, this comes down to 8 days per raise.

Muck start date
The muck start date is the most important data point of the 18-month plan. The muck start date will define how much material can be produced from a certain stope in a particular month. All start- and end-dates for other activities are based on this date. The muck start month is determined manually, based on the number of tonnes to be produced in the first month, a precise muck start date is calculated.

Backfill Method
The backfill rates for the two types of backfill vary. Rockfill is waste dumped in the stope by a truck. The pastefill flows in the open stope via a pipeline from surface.
Fill start date

The fill start date is based on the muck end date, which is calculated from the muck start date based on the scheduled tonnage for the stope. From the muck end date, a fill start month is calculated and based on the number of tonnes that will be mucked from the stope in the last month of mucking, the fill start date is calculated. A 3 day lag is applied to account for the construction of a wall to plug the stope at the bottom, as well as the installation of the pastefill pipelines or the necessary safety measures for rockfill.

The Intermediate Plan is revised annually. Once per month, the Intermediate Plan and the Short Term Plan are adjusted to ensure the plans are congruent. Every year, the Intermediate Plan is revised and updated to ensure the plan stays in line with the Life of Mine Strategy. The Life of Mine Strategy in its turn is updated annually to adjust for the progression in production and processes in the mine.
1.3.4. Short Term Plan

Short term planning consists of the detailed planning of all processes in the mine, for a period up to three months. This detailed planning provides an accurate line up of worksites and equipment that is needed to achieve the production targets set out by the intermediate term plan. The baseline of the short term plan is formed by the stope muck start date and the stope links as determined in the intermediate term plan. This section will explain how the short term plan is generated.

The short term plan contains a three month plan, a month plan and a week plan. The shorter the time period described in the plan, the more detailed the information. All short term plans use the same baseline: the muck start date and the stope links. The short term plan uses work rate to predict how long a process will take. Based on this information, the availability of equipment, services and worksite, the processes are scheduled.

The work rates for different processes as used in the 3-month plan are:

<table>
<thead>
<tr>
<th>Process</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cablebolt drilling</td>
<td>800 m/week</td>
</tr>
<tr>
<td>Cablebolt installation</td>
<td>1000 m/week</td>
</tr>
<tr>
<td>Raisebore</td>
<td>1 week per raise</td>
</tr>
<tr>
<td></td>
<td>2 raises can be done in 1.5 week</td>
</tr>
<tr>
<td>Drilling</td>
<td>75 m/shift (Solo)</td>
</tr>
<tr>
<td></td>
<td>50 m/shift (Cubex)</td>
</tr>
<tr>
<td>Mucking</td>
<td>650 t/d</td>
</tr>
<tr>
<td>Filling</td>
<td>230 t/h pastefill</td>
</tr>
<tr>
<td></td>
<td>500 t/d rockfill</td>
</tr>
</tbody>
</table>

Table 3: Work rates for processes

An analysis has been done on the Raisebore- and Drill rate, with the aim to understand the rational of the workrates chosen to use for scheduling. The results on this analysis are shown in section 1.3.4.1 and 1.3.4.2.
1.3.4.1. Raisebore Rate

The raisebore rate represents the work rate at which the raise boring process is started and completed. The Intermediate Plan applies a scheduling rate of 4.3 meters per day. This includes both moving of the raisebore as well as the actual drilling. For an average 35 m raise, this comes down to 8 days. The Short Term Plan schedules 1.5 week per raise. Stopes where more than one raise is drilled are scheduled separately, for 2 upraises and 1 downraise 1.5 to 2 weeks is planned.

Kidd owns two raise boring machines of the same type. For these two machines the drill rate has been analyzed by the Six Sigma Projects group. Six Sigma is a management strategy with the objective of improving the quality of all aspects of the mining process. The results of this analysis are shown in figure 14. The average for one raise is 13.6 days. The standard deviation is relatively high, due to outliers of more than 24 days.

**Figure 15: Raisebore rate analysis**

(Kidd Mine, 2010)
Validation and revision of the raisebore rate is advised to ensure consistent and realistic scheduling. Previous analysis done by the Six Sigma group revealed a shortage in raisebore operators. By definition there is a strong link between the availability of manpower and the work performance. Analysis to validate the raisebore rate should take the manpower contribution in consideration.

1.3.4.2. Drill rate

The drill rate used in scheduling has been analyzed. Drill rate refers to production drilling of drillholes in the stope.

Kidd Mine uses two types of drills:
- Cubex ITH drills operated on contract by Machine Roger
- Solo Top Hammer drills operated by Xstrata Copper

For the drill schedule, the applied drill rates are 50 meter per shift for Cubex drills and 75 meter per shift for Solo drills. Conversations with several people at Kidd Mine showed that the drill rate used for scheduling is mainly based on experience, no clear rational for this number could be found.

Analysis of a large data set has been done, the results show that the drill rates as applied by the scheduling group, match the average drill rates achieved by Cubex and Solo in the time period 01-Jan-2009 – 7-July-2010.

This analysis is based on SIMS data from January 1st, 2009 to July 7th, 2010. This data includes drill meters per shift, where production drilling, cleaning and redrilling are added together.

Excluded from the analysis are:
- Drill moves
- Preparation of work-site before drill move-in
- All shift – clean up
These are part of the drill move-in. They are scheduled as such and are analyzed as such.

Also excluded are shifts in which there was no driller at a drill all shift caused by one of the following reasons: unavailability of drillers, level closure (seismicity or flood), other processes in the stope, maintenance/repairs in shop, drilling conflicts. The contribution of these items to stope slippage is analyzed in the root cause analysis and the results are presented in chapter 3.

All other recorded delays are considered to be part of the drill rate. This includes travel time, gas checks, maintenance, drill failure, stuck rods, training, ground conditions, ventilation repairs, material availability and whatever else can prevent the drill from drilling.

<table>
<thead>
<tr>
<th></th>
<th>CUBEX</th>
<th>SOLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drill rate (m/shift)</td>
<td>50.2</td>
<td>77.9</td>
</tr>
<tr>
<td>Delay (hrs/shift)</td>
<td>4.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Best Performance (95% mark)</td>
<td>Drill rate (m/shift)</td>
<td>146.0</td>
</tr>
<tr>
<td>Delay (hrs/shift)</td>
<td>2.4</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 4: Drill rate

Even though an average travel time, gas checks, maintenance etc. are part of the average drill rate on which the schedules are based, all travel time, gas check delays etc. are recorded in the Supervisory Information Management System (SIMS). When SIMS data is used for analysis on delays it should be noted that the delay hours in SIMS are overstated by 4.6 hours/shift for a Solo drill and 4.4 hours/shift for a Cubex drill.
2. Data and Analysis Method

It was decided that the root cause of stope slippage for each stope can be determined by analyzing the delays in the lags and processes of the critical path. Analysis of the delay will first lead to the cause of the delay. Further analysis will lead to the root cause. For example, a delay in drilling might be caused by accessibility of the worksite. The accessibility of the worksite might be driven by seismic activity on the level of the worksite. In this example, the seismic activity is the root cause of the delay in drilling.

The analysis that has been done for each stope is:

1) Determine the turnover lag
2) Establish what processes and lags are in the critical path
3) Calculate the delays in lags between processes
4) Determine the delays in the processes itself
5) Identify the root cause of the delays

For each root cause, the number of hours of the delays is determined. To rank the root causes, it was decided to compile the causes into categories, the number of hours is summed and the contribution for each root cause is calculated. The unit “hours” is chosen because this is an absolute unit, delays are recorded in SIMS in this unit and the unit indicates for how long resources where tied up in processes and worksite that were not scheduled. “Hours” can be used for analysis on multiple topics, where percentage is bound to the one analysis it is calculated from.

The root causes are ranked based on the percentage contribution to the total slippage of all stopes in the analyzed dataset.
2.1. **Critical Stope Link**

The existence and size of the turnover lag is established by calculating the difference between the muck start date of the stope and the fill end date of the preceding stope. In order to find the fill end date of the stope predecessor, the critical stope predecessor has been determined.

For every stope, all stope predecessors and their typical stope links are looked up in the intermediate term plan. For each of these stope predecessors, the fill end date has been determined. Given the type of stope link, the anticipated turnover lag is determined. Based on this anticipated lag, the fill end date and the muck start date, the critical stope link can be determined. The critical predecessor is that stope that has the relative smallest turnover lag. This is illustrated in the following example for an imaginary “Stope 1”.

The investigated stope: Stope 1. The actual recorded muck start date of ‘Stope 1’ is 15 May 2010. Table 5 shows the stope predecessors linked to ‘Stope 1’, the type of link and the actual recorded date on which the filling of the particular stope predecessor was completed.

From this fill end date, the lag to the muck start date is calculated. This number is adjusted for the link type with the anticipated number of days in the turnover as explained in section 3.2.

<table>
<thead>
<tr>
<th>Stope name</th>
<th>Link type</th>
<th>Fill end</th>
<th>Actual</th>
<th>Considering link type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stope 2</td>
<td>VOID</td>
<td>5 May 2010</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Stope 3</td>
<td>UP</td>
<td>13 April 2010</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Stope 4</td>
<td>PYRAMID</td>
<td>27 March 2010</td>
<td>49</td>
<td>7</td>
</tr>
</tbody>
</table>

*Table 5: Determination of critical stope link*

The critical stope link is that stope link that is the smallest, in this case ‘Stope 4’.
2.2. **Critical Path**

The critical path has been determined by analyzing the lag times between processes. Due to the variety in the order of the processes, every stope has been analyzed individually. To determine which process is in the critical path and which are not, assumptions have been made on the cut-off time for lags between processes:

- For a Pyramid link, all processes are in the critical path. This is inherent to the type of link.
- For Void and Up links, only those processes are in the critical path that start no more than 30 days after the end of the previous process. The time period of 30 days will allow enough time to make all resources available to do the job and adjust the schedules accordingly.

By definition, the lags are based on the first and last date that a process took place. In case a process is intertwined with another, both processes are considered to be part of the critical path. For example, cablebolt installation is started, but not finished when the raiseborer moves in. When the raiseborer is finished, the cablebolt installation is completed. Depending on the end date of the last process, both processes are found to be part of the critical path or both are not.

It is decided that processes that are not in the critical path, do not contribute to the turnover lag. It is decided that the turnover lag is caused by all delays in all processes and lags that are in the critical path.
2.3. **Delay in process**

Delays in a process occur when the actual number of workdays for that process exceeds the number of planned days. A delay in a process can contribute to the turnover lag if that process is part of the critical path. It has been determined that a delay in a process can be calculated by extracting the planned days from the actual days. For each process, the first and last day have been extracted from SIMS information based on the definitions presented in section 2.5.

Some processes are split up and another process may be intertwined. In this case the gap in the process will be evaluated as a delay in itself and the delay for the process will be based on the actual number of workdays.

2.4. **Supervisory Information Management System**

Data on the actual performance of the mine contains information on manpower, equipment number, worksite, process, and the achieved performance in meters, tonnes, kilograms as applicable. The accurate recording of actual performance is very important to the mine as decision concerning budget and strategy are based on production performance and trends. The information on actual performance is conveyed from the workers underground via work-reports to the supervisors. The supervisors ensure the information is recorded in the Supervisory Information Management System (SIMS).

The Supervisory Information Management System is a data entry system, especially created for the mining industry (Flairbase;, 2010). The software enables supervisors and staff to track production performance from all aspects of the mine, the data is conveniently gathered in one database, accessible for all staff.

It was observed that all data is entered in SIMS by supervisors. Each supervisor is responsible for the accurate recording of his crew’s production and time entries.
supervisor tracks the meters or tonnes of work done by his crew members. Also the supervisor tracks the delays, the number of hours an employee was not able to perform work during his shift. SIMS provides categories into which the delays are divided, based on the nature of the delay: drilling, raise bore and development; muck flow; planning and communication; ventilation & blasting, etc. Supervisors can make adjustments for equipment that is not being used during a shift.

Even though accurate recording is of vital importance to the mining operation, two major problems have been observed in the current situation:

- Nature of training: the supervisors do not receive any formal training on the data entry in SIMS, only informal training from other supervisors. This leads to a lot of confusion, especially on the “delay” aspect. Every supervisor interprets the delay codes differently.
- Lack of feedback on SIMS data entry: supervisors are considered to be critical in the process of accurate data recording. However, the supervisors do not receive any feedback on the data entry. The supervisors may not feel responsible for the information they put in. Some of the data can only be entered at the end of the shift, the pressure at the end of the shift and the wish to go home may lead to a work environment where inaccuracies can enter the data.

Both problems are found to add a level of uncertainty to the data. The reliability of the data in SIMS can be significantly improved if formal training and feedback is provided to the supervisors. The SIMS entries used for this thesis are checked and manually altered to sustain consistency in the dataset. For the data-set used for this thesis, 27% of the dates extracted from SIMS did not match the start and end dates as defined for the different processes. This differences in start- an end-dates may be caused by either wrong data entry, wrong location or date, or by a different use of the definitions of a process. Undercut- slashes for mucking or the placement of one bucket of waste material in an open stoppe for backfilling are examples of different definitions of a process.
A comparison has been made between the data entries in SIMS and the delay hours recorded by the workers. It was found that 91% of the recorded delay hours match the SIMS entries. It should be noted that this is a relative comparison; workers may be not objective when it comes to recording delays.

2.5. Extracted data

To establish the actual work dates for a process in a stope, information has been extracted from SIMS. The dates extracted from SIMS are:

- Development End date
- Cablebolt Drilling: start and end date
- Cablebolt installation: start and end date
- Raiseboring: start and end date
- Drilling: start and end date.
- Load date
- Blast date
- Mucking: start and end date
- Backfilling: start and end date

The data in SIMS was cleaned up to eliminate noise that might be present in the data. This noise can be caused by rushed work from the people who put in this information, vague or missing information in SIMS itself, unclear definitions and the lack of training on how to use SIMS. It has been observed that this noise is often caused by a mismatch between actual work location, equipment and recorded work location. The work performance is recorded correctly, but the equipment used and/or the work location are mismatched in 4% of all data entries. These mismatches are corrected by the Production Engineering group.
Definitions for dates have been designed to collect consistent data. These definitions are:

Development End Date: the last day on which a development crew worked in a drift, before the start of raiseboring.

Cablebolt Drilling: the first and the last day on which cablebolt drilling took place in the headings related to the stope.

Cablebolt Installation: the first and last day on which cablebolt installation took place in the headings related to the stope.

Cablebolt workdays: the number of days a crew actually worked in this heading. Often cablebolting is done in multiple series of workdays.

Raiseboring: the first day on which setting up the raisebore started and the last day of tearing down and moving out the raisebore.

Drilling: the first day the drill should have started drilling after it was moved in and set up. The drill end date is the last day the drill drilled before the first blast.

Muck start date: the first day of mucking after the first blast. Undercut slashes create production muck but are not part of the actual mucking.

Fill end date: the last day of filling a stope. A dump of a truckload of waste days after the bulk of the stope was filled, is not considered part of the filling process.
2.6. Dataset

The dataset contains fifty-five stopes. All stopes are located in #3 Mine and D Mine. The stopes in #1 Mine are left out, due to the different mining method used compared to #3 Mine and D Mine. The dataset covers all ore zones in the mine, both vertical and horizontal. The muck start date of the stopes is between September 2009 and July 2010. The stopes are linked with each other by void, up or pyramid links. These boundaries ensure that this dataset is representative for the mine.

Over a period of three months 52 data points have been gathered for all 55 stopes. All data points were extracted from the Intermediate Term Plan and SIMS. Every single point was manually checked and altered if necessary, to ensure consistency in the dataset. Some information was found to be missing or highly unlikely. This information was gathered from or checked with other sources, such as production line-ups and work-reports filled out by workers.

From the 52 data points per stope, the critical path as well as delays in the processes and lags have been established. An example of a stope is given as an illustration for the dataset. The full dataset can be found in the Appendix.

<table>
<thead>
<tr>
<th>Data point</th>
<th>Value</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stope name</td>
<td>73-943-ST</td>
<td></td>
</tr>
<tr>
<td>Development start date planned</td>
<td>15 Aug 09</td>
<td>Look up in Intermediate Term Plan</td>
</tr>
<tr>
<td>Development end date planned</td>
<td>30 Aug 09</td>
<td>Look up in Intermediate Term Plan</td>
</tr>
<tr>
<td>Development start date actual</td>
<td>3 Jan 05</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Development end date actual</td>
<td>25 Oct 09</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Cablebolt start date planned</td>
<td>14 Sep 09</td>
<td>Calculated</td>
</tr>
<tr>
<td>Cablebolt end date planned</td>
<td>19 Sep 09</td>
<td>Calculated</td>
</tr>
<tr>
<td>Cablebolt drill start date actual</td>
<td>4 Nov 09</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Cablebolt drill end date actual</td>
<td>12 Nov 9</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Cablebolt install start date actual</td>
<td>12 Dec 09</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Cablebolt install end date actual</td>
<td>16 Dec 09</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Event</td>
<td>Date Planned</td>
<td>Date Actual</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Raisebore start date</td>
<td>20 Sep 09</td>
<td>23 Nov 09</td>
</tr>
<tr>
<td>Raisebore end date</td>
<td>29 Sep 09</td>
<td>29 Sep 09</td>
</tr>
<tr>
<td>Drill start date</td>
<td>30 Sep 09</td>
<td>30 Sep 09</td>
</tr>
<tr>
<td>Drill end date</td>
<td>5 Oct 09</td>
<td>5 Oct 09</td>
</tr>
<tr>
<td>Load date</td>
<td>16 Jan 10</td>
<td>16 Jan 10</td>
</tr>
<tr>
<td>Blast date</td>
<td>27 Jan 10</td>
<td>27 Jan 10</td>
</tr>
<tr>
<td>Muck start date</td>
<td>20 Oct 09</td>
<td>20 Oct 09</td>
</tr>
<tr>
<td>Muck end date</td>
<td>22 Nov 09</td>
<td>22 Nov 09</td>
</tr>
<tr>
<td>Fill start date</td>
<td>4 Dec 09</td>
<td>4 Dec 09</td>
</tr>
<tr>
<td>Fill end date</td>
<td>28 Dec 09</td>
<td>28 Dec 09</td>
</tr>
<tr>
<td>Stope link 1 – name</td>
<td>75-917-ST</td>
<td>75-917-ST</td>
</tr>
<tr>
<td>Stope link 1 – type</td>
<td>Void</td>
<td>Void</td>
</tr>
<tr>
<td>Stope link 1 – fill end</td>
<td>26 Jan 10</td>
<td>26 Jan 10</td>
</tr>
<tr>
<td>Stope link 1 – turnover lag, # days</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Stope link 2 – name</td>
<td>74-926-ST</td>
<td>74-926-ST</td>
</tr>
<tr>
<td>Stope link 2 – type</td>
<td>Void</td>
<td>Void</td>
</tr>
<tr>
<td>Stope link 2 – fill end</td>
<td>8 Aug 09</td>
<td>8 Aug 09</td>
</tr>
<tr>
<td>Stope link 2 – turnover lag, # days</td>
<td>173</td>
<td>173</td>
</tr>
<tr>
<td>Stope link 3 – name</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stope link 3 – type</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stope link 3 – fill end</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stope link 3 – turnover lag, # days</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stope link 4 – name</td>
<td>--</td>
<td>Look up in Intermediate Term Plan</td>
</tr>
<tr>
<td>---------------------</td>
<td>----</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Stope link 4 – type</td>
<td>--</td>
<td>Look up in Intermediate Term Plan</td>
</tr>
<tr>
<td>Stope link 4 – fill end date</td>
<td>--</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Stope link 4- turnover lag, # days</td>
<td>--</td>
<td>Calculated</td>
</tr>
<tr>
<td>Stope link 5 – name</td>
<td>--</td>
<td>Look up in Intermediate Term Plan</td>
</tr>
<tr>
<td>Stope link 5 – type</td>
<td>--</td>
<td>Look up in Intermediate Term Plan</td>
</tr>
<tr>
<td>Stope link 5 – fill end date</td>
<td>--</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Stope link 5 – turnover lag, # days</td>
<td>--</td>
<td>Calculated</td>
</tr>
<tr>
<td>Critical link – name</td>
<td>75-917-ST</td>
<td>Calculated</td>
</tr>
<tr>
<td>Critical link – turnover lag, # days</td>
<td>2</td>
<td>Calculated</td>
</tr>
<tr>
<td>Critical link – type</td>
<td>Void</td>
<td>Look up in Intermediate Term Plan</td>
</tr>
<tr>
<td>Critical link – fill end date</td>
<td>26 Jan 10</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Order of processes</td>
<td>Determined for all processes</td>
<td></td>
</tr>
<tr>
<td>Lag between processes</td>
<td>Calculated for all processes</td>
<td></td>
</tr>
<tr>
<td>Pre-blast drill meters designed</td>
<td>845.3</td>
<td>Look up in design</td>
</tr>
<tr>
<td>Pre-blast drill meters – production</td>
<td>2090.1</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Pre-blast drill meters – cleaning</td>
<td>34.75</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Pre-blast drill meters – redrilling</td>
<td>0.0</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>After blast drill meters designed</td>
<td>1213.1</td>
<td>Look up in design</td>
</tr>
<tr>
<td>After blast drill meters – production</td>
<td>0.0</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>After blast drill meters – cleaning</td>
<td>952.03</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>After blast drill meters - redrilling</td>
<td>0.0</td>
<td>Look up in SIMS</td>
</tr>
<tr>
<td>Extra days pre-blast drilling – production</td>
<td>8.3</td>
<td>Calculated</td>
</tr>
<tr>
<td>Extra days pre-blast drilling – cleaning</td>
<td>0.2</td>
<td>Calculated</td>
</tr>
<tr>
<td>Extra days pre-blast drilling - redrilling</td>
<td>0.0</td>
<td>Calculated</td>
</tr>
</tbody>
</table>
3. Results

3.1. Root Cause Analysis

To determine the root cause of stope slippage for each stope the method as established in chapter two has been followed. For each stope is determined:

1) Turnover lag
   This lag is defined as the end of filling to the start of mucking. In order to calculate this, the critical stope predecessor has been determined.

2) Critical path
   The critical path has been determined as described in section 4. For each stope this provides information on the processes that might have contributed to the turnover lag, and the processes that could not have contributed.

3) Delays in lags between processes
   For each possible lag an anticipated number of days have been established. A delay in a lag occurs when the actual lag exceeds this anticipated lag. For each delay in a lag, the cause of this delay is established and analyzed.

4) Delays in the processes itself
   The number of days planned to spend on the process have been calculated based on the work rates used in the Intermediate Term Plan, or the Short Term Plan for those processes where no Intermediate Term Plan – Rate was available. This has been compared to the actual number of days that was worked on this process. The delay has been analyzed and root causes determined. The delay in a process can have multiple causes. For each category, the contribution of this delay to this particular category is calculated. All delays are recorded in days.

5) Root Causes of the delays
   The causes of the different delays have been labeled and listed for the appropriate category. The contribution from each process to a category is all listed separately.
For each root cause, the number of hours of the delays is determined. To rank the root causes, the causes are compiled into categories, the number of hours is summed and the contribution for each root cause is calculated. The root causes are ranked based on the percentage contribution to the total slippage of all stopes in the analyzed dataset.

3.2. **Stope slippage**

This section will present the analysis of the turnover lag for the different stope links as found in the analyzed dataset.

Analysis has shown that the average number of turnover days is higher than the anticipated number for every type of stope link. To get a better understanding of this data, a histogram is provided.

<table>
<thead>
<tr>
<th>Link type</th>
<th>Anticipated</th>
<th>55-stope average</th>
<th>January 2008 - July 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Void</td>
<td>0</td>
<td>10.4</td>
<td>10.8</td>
</tr>
<tr>
<td>Up</td>
<td>3</td>
<td>18.2</td>
<td>24</td>
</tr>
<tr>
<td>Pyramid</td>
<td>42</td>
<td>50.2</td>
<td>60</td>
</tr>
</tbody>
</table>

*Table 6: Turnover lag - anticipated and average*

*Figure 16: Histogram of turnover days per link type*
Figure 15 shows that the average for the Up and Void link is defined by extremes: 100 and -65 respectively. Despite the extremes, the peak in frequency for both up and void links is at 9 days, which is well above the anticipated number of days.

There is one negative turnover lag in this dataset. Kidd Mine does not schedule for negative turnover lags, but in special cases it is allowed. The negative turnover lag in the dataset is a Void link. For this link, permission was given to blast the next stope when the predecessor was only filled for 60%. It was believed this 60% fill would provide enough support to carry the next void.

When the turnover lag is shown on a time line as shown in figure 17, all link types show a clear trend downwards. This trend in a reducing turnover lag is a positive development for the mine.

![Figure 17: Trends of turnover lags per link](image-url)
3.3. **Root Causes**

Due to practical considerations it was decided to group the causes into four categories. It was assumed these four categories represent the four components needed for a smooth mining cycle / turnover. The components are:

- Worksite: available and prepared
- Manpower: available and licensed
- Equipment and material: available and running
- Management and Engineering: a design, a plan/schedule (what, where, when, who).

Each component has been split up further into sub-categories. This is shown in a fishbone diagram in figure 18. For simplicity, only those items are shown on the fishbone diagram, that cause a turnover lag. The mining cycle contains too many components to all be shown in one diagram.

One should note that all causes are forced into a category. However, there are a lot of grey areas created by interpretation of the data. Depending on your standpoint causes could be placed in different categories or grouped different altogether. For example, grouping could be done based on process or on level of responsibility: workers, supervisors, superintendents, engineers, etc. The nature of the root causes as found in the root causes analysis was reason to choose the “four component”-approach. To reduce stope slippage, a change in management processes is required. Grouping by process or level of responsibility will not encourage full cooperation of everyone who is involved.
Besides the grouping, one cause might have multiple aspects to it, or have strong interaction with other categories, which creates a grey area as well. Examples of grey areas are communication and poor line up; equipment failure and prioritizing; extra drilling, resource levels and lags between processes. Due to this grey area, the solution of one problem might create a shift in distribution of contribution to the turnover lag.

An explanation of the root causes that contribute to the turnover lag is shown in section 3.3.1 to 3.3.3. The explanations resulted from the analysis done in this thesis.
Figure 18: Root causes of stope slippage
3.3.1. Equipment & Materials

*Equipment Failure*

The downtime of the equipment due to failure, maintenance or repairs. Part of this downtime is accounted for in scheduling and budgeting. This root cause represents all delays where the process suffered from the equipment downtime.

- *Drill failure*
- *Raiseborer failure*
- *Scoop failure*

*Materials*

Delays due to the availability of materials. The materials demand can be predicted, the lack of the right materials is recorded as a delay.

- *Remote stand*
- *Drill rods*
- *Drill bits*

*Services*

Most equipment in the mine needs air, power and/or water to operate. Interruptions in the supply of these services or the lack of the required pressure are recorded as a delay due to the unavailability of the proper services.

- *Air*
- *Power*
- *Water*
3.3.2. Management & Engineering

Management and engineering captures all delays that are related to management decisions, plans and schedules. It involves everything that needs to be in place to get the right employee on the right worksite with the appropriate equipment, providing him/her with clear instructions on what to do.

*Communication* delays induced by the lack of communication. This involves both the vertical (supervisor ↔ coordinator ↔ superintendent) as well as horizontal communication (superintendent ↔ superintendent; engineer ↔ engineer). Definitions need to be clear to all employees involved to avoid misunderstandings.

*Design*

*Issued prints* Proper prints were issued too late for the worker to do the planned work.

*Slot design* The slot was designed in such a way that one or more holes are impossible to drill due to the location of holes and the dimensions of the drill.

*Drilling*

*Blast permission* For every blast, several departments have to give permission by signing a blast notice. Kidd Mine intends to operate as a 24/7 operation; however some blasts get delayed over the weekend because the blast notice did not get signed on Friday.

*Drill instructions* The drilling superintendent provides the supervisors with drill instructions. Delays are caused by the lack of these instructions or confusing instructions. Drill instructions should comply to the blockplan and regularly and in a clear way be communicated via the supervisor to the worker.

*Drill moves* Scheduled drill moves contain the drill move after completion of drilling as was instructed. Unscheduled drill moves occur on a regular basis causing delays in the drilling.
Some of these moves might be necessary to prevent delays in high priority locations when other drills break down or cannot perform as expected. Unscheduled drill moves put a lot of pressure on planners, supervisors and workers due to the unpredictable nature of the moves.

*Load time*  
There are different size blasts, every blast requires a different amount and type of explosive. The schedule does not account for different blast sizes and load times.

*Extra Drilling*  
Extra drilling captures all delays encountered by the drilling that was done on top of the designed drilling, prior to the first blast.

*Production Drilling* includes all extra drilling that was not agreed upon in the design of the stope. For example extra rings are drilled but not blasted with the first blast.

*Redrill & Cleaning* represents the cleaning of drilled holes and the re-drilling of holes that were not drilled properly or squeezed and closed over time. The schedule does not account for this, therefore all redrilling and cleaning causes a delay.

*Scheduling*  
*Raisebore Rate* is the rate at which raiseboring is scheduled. The rate is based on the philosophy that one raise per stope is drilled. Some stopes have up and down raises. The raiseboring rate does not provide guidelines on the scheduling for up and down raises.

*Cablebolt Rate* The productivity rate for cablebolting could not be validated. Since the productivity rate is not always achieved, the rate should be reviewed.

*Long Term Plan* Sequence changes in the Long Term Plan ask for sudden changes in the short term plan. These changes are not always given enough notice and cannot be anticipated on by the
short term plan. The changes can be caused by reaction to pricing, rearranging the sequence to make up for low production numbers.

Completeness The schedule includes all standard processes. Processes that are not required for all stopes are often not entered in the schedule. This incomplete scheduling puts pressure on the schedules since the extra processes ask for an extended preparation time of the worksite. Scheduling of all necessary processes should be ensured for all stopes.

Undercut Slash is a small blast, taken in the undercut of the stope to create enough void for the first stope blast. Taking of an undercut slash occurs regularly but is not planned for.

Ground Control Instrumentation is instrumentation to measure stress and ground movement. The instrumentation is installed to monitor the pillars between stopes.

Drill Rate The drill rate is the rate at which drilling is scheduled. The long term plan schedules all drilling for Kidd owned drills. The short term plan distinguishes Kidd owned drills from contractor drills, both have a different drill rate. The drill rates are based on average performance and do not allow for spikes in drill demand.

Travel time is recorded by supervisors at a steady number of 1.5 or 2 hours per shift. Since the drill rate is based on the average performance, an average travel time is already included in the schedule and should not be recorded as a delay. For this project, travel time is handled as all other delays.

Unplanned work is recorded as a delay in SIMS. Unplanned work should always have an explanation. This type of delay needs to be quantified as to determine whether this is a real problem or just used as an excuse to mask other delays.
Prioritizing

The priority of processes is an important factor to prevent an excessive turnover lag. This category refers to the priority given to the process. Delays may occur in the production schedules or the compliance to the plan.

Changing Location captures the moving of men or equipment during a shift, before a task is completed. This category has a strong connection to the category “drill moves”.

(Remote) Drilling Conflicts refers to conflict between drilling and other processes. The drilling cannot operate continuously because other processes with equal priority require the same work-area or services. This relates to shifts where the drill is operating but is interrupted.

Lag between processes is created when a succeeding process is not started within the anticipated lag time. The late start date could be caused by a wrong priority, or the lack of resources.

Poor Line Up captures the deficiency between the production schedule and the line up by the supervisor.

Priority & Resources relates to the priority given to the process considering the resources that are available. Prioritizing might be impacted by the resource levels. This root cause may have a strong connection with equipment and manpower availability.

Other process in stope defines the delays where a process is interrupted by another process. This could be for time periods from hours up to days. There is a strong connection with the “drilling conflicts” category.
3.3.3. Manpower

To operate a piece of equipment, a properly trained and licensed operator is required. Each crew should consist of a sufficient number of workers to operate all available equipment. The workers should have the right training to operate the equipment. To allow for flexibility in line-up, it is beneficial to train workers on more than one piece of equipment. Lack of either manpower or proper training will lead to a decrease in productivity rate and an increase of idle time for equipment.

*No operator available*  The crew has not enough manpower to operate all equipment, due to the absence of workers. The categories of absence are listed below.

*Sick*

*Training*

*Meeting*

*Vacation/ Allowed Absence*

*Not enough licensed people on crew* refers to the lack of flexibility in line up due to the insufficient number of licenced workers. A process in a specific worksite might have the appropriate priority, if there is no licenced worker to operate the equipment that is assigned for the job, the process cannot proceed.
3.3.4. Worksite

An essential component for the mining cycle is a worksite to perform the job. A worksite needs to exist, be accessible and safe and needs to be prepared and suitable for the task at hand.

*Accessibility* includes all circumstances that make the worksite un-accessible due to safety concerns.

*Flood*

*Heat Stress*

*Incident/Accident investigation*

*Seismic*

*Ventilation & Gas checks*

*Unsupported ground*

*Construction & Installation* describes all work that is needed to create a safe work environment and prepare the worksite for the upcoming process.

*Ground control* is split between enhanced support, the installation of extra support planned after the 2009 rockbursts, and rehab, the re-installation of the standard ground support.

*Enhanced Support* demanded a lot of time and resources, which put pressure on the time and resources available for other processes. The bulk of the work is scheduled to be finished by October 2010. This delay will reduce significantly once the majority of the enhanced support installation is finished.

*Rehab* describes the work that needs to be done to bring the ground support back to standard. This needs to be done when the ground support shows signs of ground movement or changes in rock stress. Rehab is per definition a process that anticipates on the changes in the rock, therefore it is very difficult to accurately predict this, which makes scheduling for rehab nearly impossible.
Mark-up / Surveyors are errors in the mark-up of drill rings and raise location. This category includes all delays due to the lack of and errors in the mark-up.

Raisebore Pad captures all delays due to the construction of the raisebore pad. A 3-day lag is anticipated for the construction of the raisebore pad. Delays are recorded when the construction takes more than 3 days, or the raisebore pad is not poured correctly and has to be re-done.

Preparation of worksite describes all delays due to the unplanned work needed to prepare the worksite. When a crew leaves the worksite due to completion of the work, the worksite should be left in such a state that the next process can start without the need for extra clean-up or installation of services. This category should require an explanation in SIMS to quantify the delay and determine which part is a real delay and which part could be scheduled for. The question was raised whether this delay is used as an excuse to mask other delays.

Development refers to all development that need to be done to create a worksite. This category is divided into new development and development through paste. The scheduling of new development depends on the availability of resources and the priority of the drift, development through paste depends on the previous mentioned components as well as the filling of the preceding stope.

New Development is the development of new headings through waste or ore. Delays are recorded in this category if the development was properly scheduled and the development had a low development rate or gaps in the workdays.

Development through paste captures all development that is done through pastefill, it is the re-opening of used headings.
*Bulkhead location* determines the delay caused by development through paste that needed to be done but was not anticipated on because the bulkhead was placed in a different location than planned.

*Work rate* the work rate for development through paste is assumed to be equal to the work rate for development through rock. This delay captures those situations where the work rate for development through paste was lower than the rate for development through rock.

*Ground conditions* refers to all delays associated with the conditions of the ground that influence the process in such a way that a delay occurs.

*Squeezing ground* describes the squeezing of the ground after a hole is drilled. Severely squeezed holes require cleaning and possible redrilling in order to enable the loaders to load the holes according to the loading print.

*Stuck rods* includes the time spend to pull stuck rods out of the squeezed hole. The drill cannot continue drilling any other hole until the rods are removed from the hole.
3.4. **Ranking of Root Causes**

To indicate priority within the root causes, it was decided to rank the root causes based on the impact of each category. Eliminating of the root cause will lead to a decrease in delays, the bigger the impact of a root cause, the bigger the effect might be when the problem of that root cause is solved. The likelihood of success in eliminating a root cause is not used in the ranking since the likelihood of success is not established. It is assumed that the likelihood of success is determined based on the willingness to change, the number of people involved and the complexity of the change. Determining these three parameters for every root cause is beyond the scope of this thesis.

For every root cause listed above, the delay has been recorded in number of hours or number of days. Based on the number of hours, the contribution of the root cause to the total turnover for the complete dataset can be calculated. This percentage is presented in the Fishbone Chart in figure 20.

The root causes and their percentage impact are listed and sorted based on the impact. The table with this ranking is show in figure 19.

![Pareto diagram of Root cause categories](image19)

**Figure 19: Pareto diagram of Root cause categories**
Figure 20: Root causes of stope slippage - including impact percentage
Management & Engineering (64.7%)

<table>
<thead>
<tr>
<th>Category</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling</td>
<td>35.1%</td>
</tr>
<tr>
<td>Prioritizing</td>
<td>28.4%</td>
</tr>
<tr>
<td>Drilling conflicts</td>
<td>0.1%</td>
</tr>
<tr>
<td>Poor line up</td>
<td>4.5%</td>
</tr>
<tr>
<td>changing location</td>
<td>0.4%</td>
</tr>
<tr>
<td>other process in stope</td>
<td>7.0%</td>
</tr>
<tr>
<td>priority &amp; resources</td>
<td>4.9%</td>
</tr>
<tr>
<td>lag</td>
<td>5.1%</td>
</tr>
<tr>
<td>other</td>
<td>6.4%</td>
</tr>
<tr>
<td>Drill rate</td>
<td>3.3%</td>
</tr>
<tr>
<td>Completeness</td>
<td>2.5%</td>
</tr>
<tr>
<td>CB Rate</td>
<td>0.6%</td>
</tr>
<tr>
<td>RB Rate</td>
<td>0.3%</td>
</tr>
<tr>
<td>Long term plan</td>
<td>0.5%</td>
</tr>
<tr>
<td>Extra drilling</td>
<td>10.1%</td>
</tr>
<tr>
<td>Cleaning</td>
<td>4.3%</td>
</tr>
<tr>
<td>Production Drilling</td>
<td>4.0%</td>
</tr>
<tr>
<td>Redrilling</td>
<td>1.8%</td>
</tr>
<tr>
<td>Drilling</td>
<td>8.1%</td>
</tr>
<tr>
<td>Drill moves</td>
<td>5.4%</td>
</tr>
<tr>
<td>Load time</td>
<td></td>
</tr>
<tr>
<td>Drill instructions</td>
<td>2.1%</td>
</tr>
<tr>
<td>Blast permission</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>7.9%</td>
</tr>
<tr>
<td>Design</td>
<td>3.3%</td>
</tr>
<tr>
<td>Slot design</td>
<td>0.2%</td>
</tr>
<tr>
<td>Issued prints</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

Table 7: Contribution of root causes - Management & Engineering
Worksite (25.7%)

<table>
<thead>
<tr>
<th>Construction &amp; Installation</th>
<th>17,2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark up / Surveyors</td>
<td>0,4%</td>
</tr>
<tr>
<td>Raisebore pad</td>
<td>0,7%</td>
</tr>
<tr>
<td>Preparation of worksite</td>
<td>0,4%</td>
</tr>
<tr>
<td>Ground control</td>
<td>13,0%</td>
</tr>
<tr>
<td>Enhanced support</td>
<td>11,8%</td>
</tr>
<tr>
<td>rehab</td>
<td>1,2%</td>
</tr>
<tr>
<td>Development</td>
<td>5,9%</td>
</tr>
<tr>
<td>New Development</td>
<td>4,3%</td>
</tr>
<tr>
<td>Development through paste</td>
<td>1,6%</td>
</tr>
<tr>
<td>Bulkhead location</td>
<td>0,6%</td>
</tr>
<tr>
<td>Designed</td>
<td>1,0%</td>
</tr>
<tr>
<td>Ground conditions</td>
<td>1,8%</td>
</tr>
<tr>
<td>Stuck rods</td>
<td></td>
</tr>
<tr>
<td>Squeezing ground</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td>0,8%</td>
</tr>
<tr>
<td>Incident / Accident</td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td></td>
</tr>
<tr>
<td>Ventilation &amp; Gas check</td>
<td></td>
</tr>
<tr>
<td>Unsupported ground</td>
<td></td>
</tr>
<tr>
<td>Flood</td>
<td></td>
</tr>
<tr>
<td>Seismic</td>
<td></td>
</tr>
<tr>
<td>Heat Stress</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Contribution of root causes - Worksite

Equipment & Materials (6.8%)

<table>
<thead>
<tr>
<th>Equipment Failure</th>
<th>3,6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisebore failure</td>
<td></td>
</tr>
<tr>
<td>Scoop Failure</td>
<td></td>
</tr>
<tr>
<td>Drill failure</td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>2,5%</td>
</tr>
<tr>
<td>remote stand</td>
<td>0,1%</td>
</tr>
<tr>
<td>casing</td>
<td>0,0%</td>
</tr>
<tr>
<td>Rods</td>
<td>0,2%</td>
</tr>
<tr>
<td>Bull hose</td>
<td>0,0%</td>
</tr>
<tr>
<td>Drill bits</td>
<td>0,2%</td>
</tr>
<tr>
<td>Services</td>
<td>0,7%</td>
</tr>
<tr>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Contribution of root causes - Equipment & Materials
Manpower (2.8%)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not enough people licensed</td>
<td>1.9%</td>
</tr>
<tr>
<td>No operator available</td>
<td>0.8%</td>
</tr>
<tr>
<td>Sick</td>
<td>0.2%</td>
</tr>
<tr>
<td>Training</td>
<td>0.1%</td>
</tr>
<tr>
<td>Meeting</td>
<td>0.3%</td>
</tr>
<tr>
<td>Vacation / Allowed Absence</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

Table 10: Contribution of root causes – Manpower

From the ranking of the root causes, the first thing that was noticed is the contribution of 64.7% by Management and Engineering. Some root causes in the Management & Engineering category lay in grey areas and might be placed in other categories depending on the reasoning of the analyst. However, the ratio between Management & Engineering and the other categories is adequately high that the category Management & Engineering will always be the biggest contributor to the turnover lag for this dataset.

The next point that was noticed is the contribution of the sub-category Scheduling compared to other categories. Scheduling (35.1%) by itself has the same contribution to the turnover lag as Worksite (25.7%), Equipment & Materials (6.8%) and Manpower (2.8%) combined. Scheduling is a complex topic that involves many departments, process-owners, parameters, work rates, a big stream of information, and even more people to communicate this to. Making changes to improve the scheduling process and decrease the contribution of scheduling to the turnover lag is expected to be challenging.

The first step to make changes in the scheduling process should be measuring the compliance to plan. This should include a measure of work performance in meters and tones as well as a measure on the location where this work was performed. Meeting a development target of 10 meters is not worth much if the location of this development does not match the location as scheduled. The level of compliance to the plan will give an indication of the effects of the process changes generated from the analysis of the compliance to plan.
The delays marked as extra drilling (10.1%) have been found to be caused by management and engineering decisions. The delays in extra drilling are a grey area. Part of this delay might be caused by resource constraints and worksite availability. However resource constraints and worksite availability are, minus the odd exception, controlled by management. Strictly following the drill instructions as agreed upon in the block plan will impact the delays for production drilling, this will automatically bring some relief to the resource constraints.

It was found that delays in the drilling category (8.1%) are mainly caused by unplanned drill moves and the lack of clear drill instructions. Unplanned drill moves can be driven by poor equipment performance or changes in priority. Equipment performance can be measured and anticipated; with the proper controls this delay could be significantly reduced. Even though not all unplanned drill moves are preventable, the decision making process for these moves is unclear. A clear logic for drill moves will make communication easier and create greater understanding for all people involved in the drill move and the effects on other processes. The lack of clear drill instructions is a grey area that overlaps with Communication. Drill instructions are inherently linked to the blockplan which means that drill instructions are always available. The problem seems to be to get the drill instructions from the blockplan to the drill operator.

The delays in the Communication category have been found to occur both horizontally (superintendent to superintendent) as well as vertically (supervisor – superintendent) up and down. Most communication delays are driven by people’s misunderstanding of who is in charge of or effected by a process. Employees are not fully aware of other people’s responsibility. The information stream should be evaluated and formed into a flowchart.
The root cause analysis shows that in the category Worksite (25.7%), Construction & Installation (17.3%) and Development (5.9%) stand out. The majority of the delay is shown to be caused by enhanced support (11.8%). A lot of this work was initiated due to the major seismic events in January 2009 and June 2009, the bulk of the work will be done in October 2010. It can be concluded that this delay is likely to go away by following the plan, however caution is needed since the installation of enhanced support can still have a significant impact on the processes in surrounding areas.

Development is shown to account for 5.9% of the delays. Most commonly occurring problems with development are the late end date of new development, the work rate of development through paste and the location of the bulkhead. The biggest contributor is new development, which is found to be mainly driven by gaps in the development. For example: the whole drift is driven at expected rate, the last slash is delayed by a couple of days. It is assumed that the bonus system influences this behavior.

Overall it has been concluded from the analysis that the category Management & Engineering is by far the biggest contributor to stope slippage. Grey areas have been found to create distortion in the categorizing. It is advised to identify these grey areas. It has been determined that changes in the scheduling, design- and execution processes may lead to a significant decrease in stope slippage.
3.5.  Application of root cause analysis to other mining operations

This section will outline the application of this thesis to other mining operations. This thesis has presented an approach to identify and rank the root causes of stope slippage, based on a case study at Kidd Mine. Kidd Mine operates at great depth, in a geotechnical challenging orebody. Many Canadian metal mines face the same challenges, which resulted in renewed stope parameters (Potvin, 2000). Several mines showed a change from sublevel stoping with multiple lifts to open stoping with ‘short stopes’ with a single or double lift, for example Williams Mine, Golden Giant and Kidd Mine (Potvin, 2000). Besides geotechnical changes due to the difference in stope dimensions, the fast cycle and turnover time of these ‘short’ stopes has a severe impact on the operations planning in a mine.

In open stope mining operations, timing of the mining of each stope is crucial for the mining sequence. The shape of the mining sequence is critical for stress distributions. Besides this, the stability of the stope walls is affected by time (Potvin, 2000), which again stretches the importance of the right timing of all mining processes to keep the sequence on schedule. When too much time is left between the mining of primary and secondary stopes in a sequence, high stress levels can be build up in the secondary stopes, which may lead to challenging rock conditions for the installation of ground support or for production drilling. Accurate planning and execution of all processes does not only impact the production in the near future, it may also influence the long term production forecasts.
In this thesis, an approach is designed to identify and rank the root causes of stope slippage. In order to apply this approach to other mining operations, the mining operations should meet these requirements:

- the mining sequence is of crucial importance to the scheduling and planning of the mine: the sequence needs to stay on track to ensure that the life of mine planning targets can be achieved.
- Stope slippage leads to a fall back in a sequence. To make up for this, the schedule needs to be adapted, which may lead to delays in other processes and a fall back in production.
- Turnover between stopes is a critical component of mine planning.
  - The production is bound to the availability of mining fronts. The production target can only be achieved if the maximum number of fronts is available.

The approach chosen for the application of the analysis method in this thesis is presented in the flowchart below. The analysis is divided into three parts: first a general understanding of the mining operation needs to be established. The mining cycle needs to be understood, to ensure an all inclusive analysis of all relevant processes. Understanding of the mining sequence is crucial to understand the stope links and the critical stope predecessor. The processes need to be properly defined to avoid confusion and discussion about the results. Work rates used for scheduling are needed to calculate the delays in processes.
Figure 21: Flowchart Stope Slippage Root Cause Analysis
Second part of the analysis, individual stope analysis is done. The different steps in the analysis are:

*Geomechanical interaction between stopes*: stope links. This is determined to identify the relation between stopes and how the stope is impacted by the performance of other stopes. This is an important first step, since it identifies the different sequences, the level of connections with other stopes, which is an indication of the priority of a sequence to the mine operation.

*Actual work performance* registers the work as it is actually done. Accurate recording of work performance is necessary to create a detailed data set and increase the reliability of the results of the analysis. Without reliable results, the analysis can not be a solid basis for the change necessary to reduce the turnover lag.

*Calculation of turnover lag*: will determine whether stope slippage occurs for this stope. The turnover lag will identify which stope is the critical predecessor, thus determine the number of days stope slippage and which processes are in the critical path.

*Determinaton of the cricital path* follows from the identification of the critical stope predecessor. Both the type of stope link and the fill end date of the stope predecessor determine which processes are in the critical path and which are not. Stope slippage can only be caused by processes in the critical path. Delays in processes that are not in the critical path, are a problem for the mine operation, but do not contribute to the stope slippage for this stope.

*Planned work* is the information needed to compare the actual work performance with. The information on the planned work can be gathered from work schedules and scheduled work rates. Work rates used for scheduling should be verified and validated to ensure that the scheduled processes are possible to execute in reality.

*Delays in processes and lags* can be calculated based on the planned work and the actual work performance. For those processes that are in the critical
path, delays in the process or the lag between process are a contributing cause of stope slippage.

*Determinations of causes of stope slippage and the contribution of each cause to the turnover lag.* For each process and lag, the different causes of the delay are identify and quantified. Within one process, more than one cause for stope slippage can be identified. For each cause of a delay, the number of days delay is determined, from which the contribution to the stope slippage can be calculated. Identifying the causes is the first step in finding the root cause. The contribution of each cause needs to be known to rank the root causes and give priority to those root causes with the biggest impact on stope slippage.

*Root cause analysis* distills the root cause from the causes as identified for each process and lag. Root causes are those causes that can be changed, situations, processes and methods for which you can choose a different approach. The root cause analysis identifies the problem, but does not provide a full solution.

*Calculate the contribution of each root cause to the turnover lag.* Based on the impact of each cause, the contribution of the root cause to the stope slippage can be calculated. The contribution of each root cause to the overall stope slippage will indicate the priority that should be given to the root cause when looking for solutions to reduce the delays.
When a sufficient dataset is available, the results of the analysis for each individual stope can be compiled for the total mining operation so that the root causes can be ranked. The dataset should cover every sequence in that part of the mine that is investigated, and at least two moments per sequence where the mining of a stope moves on from one stope to the next:. Two stope turnovers per sequence will create a dataset that extends over a time period of more than six months with enough datapoints to identify outliers and trends. Compilation of the root causes and their contribution to the overall, mine wide stope slippage will help set priorities for the follow-up projects that aim to reduce the delays induced by a root cause.
4. Conclusion and Recommendations

4.1. Conclusion

In mines that operate at great depth, there is a strong connection between the extraction sequence and the operations planning. Delays in one stope can have a major impact on the planning of several other stopes. The crucial aspect in this connection between sequence and scheduling is the turnover from one stope to the next stope in the sequence. Stope slippage, the delay in turnover between stopes, is a complex problem and can have a great impact on a mine operation. Understanding of the turnover, stope slippage and the impact on the mine operation is important for efficient operation of a mine.

At Kidd Mine, the average backfill to muck lag in the mining cycle is 25 days, however in the ideal situation this lag would be an average of 12 days. In the period September 2009 – July 2010, 55 stopes are investigated and the root causes for stope slippage are determined. The average turnover lag for the different stope links exceeded the anticipated number for all link types.

Based on data from the Intermediate Term Plan and data recording in SIMS, the root causes are defined. All data point have to be screened manually, due to the intertwining of processes and the presence of noise in the recorded data. Clear definitions on start and end date are necessary to obtain consistent information. Due to the size of the operation in terms of tonnage as well as employees, without an automatic performance recording system, it is not possible to manually find and correct all data that is not in agreement with the determined definitions.

The root causes are defined and categorized. The categories are based on the four components that are needed to let every processes run smooth: an accessible and safe Worksite, available and licensed Manpower, Equipment that is running as planned and the fourth component: a design, plan and schedule provided by Management & Engineering.
For each category and sub-category, the contribution to the turnover of each stope was calculated based on the number of days delay for each category. The ranking is done by category, within each category the subcategories are ranked as well. Management & Engineering is the biggest contributor to the turnover with 64.7%. Worksite is the second contributor (25.7%), while Equipment & Materials and Manpower make up the remaining 9.6%. Solving of the problems that drive stope slippage has to prioritized by contribution of the sub-category: the sub-category “Scheduling” (35.1%) by itself is larger than the category “Worksite” (25.7%).

Further analysis is needed on some topics to determine the interaction with other root causes. The work rates for development and cablebolting should be reviewed, the compliance to plan should be measured, the resource levels for equipment and manpower should be validated.
4.2. Recommendations

This section will present general recommendations for the root cause analysis of stope slippage and the recommendations made to Kidd Mine with regards to the project on stope slippage. The aim of the recommendations is not to present a solution, but to show in which direction the solution could be found.

Mines that operate at great depth are recommended to have a close look at the work performance compared to the long term plan. The mining cycle for these projects should include all processes for a stope and the turnover from a stope to the next stope in the sequence. The turnover often is ignored, but can have a great impact on the operation. For deep mines, with a strong connection between the extraction sequence and the scheduling, the turnover can be crucial to run an efficient operation. The turnover is a complex part of the mining cycle, multiple processes and many employees are involved, which makes this part of the mining cycle not an attractive subject for change, but due to this complexity, a big increase in production and efficiency can be achieved when the turnover is fully understood and optimized.

In order to perform a solid analysis of the problems in the turnover lag, the dataset should cover all extraction sequences over a time period in which at least two turnovers per sequence can take place. In case the mine applies multiple mining methods, the datasets for each mining method should be analyzed separately since the scheduling and work rates depend on the mining method applied.

This thesis deals with all processes in the mining cycle, from development to backfilling. In the case of Kidd Mine, the number of root causes in the fishbone diagram and all grey areas show that a reduction of stope slippage involves and effects many people. The given recommendations intend to reduce the problems occurring in different root causes. It is expected that the biggest impact could be achieved by a change in management and execution of the processes.
In order to get a full understanding of the interaction between root causes, it is advised that the work rates are reviewed, the compliance to plan is measured and the resource levels for equipment and manpower are validated. The work rate for drilling has been investigated, decisions should be made whether the current work rate is the preferred way of scheduling the drilling process. The work rate for raiseboring has been reviewed by the Six Sigma group. For raiseboring, it has been shown by Six Sigma that a shortage of manpower exists. It is advised to re-evaluate the raisebore work rates that are used for scheduling, once the manpower shortage is resolved.

It is suspected that the bonus system might promote delays in completing small and less popular tasks, even though these tasks are in the critical path regarding the stope cycle. It is advised to review and modify the bonus system to encourage compliance to plan.

In order to measure the reduction in stope slippage and keep track of the contribution of every root cause, the mine should keep track of the performance of every process. A complete analysis of dates, delays, causes and root causes of those delays is estimated to take up 1 workday per stope. The set-up of the system to analyse the stope slippage and calculate the contribution of the root causes requires a good understanding of the mining operation, the processes and the extraction sequence. Depending on the knowledge of the employee setting up the system, this is estimated to take one to four months. At Kidd Mine, on average two stopes come into production every week, therefore tracking the stope slippage and contribution of root causes should take up to 20% of one full time position. The analysis of the root causes of stope slippage require access to all data recording systems in an mining operation as well as co-operation of other employees regarding explanations on data entries and management processes.

Management & Engineering

There is strong interaction between delays in drilling, prioritizing and communication. It is advisable that the extent of this interaction is analyzed and identified. The amount of overlap between the root causes in the grey areas should be measured, clear definitions should be agreed upon to distinguish the root causes.
**Scheduling**

- The methods to prioritize work should be easier to understand. It is advised to create a flowchart to outline the decision making process on prioritizing of work.

- The productivity rates should be verified to ensure that compliance to plan is actually possible.

- Flexibility of the plan and schedules to anticipate on changes in extraction sequence and performance of processes should be determined, and when proven insufficient, the flexibility should be improved. Kidd Mine is a large organization, with many processes and many process-owners, therefore small adjustments might result in big changes from the schedule. The Intermediate Term Plan, Short Term Plan and Production Schedules should be able to anticipate on these changes in order to adapt to these changes and prevent delays and stope slippage.

**Extra drilling**

- Drill instructions should be followed as agreed upon in the blockplan. The drill-and blast sequence for the stope should be communicated via the drillbook as well as via the superintendent and supervisors. Adjustments to this drill sequence can only be made if agreed upon by the engineering department and the drilling department.

- The effect of resource constraints and worksite availability on the prioritizing of work should be investigated. Both the constraint on resources and the availability of the worksite cause a late move-in date for the drill, which may lead to shifts in priority.

**Drilling**

- A decision tree/flowchart should be created to outline clear logic for drill moves. Not every drill shows the same performance in all ground conditions. Moving of drills might not always be a bad idea. However, the lack of communication about the justification of the drill move, creates confusion and frustration for the workers, the designers and the schedulers.
- Provide clear drill instructions and detailed drill plans. Ensure drill instructions also cover the weekends.
- Ensure daily coverage for approval of blasts. Blasts should not be delayed by the lack of the necessary signatures but safety procedures have to be followed.

**Communication**
- The information flow should be reviewed to identify bottlenecks in the flow streams. Each person’s responsibility should be clarified so that all employees are aware of his tasks and responsibility and all employees know who to go to.
- Create a communication flowchart to show the line of communication based on the function, not on a person. This will ensure information is passed to the right people when employees are off or change job position.
- Improve both horizontal and vertical communication. Communication is not a top-down process within an organization; information should be transferred in all directions: top-down, bottom-up and horizontal from supervisor to supervisor, engineer to engineer, etc.

**Worksite**

**Enhanced Support**
- Review the scheduling of enhanced support to continue the minimal contribution to the turnover lag between stopes.

**Development**
- Verify development productivity rates. Distinguish between development through waste and development through paste. A distinction between the two might lead to a more realistic schedule and therefore less delays.
- Prevent gaps within development of drifts, by prioritizing accordingly. Data has shown that the prioritizing of development changes often. Scheduling should ensure that small but crucial tasks in development, for example the last slashes in a drift, are given a high priority as to make development not a delaying factor in stope slippage.
SIMS
- Provide formal training to supervisors to ensure consistent data- and delay-recording
- Respect supervisor’s responsibility for the data entries in SIMS. When supervisors feel more responsible for this data recording, the accuracy of the data will improve.

Bibliography


Appendix I. Definitions

This appendix presents definitions of several words used in this thesis.

Development: driving of headings and application standard ground support.
Cable bolting: installation of cable bolts to provide extra ground support.
Raiseboring: drilling of a raise to create adequate void for the blast.
Drilling: drilling of holes to allow equal distribution of explosives that will break the rock to the desired size.
Mucking: transportation of the broken rock to an ore-pass by use of scooptrams.
Backfilling: filling of open stopes to provide support to surrounding rock.
Mining cycle: series of processes needed to extract all ore from a stope and fill the open hole.
Appendix II. Individual Stope Analysis Sheets

3 Mine Phase 1
Stope Analysis 47-784-ST

Development end date: **25 augustus 2009**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Planned days</th>
<th>Actual start date</th>
<th>Actual workdays</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cablebolt Drilling</td>
<td></td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cablebolt Installation</td>
<td></td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raisebore</td>
<td>21.0</td>
<td>29 augustus 2009</td>
<td>27.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Drilling</td>
<td>11.9</td>
<td>6 october 2009</td>
<td>11.0</td>
<td>NO</td>
</tr>
</tbody>
</table>

Pre-drilling:

- Designed: 2043.8
- Production Drilling: 1898.4
- Cleaning: 0.0
- Redrilling: 0.0

Blasted:

- First blast Toes
- Location of Raise middle of drift, left side

of slot

After blast:

- Designed: 3390.5
- Production Drilling: 2768.6
- Cleaning: 646.39
- Redrilling: 0.0

Turnover

- Previous stope 47-783-ST
- Link type: PYRAMID
Fill end date: 14 augustus 2009
Turnover days: 66
Drill end date: 16 october 2009
Load date: 16 october 2009
Blast date: 19 october 2009
Muck start: 19 october 2009

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 4 days
- Lag 2 (Raiseboring – Drilling): 11 days
- Lag 3 (Drilling – Loading): 0 days
- Lag 4 (Loading – Blasting): 2 days
- Lag 5 (Blasting – Mucking): 0 days

Critical activity:
Scheduled for raiseboring: 21.0 days. Scheduled for drilling: 11.9 days
Acceptable turnover lag for a Pyramid link is 42 days. Minus the scheduled activities, this leaves
9 days for development. Development took 11 days for 15 meters, this is exactly the rate as it is
scheduled in the the 18-month plan.
The bulkhead was placed 3 meters from where it should have been, which was another 2
meters from the designed brow. This caused for 5 meters extra development, which took
approximately 3 days.
Without the extra development and no lags between activities, this stope could have had a
turnover-lag of exactly 42 days.
The bulkhead placement caused 3 days extra development. The raisebore had a delay of 6 days.
The turnover lag between raiseboring and drilling added another 11 days. This leads to a
turnover lag of 66 days. The 4 day lag from development and raiseboring is an acceptable lag.
Delay in raiseboring is cause by the switch of drills. The downraise is drilled by a Kidd crew (483
drill). The inverse raises (up) are drilled by Machine Roger. The MR drill could not move in
earlier because it was drilling on 2022-K-SLC.
The lag between raiseboring and drilling is caused by the poor line-up of drills. It was unclear
which drill was to go to which location, this line-up changed a lot. The problems are caused by
poor prioritizing of the drills.
Root cause:
- Bulkhead location (3 days)
- Raisebore moves (6 days)
- Drill prioritizing (11 days)

Note: this stope is a double lift. A double lift has three raises: one down raise, two upraises.
Down and up raise are usually drilled with different drills (MR vs Kidd), this is implicitely
included in the calculated time, but not really specified.
## Stope Analysis 47-785-ST

**Development end date:** 28 April 2010

### Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

### Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

### Raisebore:
- Planned days: 20.6
- Actual start date: 2 May 2010
- Actual workdays: 32
- Delay: 11.4

### Drilling:
- Planned days: 9.5
- Actual start date: 3 June 2010
- Actual workdays: 19
- Delay: 9.5

### Turnover
- Previous stope: 48-784-ST
- Link type: UP
- Fill end date: 18 June 2010
- Turnover days: 5
- Drill end date: 22 June 2010
- Load date: 22 June 2010
- Blast date: 23 June 2010
- Muck start: 23 June 2010

### Order of activities:
- Development – Raiseboring – Drilling

### Lag times:
- Lag 0 (Filling – Development): 21
- Lag 1 (Development – Raiseboring): 4
- Lag 2 (Raiseboring – Drilling): 0
Lag 3 (Drilling – Loading): 0
Lag 4 (Loading – Blasting): 0
Lag 5 (Blasting – Mucking): 0

Critical activity:
Both raiseboring and drilling equally contributed to the delay in the turnover lag.

The development on 46-78 xc was done late. This development was related to the filling of the 47-784-ST. The filling of the 47-785-ST was done on 13 March 2010, while the development started on April 5th.
The development started with the removal of the bulkhead. There is a lag between the end of filling and the start of development to allow the paste to cure. Two days after the stope is filled, the bulkhead can be removed. This leads to a 21 days delay in the fill-to-development lag.

47-784-ST CMS was taken on December 22nd 2009.
Wall was shot on January 14th 2010. This did not show up on Production Engineering Schedule until March 24.

March 13: filling done
Supervisor’s Morning Meeting on 46-785 SL
March 22: to inspect
March 23: inspection today
March 24: wall is 50m from plug
March 25: wall is 50 m from plug
March 26: need design
March 27: need design
March 28: need plan
March 29: need plan
March 30: need plan; surveyors to issue
March 31: need plan; surveyors to issue
April 1: need power cable
April 2: need power cable
April 5: bulkhead blasted

Week Plans:
Week 12 (Mar 14-20): no mention of this SL.
Week 13 (Mar 21-27): “need block plan approval” (Block Plan was approved in February. They need a driving lay-out).
Week 14 (Mar 28-Apr 3) the development of 46-785 SL has a scheduled start date in Week 15 (Apr 4-10).
This schedule is not according to the 18-month plan. It wasn’t scheduled earlier because there was no need to. There was enough time for raiseboring and drilling.
Raiseboring:

Raises were drilled with two different drills: MR1 for the upraises and 483 for the downraise. The extra move in, set-up and tear down, move-out time counts for at least four days of the delays.

In between, the stope sat idle for 5 days, there was no drill available.

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>RB</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>81 D Material &amp; Services Material availability</td>
<td>114</td>
<td>18</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development Drill move</td>
<td>75</td>
<td>29</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development Prepping drill site</td>
<td>60</td>
<td>6</td>
</tr>
<tr>
<td>123 I Manpower Absent</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>19 E Planning And Communication Work Site Not Ready</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development Other process in stope</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>149 B Drilling, Raise bore And Development No driller available</td>
<td>10</td>
<td>58</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting LHB / Gas Check</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development Stuck Rods</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development Drill failure</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>150 B Drilling, Raise bore And Development Down for Maintenance/Repair</td>
<td>6</td>
<td>68</td>
</tr>
<tr>
<td>2 I Manpower Meeting</td>
<td>6</td>
<td>3</td>
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<tr>
<td>130 I Manpower Sick</td>
<td>5</td>
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<tr>
<td>12 H Safety &amp; General Conditions Unsafe Condition</td>
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<td>47 B Drilling, Raise bore And Development Drilling conflicts</td>
<td>8</td>
<td></td>
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<tr>
<td>86 E Planning And Communication Unplanned work</td>
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<td>93 F Ventilation &amp; Blasting Repair ventilation</td>
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<td>118 H Safety &amp; General Conditions Preparation of worksite</td>
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<td>120 H Safety &amp; General Conditions Seismicity</td>
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<td>6 I Manpower Training</td>
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<tr>
<td>18 J Fixed Equipment / Infrastructure Power Failure</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Delay 81 – Material availability
No drill available to drill downraise.

Delay 145 – Drill move
Two different drills for upraises and downraise.

Delay 132 – Prepping drill site
Building muck pad, install cage, washing down cutting, tearing down for bulkhead install by Dumas

Delay 123 – Manpower absent
Driller absent – allowed leave.

Delay 19 – Worksite not ready
Need muck pad to move in raisebore.
Delay 148 – Other process in stope
Bulkhead install.

Delay 149 – No driller available
Driller absent – allowed leave.

**Drilling**
Delay 150 – Down for maintenence/repair
Drill was in shop before they could set up.

Delay 149 – No driller available
Consistently no driller for this drill on this crew. There seems to be one driller licensed for this drill on this crew, this guy is also licensed for the 465 drill, so if there’s no one else to operate the 465 and it’s higher in priority, the 463 will be idle.

Delay 145 – Drill move
Moving drill in and out.

Delay 81 – Material availability
Remote stand.

Root causes:
- Scheduling (both development and raiseboring)
- Availability of driller (not enough guys trained / priority)
## Stope Analysis 48-784-ST

<table>
<thead>
<tr>
<th>Activity</th>
<th>Planned Days</th>
<th>Actual Start Date</th>
<th>Actual Workdays</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cablebolt Drilling</td>
<td>1.2</td>
<td>11 December 2009</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>Cablebolt Installation</td>
<td>1.0</td>
<td>10 February 2010</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Raisebore</td>
<td>10.8</td>
<td>10 March 2010</td>
<td>8</td>
<td>NO</td>
</tr>
<tr>
<td>Drilling</td>
<td>5.6</td>
<td>19 March 2010</td>
<td>7</td>
<td>1.4</td>
</tr>
<tr>
<td>Pre-drilling</td>
<td>Designed: 957.4</td>
<td>Production Drilling: 1396.7</td>
<td>Cleaning: 0</td>
<td>Redrilling: 0</td>
</tr>
<tr>
<td>Blasted</td>
<td>First blast</td>
<td>Location of Raise</td>
<td>In the middle of fanned slot</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designed: 946.1</td>
<td>Production Drilling: 1092.6</td>
<td>Cleaning: 0</td>
<td>Redrilling: 20.5</td>
</tr>
</tbody>
</table>

**Turnover**
Previous stope: 47-784-ST
Link type: PYRAMID
Fill end date: 13 March 2010
Turnover days: 13
Drill end date: 25 March 2010
Load date: 26 March 2010
Blast date: 27 March 2010
Muck start: 27 March 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 7
- Lag 2 (Raiseboring – Drilling): 1
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 0

Critical activity:
Since this is a pyramid link, a 13-day turnover lag is acceptable. The development of the overcut was the critical activity, but could not have taken place earlier since it was bound to the filling of the 47-784-ST.
No big delays were encountered.

47-784-ST was double lift. First lift (lower part) fill end on December 31 2009. Development started January 17 2010. Second part (upper part) fill end March 13 2010. If the filling of the second part was done closer to the filling of the first part, the development would have been late.
However, this is part of the 47-784-ST and not part of the 48-784-ST.
**Stope Analysis 53-764-ST**

Development end date: **27 January 2005**

### Cablebolt Drilling
- **Planned days:**
- **Actual start date:** N/A
- **Actual workdays:**
- **Delay:**

### Cablebolt Installation
- **Planned days:**
- **Actual start date:** N/A
- **Actual workdays:**
- **Delay:**

### Raisebore
- **Planned days:** 6.1
- **Actual start date:** 26 September 2009
- **Actual workdays:** 5.0
- **Delay:** NO

### Drilling
- **Planned days:** 8.8
- **Actual start date:** 3 October 2009
- **Actual workdays:** 11.0
- **Delay:** 2.2

### Pre-drilling:
- **Designed:** 1508.1
- **Production Drilling:** 828.75
- **Cleaning:** 221.4
- **Redrilling:** 21.94

### Blasted:
- **First blast**
- **Slot & ring 1**
- **Location of Raise** middle of semi fanned slot

### After blast:
- **Designed:** 0.0
- **Production Drilling:** 0.0
- **Cleaning:** 87.78
- **Redrilling:** 0.0
Turnover

<table>
<thead>
<tr>
<th>Previous stope</th>
<th>49-784-ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link type:</td>
<td>VOID</td>
</tr>
<tr>
<td>Fill end date:</td>
<td>11 september 2009</td>
</tr>
<tr>
<td>Turnover days:</td>
<td>35</td>
</tr>
<tr>
<td>Drill end date:</td>
<td>13 october 2009</td>
</tr>
<tr>
<td>Load date:</td>
<td>15 october 2009</td>
</tr>
<tr>
<td>Blast date:</td>
<td>16 october 2009</td>
</tr>
<tr>
<td>Muck start:</td>
<td>16 october 2009</td>
</tr>
</tbody>
</table>

Order of activities:
Development – Raiseboring – Drilling

Lag times:

| Lag 1 (Development – Raiseboring): | 1703 |
| Lag 2 (Raiseboring – Drilling):    | 2    |
| Lag 3 (Drilling – Loading):        | 2    |
| Lag 4 (Loading – Blasting):        | 0    |
| Lag 5 (Blasting – Mucking):        | 0    |

Critical activity:
Lags 2 and 3 are tight, there is no significant delay in raiseboring or drilling, indicating that some sort of scheduling change caused this delay.

The 49-784-ST is mucked and filled according to plan and did not drive the schedule change.

There is no indication of radical changes in the 18-month plan. In June the muck start was scheduled for the beginning of September, in August this was update to the beginning of October.

Blockplan was first drafted in July but finally signed off in October. There was little information available on this stope, the blockplan discussion took a long time. This stope was a final stage salvage stope, therefore had no high priority.

Test holes were drilled, there was too much work to be done in the overcut therefore upholes were drilled. While drilling ran in to paste unexpected.
Stope Analysis 56-812-ST

Development end date: **18 June 2010**

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Raisebore:
- Planned days: 10.9
- Actual start date: 22 June 2010
- Actual workdays: 7.0
- Delay: NO

Drilling:
- Planned days: 3.7
- Actual start date: 30 June 2010
- Actual workdays: 5.0
- Delay: 1.3

Pre-drilling:
- Designed: 634.5
- Production Drilling: 964.2
- Cleaning: 31.6
- Redrilling: 0.0

Blasted:
- First blast
- Location of Raise left side of semi-fanned slot, left side of sort of T-slot, parallel to 3 rings, perpendicular to three other rings.

After blast:
- Designed: 1437.2
- Production Drilling:
- Cleaning:
- Redrilling:

Turnover
Previous stope 57-812-ST
Link type: UP
Fill end date: 31 may 2010
Turnover days: 42
Drill end date: 4 july 2010
Load date: 10 july 2010
Blast date: 11 july 2010
Muck start: 12 july 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 4
- Lag 2 (Raiseboring – Drilling): 1
- Lag 3 (Drilling – Loading): 6
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 1

Critical activity:
Development in the overcut was done on June 18\textsuperscript{th} (54-811 xc): had to remove cemented rockfill from 54-811-ST to create enough room for raisebore and slot drilling. Filling of 54-811-ST was finished by January 2001. Extensive rehab had to be done on the access drift (54-82 xc). Damage here was not recognized earlier since this area had not been actively mined for years. The rehab started on April 9\textsuperscript{th}, and was completely done on June 23\textsuperscript{rd}.

Development in undercut was done on June 28\textsuperscript{th}. The filling of the 57-812-S caused the unlevelling of the drift, this had to be corrected. Remove paste to create proper grade of floor.

The gap between drilling and loading is caused by the need to fix up the undercut, create the ramp, muck it out. After that, the holes were plotted and a blast letter had to be made. The blast letter was issued on Friday July 9\textsuperscript{th}. Due to the high void utilization, it was absolutely necessary that the undercut was developed to design and fully mucked out.

The 57-812-ST caused seismic events, therefore extra precautions for the blast of 56-812-ST were required.

This is a low priority stope, this probably allowed slippage to happen.

Causes: rehab, design, communication.
Stope Analysis 61-GW1-ST

Development end date: 14 June 2009

Cablebolt Drilling:
- Planned days:
- Actual start date: N/A
- Actual workdays:
- Delay:

Cablebolt Installation:
- Planned days:
- Actual start date: N/A
- Actual workdays:
- Delay:

Raisebore:
- Planned days: 6.4
- Actual start date: 19 December 2009
- Actual workdays: 10
- Delay: 3.6

Drilling:
- Planned days: 10.1
- Actual start date: 7 January 2010
- Actual workdays: 9.0
- Delay: NO

Pre-drilling:

Designed: 1727.1
Production Drilling: 1042.6
Cleaning: 0.0
Redrilling: 56.0

Blasted:

First blast
Location of Raise Fanned slot

After blast:

Designed: 0.0
Production Drilling: 0.0
Cleaning: 32.31
Redrilling: 149.35

Turnover

Previous stope 65-SL1-ST

Turnover

Previous stope 65-SL1-ST
Link type: VOID
Fill end date: 23 January 2010
Turnover days: 1
Drill end date: 15 January 2010
Load date: 22 January 2010
Blast date: 24 January 2010
Muck start: 24 January 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 188
- Lag 2 (Raiseboring – Drilling): 9
- Lag 3 (Drilling – Loading): 7
- Lag 4 (Loading – Blasting): 2
- Lag 5 (Blasting – Mucking): 0

Critical activity:
At the time of the pastefilling of 65-SL1-ST, three stopes competed for the filling. Due to the location of the stopes, the blast of 61-GW1-ST had a high risk of seismic activity. It was absolutely critical that the 65-SL1-ST was completely filled.
The 67-SL11-ST also depended on the fill of 65-SL1-ST. Both 61-GW1-ST and 67-SL11-ST could only be blasted when the 65-SL1-ST was completely filled.

For both stopes high seismic activity and high stress levels on the pillar between SL/GW and main lense, are expected. These stopes can not be blasted at the same time. Since both depend on the same fill-end, one stope will be blasted after the other.
Fill end: Saturday.
Blast 61-GW1-ST: Sunday
Blast 67-SL11-ST: Monday

Root cause: competing stopes.
3 Mine Phase 2

Stope Analysis 62-765-ST

Development end date: **21 December 2009**

Cablebolt Drilling:
- Planned days: 16.6
- Actual start date: 19 December 2009
- Actual workdays: 12.0
- Delay: NO

Cablebolt Installation:
- Planned days: 13.3
- Actual start date: 28 January 2010
- Actual workdays: 7.0
- Delay: NO

Raisebore:
- Planned days: 20.5
- Actual start date: 6 January 2010
- Actual workdays: 22
- Delay: **1.5**

Drilling:
- Planned days: 6.9
- Actual start date: 6 February 2010
- Actual workdays: 8.0
- Delay: **1.1**

Pre-drilling:
- Designed: 1175.9
- Production Drilling: 1808.9
- Cleaning: 0
- Redrilling: 0

Blasted:
- First blast: SLOT
- Location of Raise: Straight after the T

After blast:
- Designed: 2260.7
- Production Drilling: 757.8
- Cleaning: 0
Redrilling: 0

Turnover

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous stope</td>
<td>63-765-ST</td>
</tr>
<tr>
<td>Link type:</td>
<td>UP</td>
</tr>
<tr>
<td>Fill end date:</td>
<td>14 February 2010</td>
</tr>
<tr>
<td>Turnover days:</td>
<td>4</td>
</tr>
<tr>
<td>Drill end date:</td>
<td>13 February 2010</td>
</tr>
<tr>
<td>Load date:</td>
<td>15 February 2010</td>
</tr>
<tr>
<td>Blast date:</td>
<td>17 February 2010</td>
</tr>
<tr>
<td>Muck start:</td>
<td>18 February 2010</td>
</tr>
</tbody>
</table>

Order of activities:
Cablebolt Drilling – Raiseboring – Cablebolt Installation – Drilling

Lag times:

| Lag 1 (CB Drilling – Raiseboring) | 6 |
| Lag 2 (Raiseboring – CB Installing) | 0 |
| Lag 3 (CB Install – Drilling)    | 2 |
| Lag 4 (Drilling – Loading)      | 2 |
| Lag 5 (Loading – Blasting)      | 0 |
| Lag 6 (Blasting – Mucking)      | 1 |

Critical activity:
The development was late, this left no time for delays in the other activities. The main drift was finished by the end of November 2009; the T slot was developed in December 2009 (Dec. 4, 9, 20 and 21).

In August Month Plan, Production Engineering scheduled the rehab for weeks 37 to 41: 6 September to 10 October 2009.

In the September Month Plan, this is pushed out to weeks 46 to 50: 8 November to 12 December 2009. And in the October Month Plan this is pushed out to weeks 46 to 51: 8 November to 19 December 2009.

Development was tight, but delays in development could not have been known by production engineering so far ahead that they could have been anticipated in the October Month Plan. This is a scheduling problem.

Cause: scheduling (too tight)

The lag between Cablebolt Drilling and Raiseboring is 6 days. This includes the time needed to clean up after the Cablebolt Drilling, marking up the pad, pouring the pad and waiting for the cement to cure.
This could be done faster than 6 days, however it is not extremely long.
The muck rate in 63-765-ST is high, the orepass is very close to the drawpoint, a high muck rate could have been anticipated.
Stope Analysis 62-GW1-ST

Development end date: 14 June 2009

Cablebolt Drilling:
- Planned days: 16.8
- Actual start date: 13 August 2009
- Actual workdays: 11.0
- Delay: NO

Cablebolt Installation:
- Planned days: 13.4
- Actual start date: 28 August 2009
- Actual workdays: 4.0
- Delay: NO

Raisebore:
- Planned days: 6.9
- Actual start date: 8 August 2009
- Actual workdays: 4.0
- Delay: NO

Drilling:
- Planned days: 2.1
- Actual start date: 8 September 2009
- Actual workdays: 8.0
- Delay: 5.9

Pre-drilling:

<table>
<thead>
<tr>
<th>Designed</th>
<th>Production Drilling</th>
<th>Cleaning</th>
<th>Redrilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>352.1</td>
<td>1069.22</td>
<td>103.64</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Blasted:

<table>
<thead>
<tr>
<th>First blast</th>
<th>Slot Location of Raise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Middle of the slot</td>
</tr>
</tbody>
</table>

After blast:

<table>
<thead>
<tr>
<th>Designed</th>
<th>Production Drilling</th>
<th>Cleaning</th>
<th>Redrilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1406.8</td>
<td>0.0</td>
<td>552.6</td>
<td>450.18</td>
</tr>
</tbody>
</table>

Turnover

xstrata copper

TU Delft
<table>
<thead>
<tr>
<th>Previous stope</th>
<th>64-GW2-ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link type:</td>
<td>VOID</td>
</tr>
<tr>
<td>Fill end date:</td>
<td>27 september 2009</td>
</tr>
<tr>
<td>Turnover days:</td>
<td>2</td>
</tr>
<tr>
<td>Drill end date:</td>
<td>15 september 2009</td>
</tr>
<tr>
<td>Load date:</td>
<td>26 september 2009</td>
</tr>
<tr>
<td>Blast date:</td>
<td>29 september 2009</td>
</tr>
<tr>
<td>Muck start:</td>
<td>29 september 2009</td>
</tr>
</tbody>
</table>

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – Raiseboring): 5
- Lag 2 (Raiseboring – CB Installing): 1
- Lag 3 (CB Installing – Drilling): 8
- Lag 4 (Drilling – Loading): 11
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
A void link of 2 days is a decent result.
Drilling suffered a 5.9 day delay, mainly due to drilling off more than was requested by drillbook and superintendent. Instructions were to drill slot, but most of rings were drilled off as well. Since the blast had to wait for the filling of 64-GW2-ST, this did not influence the turnover.

The preceding stope had a big lag between the end of mucking and the start of filling. Still this would not have created a problem due to the big lag in drilling to loading.

The two day lag is created because the preceding stope was filled on a Saturday. For the 62-GW1-ST, a seismic event was expected, the safety precautions would contribute to the turnover lag.
Stope Analysis 62-GW2-ST

Development end date: **27 April 2010**

**Cablebolt Drilling:**
- Planned days: 1.3
- Actual start date: 16 April 2010
- Actual workdays: 3
- Delay: **0.7**

**Cablebolt Installation:**
- Planned days: 1.0
- Actual start date: 19 April 2010
- Actual workdays: 1
- Delay: **NO**

**Raisebore:**
- Planned days: 6.8
- Actual start date: 6 May 2010
- Actual workdays: 2
- Delay: **NO**

**Drilling:**
- Planned days: 2
- Actual start date: 8 May 2010
- Actual workdays: 4
- Delay: **2**

Pre-drilling [meters]
- Designed: 340.5
- Production Drilling: 517.3 → 1.2 days
- Cleaning: 0
- Redrilling: 0

Blasted:
- Toes / no toes: SLOT
- Location of Raise option: 3

After blast [meters]
- Designed: 575.2
- Production Drilling: 610.9
- Cleaning: 25
- Redrilling: 0

Turnover
- Previous stope: 61-GW1-ST
Link type: PYRAMID
Fill end date: 13 April 2010
Turnover days: 31
Drill end date: 12 May 2010
Load date: 14 May 2010
Blast date: 14 May 2010
Muck start: 14 May 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Install): 2
- Lag 2 (CB Installing – Raiseboring): 17
- Lag 3 (Raiseboring – Drilling): 1
- Lag 4 (Drilling – Loading): 2
- Lag 5 (Loading – Blasting): 0
- Lag 6 (Blasting – Mucking): 0

Critical activity:
Critical link is a pyramid link. Therefore development, raiseboring and drilling are part of the critical path. Cablebolting was done ahead of time.

**Development:**
Rounds taken:
- 20 april: 61-GW2 DD
- 21 april: 61-GW2 DD
- 27 april: 61-GW ACC
- 13 may: 62-GW ACC (back slash)

**End of Development – Start of Raiseboring**
27 april 2010: last round
28 april 2010: shoot faces
29 april 2010: screen & shoot face
30 april 2010: screening & shooting complete. Mark-up done.
1 may 2010: prepping site for pad
2 may 2010: prepping site for pad
3 may 2010: pouring pad
4 may 2010: preparation complete
5 may 2010: set up Raisebore
6 may 2010: start drilling
7 may 2010: start drilling

**Raiseboring:** did not encounter a delay.

**End of Raiseboring – Start of Drilling:** did not encounter a delay.
Drilling: encountered two days delay.

Extra drilling: 1.2 days
Unaccounted drill delays: 1.6 days

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stop</td>
</tr>
<tr>
<td>19 E Planning And Communication</td>
<td>Work Site Not Ready</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
<tr>
<td>150 B Drilling, Raise bore And Development</td>
<td>Down for Maintenance/Repair</td>
</tr>
</tbody>
</table>

Delay 3 – Travel Time
Travelling to and from worksite, lunch time, calling in for working alone.

Delay 132 – Prepping drill site
Cutting cablebolts, measuring holes for drillers

Delay 148 – Other processes in stop
Crew moving out, shotcreting in adjacent crosscut.

Delay 19 – Worksite not ready
Needs mark-up, need to repair vent.
Stope Analysis 63-765-ST

Development end date: 27 september 2009

Cablebolt Drilling:
- Planned days: 6.0
- Actual start date: 20 november 2009
- Actual workdays: 7.0
- Delay: 1.0

Cablebolt Installation:
- Planned days: 4.8
- Actual start date: 7 december 2009
- Actual workdays: 4.0
- Delay: 0.8

Raisebore:
- Planned days: 7.7
- Actual start date: 27 october 2009
- Actual workdays: 6.0
- Delay: 1.7

Drilling:
- Planned days: 4.2
- Actual start date: 20 december 2009
- Actual workdays: 4.0
- Delay: 0.2

Pre-drilling:
- Designed: 716.4
- Production Drilling: 700.6
- Cleaning: 0.0
- Redrilling: 0.0

Blasted:
- First blast SLOT
- Location of Raise Middle of fanned slot

After blast:
- Designed: 1409.2
- Production Drilling: 1452.1
- Cleaning: 0.0
- Redrilling: 144.8

Turnover
- Previous stope 66-786-ST
- Link type: VOID
- Fill end date: 6 december 2009
- Turnover days: 20
- Drill end date: 23 december 2009
- Load date: 23 december 2009
- Blast date: 26 december 2009
Muck start: 26 December 2009

Order of activities:
Raiseboring – Cablebolt Drilling – Cablebolt Installation – Drilling

Lag times:

- Lag 0 (Development – Raiseboring): 30
- Lag 1 (Raiseboring – CB Drilling): 18
- Lag 2 (CB Drilling – CB Installing): 10
- Lag 3 (CBInstalling – Drilling): 10
- Lag 4 (Drilling – Loading): 0
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
The lag times between the activities explain the 20 day turnover lag. Lag 0, 1 and 2 are excessive, lag three is longer than necessary but not completely unreasonable for the type of activities. The excessive lag times indicate poor scheduling.

Block Plan approved on September 15th.
On September 22nd, the 18-month plan called for a development end date of November 3rd 2009 and muck start on 1 February 2010.

On 18 November 2009, the muck start date was pushed forward to 22 December 2009; with a development end date on September 23.

On October 9, changes were made that pushed the 63-765-ST forward to muck start January 19th.

Cablebolt layouts were drawn on November 18th, the markup was not done yet on November 20th. Different priority scheduling could have decreased this lag and might have resulted in a lower turnover lag.

The lag times between the activities explain the 20 day turnover lag. Lag 0,1 and 2 are excessive, lag three is longer than necessary but not completely unreasonable for the type of activities.

The preceding stope was mucked fast (muck-rate 1214 tonnes/day). This could have been expected since this was a high sulphide zone. If the stope was mucked at normal rate, all activities would have been finished in time and no turnover lag would have been recorded.

The scheduling for the activities for 63-765-ST should have taken the hot muck in the preceding stope into account. The high muck rate was not anticipated in the 18-month plan.

Problem: Scheduling. (Production Eng & LT).
**Stope Analysis 63-825-ST**

Development end date: **16 augustus 2009**

**Cablebolt Drilling:**
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay:

**Cablebolt Installation:**
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay:

**Raisebore:**
- Planned days: 7.7
- Actual start date: 7 november 2009
- Actual workdays: 7.0
- Delay: NO

**Drilling:**
- Planned days: 4.7
- Actual start date: 20 november 2009
- Actual workdays: 7.0
- Delay: 2.3

**Pre-drilling:**
- Designed: 810.6
- Production Drilling: 829.1
- Cleaning: 104.0
- Redrilling: 0.0

**Blasted:**
- First blast Slot
- Location of Raise middle of slot

**After blast:**
- Designed: 879.4
- Production Drilling: 799.4
- Cleaning: 259.06
- Redrilling: 104.8

**Turnover**
Previous stope: 64-825-ST
Link type: UP
Fill end date: 16 November 2009
Turnover days: 13
Drill end date: 26 November 2009
Load date: 27 November 2009
Blast date: 29 November 2009
Muck start: 29 November 2009

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 83
- Lag 2 (Raiseboring – Drilling): 6
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 2
- Lag 5 (Blasting – Mucking): 0

Critical activity:
The preceding stope was mucked really fast, over mucked, filled at normal rate but due to fast mucking the fill end was November 16. This could have been identified at the first couple of days of mucking, and prioritizing should have been done accordingly. This priority was not recognized.

Sept. 18-month plan: fill start December 4.
October: fill start 15 November 2009

Root cause: scheduling. Failed communication about high muck rate in predecessor.
Stope Analysis 64-767-ST

Development end date: **20 March 2010**

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Raisebore:
- Planned days: 7.5
- Actual start date: 3 April 2010
- Actual workdays: 10
- Delay: 2.5

Drilling:
- Planned days: 5.5
- Actual start date: 20 April 2010
- Actual workdays: 3
- Delay: **NO**

Pre-drilling:
- Designed: 1509.3
- Production Drilling: 473.6
- Cleaning: 0
- Redrilling: 0

Blasted:
- First blast
- Location of Raise: Middle of tanned slot

After blast:
- Designed: 0
- Production Drilling: 521.7
- Cleaning: 19
- Redrilling: 0

Turnover
- Previous stope: 62-765-ST
Link type: VOID
Fill end date: 11 april 2010
Turnover days: 14
Drill end date: 22 april 2010
Load date: 23 april 2010
Blast date: 23 april 2010
Muck start: 25 april 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 14
- Lag 2 (Raiseboring – Drilling): 0
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 2

Critical activity:
Raisebore moved in two weeks after the development in the undercut was done.
Original inspection done on March 2nd. Needed rehab, remove bulkhead in overcut.
Second inspection on March 25. Five days after development was done.
Mark-up was done, needed clean-up, ready to pour pad.
Raisebores were both drilling in other locations, no equipment available.

Root cause:
Scheduling: Could have known earlier that bulkhead needed to be removed.
Communication: inspection could have taken place directly after development was done.
Site preparation: clean up should not have been necessary.
Equipment availability
**Stope Analysis 64-805-ST**

**Development end date:** **9 May 2010**

**Cablebolt Drilling:**
- Planned days:
- Actual start date: N/A
- Actual workdays:
- Delay:

**Cablebolt Installation:**
- Planned days:
- Actual start date: N/A
- Actual workdays:
- Delay:

**Raisebore:**
- Planned days: 7.5
- Actual start date: 8 May 2010
- Actual workdays: 8
- Delay: 0.5

**Drilling:**
- Planned days: 10
- Actual start date: 21 May 2010
- Actual workdays: 12
- Delay: 2

**Pre-drilling:**
- Designed: 1746.7
- Production Drilling: 1786.7
- Cleaning: 209.5
- Redrilling: 12.3

**Blasted:**
- Toes / no toes: TOES
- Location of Raise: In the middle of the stope, rings behind it

**After blast:**
- Designed: 237.4
- Production Drilling: 108.8
- Cleaning: 407.51
- Redrilling: 0

**Turnover**
Previous stope
Link type:
Fill end date:
Turnover days:
Drill end date:
Load date:
Blast date:
Muck start:

64-767-ST
VOID
20 May 2010
17
2 June 2010
3 June 2010
4 June 2010
6 June 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:

Lag 1 (Development – Raiseboring): -1
Lag 2 (Raiseboring – Drilling): 5
Lag 3 (Drilling – Loading): 1
Lag 4 (Loading – Blasting): 1
Lag 5 (Blasting – Mucking): 1

Critical activity:
Development was done late.
UNDERCUT: 64-806-ST was mined before the 64-805-ST, so had to develop through paste.
Fill end date 64-806-ST: 17 November 2008.
Undercut development resumed: 19 december 2009

Two weeks delay for installing steel arches. One week as “Spare – No Power”.

OVERCUT: 63-806-ST was mined before 64-805-ST, so had to develop through paste.
Fill end date 63-806-ST: 19 march 2009
Overcut development resumed: 12 January 2010
Steel sets were needed, had to be ordered. Two weeks delay waiting for steel sets. Five weeks installing the steel sets.
In both OC and UC the paste was really bad, it looked more like oxidized muck. Once a hole was drilled, you could barely see it.

Cause: development was late. Installation of steel arches was known in advance.

Root cause: scheduling.
Stope Analysis 64-825-ST

Development end date: **31 July 2009**

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Raisebore:
- Planned days: 7.6
- Actual start date: 10 Augustus 2009
- Actual workdays: 10.0
- Delay: 2.4

Drilling:
- Planned days: 7.8
- Actual start date: 19 September 2009
- Actual workdays: 16.0
- Delay: 8.2

Pre-drilling:
- Designed: 1331.7
- Production Drilling: 2036.1
- Cleaning: 0.0
- Redrilling: 0.0

Blasted:
- First blast
- Location of Raise: Middle of fanned slot

After blast:
- Designed: 723.7
- Production Drilling: 0.0
- Cleaning: 79.7
- Redrilling: 0.0

Turnover
Previous stope 61-805-ST
Link type: VOID
Fill end date: 1 october 2009
Turnover days: 6
Drill end date: 4 october 2009
Load date: 5 october 2009
Blast date: 7 october 2009
Muck start: 7 october 2009

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 10
- Lag 2 (Raiseboring – Drilling): 30
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 0

Critical activity:
The filling of the preceding stope started later than anticipated. The fill rate was reasonable.
The fill end was fully anticipated, leaving causes for slippage in the 64-825-ST itself.
The drill was moved in on time, however the drilling suffered a delay since the whole stope was drilled off. The time needed for this extra drilling is 4.7 days.

Extra drilling: 4.7 days
Unaccounted delays: 5.8 days

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure</td>
</tr>
<tr>
<td>79 D Material &amp; Services</td>
<td>Water problem</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
</tr>
<tr>
<td>149 B Drilling, Raise bore And Development</td>
<td>No driller available</td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stope</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
</tr>
<tr>
<td>78 D Material &amp; Services</td>
<td>Compressed air problem</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods</td>
</tr>
<tr>
<td>6 I Manpower</td>
<td>Training</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
<tr>
<td>47 B Drilling, Raise bore And Development</td>
<td>Drilling conflicts</td>
</tr>
</tbody>
</table>

Delay 3 – Travel Time
Travel to work site, call in for working alone, lunch

Delay 65 – Drill failure / Down for Maintenance / Repairs
Problems with hydraulic hose and feed cable

Delay 79 – Water Problem
No water on level

Delay 145 – Drill move
Moving around drill for drilling remote

Delay 149 – No driller available
Driller is on vacation.

Delay 148 – Other process in stope
Borehole survey, paste filling in 63-GW stope

Delay 132 – Prepping drill site
Cleaning up, setting up

Delay 78 – Compressed air problem
No air on level / low pressure

Delay 2- Meeting
Safety meeting

Delay 51 – Stuck Rods

Delay 6 - Training

Delay 1 – Gas check

Delay 47 – Drilling Conflicts
Conflicts in remote drilling.
Stope Analysis 65-860-ST

Development end date: 13 October 2009

Cablebolt Drilling:
  Planned days: 65–860‐ST
  Actual start date: N/A
  Actual workdays: Delay:

Cablebolt Installation:
  Planned days:
  Actual start date: N/A
  Actual workdays:
  Delay:

Raisebore:
  Planned days: 7
  Actual start date: 22 February 2010
  Actual workdays: 3
  Delay: NO

Drilling:
  Planned days: 13.7
  Actual start date: 22 March 2010
  Actual workdays: 29
  Delay: 15.3

Pre-drilling:
  Designed: 2343.0
  Production Drilling: 2109.4
  Cleaning: 127.0
  Redrilling: 0

Blasted:
  First blast SLOT
  Location of Raise Middle of the (semi)
  fanned slot
  After blast:
  Designed: 0
  Production Drilling: 0
  Cleaning: 0
  Redrilling: 0

Turnover
Previous stope: 66-861-ST
Link type: UP
Fill end date: 24 march 2010
Turnover days: 9
Drill end date: 30 march 2010
Load date: 31 march 2010
Blast date: 2 april 2010
Muck start: 2 april 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development– Raiseboring): 132
- Lag 2 (Raiseboring – Drilling): 5
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 0

Critical activity:
A nine-day turnover lag for an up link is acceptable. However, the drilling suffered a significant delay.
This delay may have cause the turnover lag to be bigger than necessary.

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>151 B Drilling, Raise bore And Development</td>
<td>No drill plan 200</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move 49</td>
</tr>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time 42</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure 22</td>
</tr>
<tr>
<td>150 B Drilling, Raise bore And Development</td>
<td>Down for Maintenance/Repair 21</td>
</tr>
<tr>
<td>19 E Planning And Communication</td>
<td>Work Site Not Ready 20</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check 11</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods 3</td>
</tr>
<tr>
<td>53 B Drilling, Raise bore And Development</td>
<td>Drill Bits 3</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting 2</td>
</tr>
<tr>
<td>93 F Ventilation &amp; Blasting</td>
<td>Repair ventilation 2</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site 1</td>
</tr>
</tbody>
</table>

The drill broke down after three days of drilling and had to move to 46 shop for repairs. Once drill came out of shop, the drill was moved to another stope. 65-860-ST sat idle until another drill was moved in.

Scheduling of the drill moves cause the 9 days turnover lag. 65-860-ST was missing on the priority list from March 7 untill March 19.
No comments on Supervisor’s Morning Meetings sheets.
Delay cause by planning & scheduling. No drill site available to drill. All other drills were drilling.
Stope Analysis 65-SL1-ST

Development
Start date: 1 october 2009
Number of days: 30
End date: 30 october 2009

Cablebolt Drilling:
Planned days: 7.5
Actual start date: 27 february 2008
Actual workdays: 9.0
Delay: 1.5

Cablebolt Installation:
Planned days: 6.0
Actual start date: 23 june 2008
Actual workdays: 9.0
Delay: 3.0

Raisebore:
Planned days: 6.5
Actual start date: 4 november 2009
Actual workdays: 11.0
Delay: 4.5

Drilling:
Planned days: 2.6
Actual start date: 24 november 2009
Actual workdays: 6.0
Delay: 3.4

Pre-drilling:
Designed: 439.3
Production Drilling: 720.5
Cleaning: 0.0
Redrilling: 0.0

Blasted:
First blast
Location of Raise middle of slot

After blast:
Designed: 356.1
Production Drilling: 128.32
Cleaning: 101.5
Redrilling: 0.0
Turnover

Previous stope: 64-GW2-ST
Link type: PYRAMID
Fill end date: 27 september 2009
Turnover days: 68
Drill end date: 29 november 2009
Load date: 3 december 2009
Blast date: 4 december 2009
Muck start: 4 december 2009

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 4
- Lag 3 (Raiseboring – Drilling): 9
- Lag 4 (Drilling – Loading): 4
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
Development dates: October 1,3,6,12,16,30.

For this pyramid link, bulkhead removal of the 64-GW2-ST and development was needed. The development started 4 days after the end of fill, which is acceptable. The bulkhead was placed 7 meters from the designed location, causing an extra 5 meters of paste removal needed. In 18 days, 18.2 meters of the development was done, then it took another 12 days to take the final 1.5 meters. This happened because a revision in the driving layout was needed: added a round to south side since development in north side couldn’t be done.

Since all activities are in the critical path, all delay contribute to the overall delay.

Development was delayed by 11 days.
Raisebore: 4.5 days
Raisebore-drilling: 7 days
Drilling: 3.4 days

Total: 26 days.
Delays in Raiseboring and Drilling:

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>RB</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 E Planning And Communication</td>
<td>Surveyors</td>
<td>50</td>
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<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
<td>42</td>
</tr>
<tr>
<td>149 B Drilling, Raise bore And Development</td>
<td>No driller available</td>
<td>20</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
<td>18</td>
</tr>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time</td>
<td>7</td>
</tr>
<tr>
<td>150 B Drilling, Raise bore And Development</td>
<td>Down for Maintenance/Repair</td>
<td>38</td>
</tr>
<tr>
<td>151 B Drilling, Raise bore And Development</td>
<td>No drill plan</td>
<td>4</td>
</tr>
<tr>
<td>4 E Planning And Communication</td>
<td>Changing Location</td>
<td>3</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure</td>
<td>2</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
<td>2</td>
</tr>
</tbody>
</table>

Raisebore delays:

Delay 25 – Surveyors
Mark up was wrong, back and front site are marked wrong. Waited 3 days before this was corrected.

Delay 145 – Drill move
Moving in, moving out.
Delay 149 – No driller available
Driller is on vacation.
Delay 132 – Prepping drill site
Setting up the raisebore
Delay 3 – Travel time
Getting to work site, lunch time, calling in when working alone.

Drilling delays
Extra drilling: 1.9 days
Accounted for: 0.5 days
Unaccounted delays: 3.1 days (overlaps with extra drilling).

Delay 150 – Down for Maintenance / Repair
Drill would not power up, had to go to shop to get it fixed.

Delay 3 – Travel time
Getting to work site, lunch time, calling in when working alone.

Delay 145 – Drill move
Moving drill from crosscut to shop and back to crosscut.

Delay 151 – No drill plan
Waiting for drill prints.
### Stope Analysis 66-786-ST

**Development end date:** 15 march 2009

#### Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

#### Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

#### Raisebore:
- Planned days: 6.9
- Actual start date: 22 augustus 2009
- Actual workdays: 5.0
- Delay: NO

#### Drilling:
- Planned days: 10.3
- Actual start date: 14 october 2009
- Actual workdays: 9.0
- Delay: NO

#### Pre-drilling:

<table>
<thead>
<tr>
<th></th>
<th>Designed: 1765.9</th>
<th>Production Drilling: 1605.5</th>
<th>Cleaning: 66.5</th>
<th>Redrilling: 0.0</th>
</tr>
</thead>
</table>

#### Blasted:

<table>
<thead>
<tr>
<th></th>
<th>First blast slot</th>
<th>Location of Raise: middle of fanned slot</th>
</tr>
</thead>
</table>

#### After blast:

<table>
<thead>
<tr>
<th></th>
<th>Designed: 0.0</th>
<th>Production Drilling: 0.0</th>
<th>Cleaning: 88.39</th>
<th>Redrilling: 168.37</th>
</tr>
</thead>
</table>

**Turnover**
Previous stope: 66-821-ST
Link type: VOID
Fill end date: 23 October 2009
Turnover days: 2
Drill end date: 22 October 2009
Load date: 23 October 2009
Blast date: 25 October 2009
Muck start: 25 October 2009

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 160
- Lag 2 (Raiseboring – Drilling): 48
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 0

Critical activity:
GF log instructed to drill off the whole stope. Drill book did not have any instruction on drill / blast sequence.
For the amount of drilling that needed to be done, the drill could have moved in earlier.

On October 12 D/S, drill was moved from 70-862-ST to 66-786-ST. For 66-786-ST pipe need to be taken down (4 lengths) (12 N/S). October 13 D/S: need mark-up & prints.
October 14 N/S: started drilling.

Poor clean-up made ring 1 inaccessible. Ring 1 needs to be dumped out from Row A. This causes extra work in drilling since you have to wait for new print while moving drill all over the stope as to not let drill sit idle.

The preceding stope (66-821-ST) had a very high muck rate and was therefore filled much earlier than anticipated. A turnover of 2 days is not bad considering this change in fill end date.
Stope Analysis 66-861-ST

Development end date: 11 March 2009

Cablebolt Drilling:
- Planned days: 12.7
- Actual start date: 27 March 2009
- Actual workdays: 16
- Delay: 3.3

Cablebolt Installation:
- Planned days: 10.2
- Actual start date: 20 June 2009
- Actual workdays: 5.0
- Delay: NO

Raisebore:
- Planned days: 7.0
- Actual start date: 27 November 2009
- Actual workdays: 15.0
- Delay: 8.0

Drilling:
- Planned days: 3.3
- Actual start date: 15 December 2009
- Actual workdays: 4.0
- Delay: 0.7

Pre-drilling:
- Designed:
- Production Drilling:
- Cleaning:
- Redrilling:

Blasted:
- First blast
- Location of Raise: straight after the T

After blast:
- Designed:
- Production Drilling:
- Cleaning:
- Redrilling:

Turnover
- Previous stope: 67-863-ST
Link type: UP
Fill end date: 9 january 2010
Turnover days: 1
Drill end date: 18 december 2009
Load date: 9 january 2010
Blast date: 10 january 2010
Muck start: 10 january 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): 70
- Lag 2 (CB Installing – Raiseboring): 156
- Lag 3 (Raiseboring – Drilling): 3
- Lag 4 (Drilling – Loading): 22
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
The 67-863-ST was right underneath the 66-861-ST. The 67-863-ST was rock-filled, therefore no time was needed to remove the pipe.

1 day turnover for an up link, a stope directly above the previous one, is a good achievement.
Filling was done on Saturday January 9 during D/S; the next opportunity to blast was Sunday January 10 at 5 am. This shows up as a 1 day lag, but in reality is no turnover lag at all.
Stope Analysis 66-864-ST

Development end date: **26 May 2010**

**Cablebolt Drilling:**
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

**Cablebolt Installation:**
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

**Raisebore:**
- Planned days: 7.1
- Actual start date: 7 June 2010
- Actual workdays: 2
- Delay: NO

**Drilling:**
- Planned days: 6.5
- Actual start date: 15 June 2010
- Actual workdays: 6
- Delay: NO

**Pre-drilling:**
- Designed: 1107.1
- Production Drilling: 1125.0
- Cleaning: 41.0
- Redrilling: 0.0

**Blasted:**
- First blast Toes
- Location of Raise Middle of fanned slot

**After blast:**
- Designed: 1533.9
- Production Drilling: 929.3
- Cleaning: 0
- Redrilling: 0

**Turnover**
- Previous stope 65-860-ST
Link type: PYRAMID
Fill end date: 9 May 2010
Turnover days: 47
Drill end date: 20 June 2010
Load date: 24 June 2010
Blast date: 25 June 2010
Muck start: 25 June 2010

Order of activities:
Raiseboring – Drilling

Lag times:
    Lag 1 (Development – Raiseboring): 12
    Lag 2 (Raiseboring – Drilling): 7
    Lag 3 (Drilling – Loading): 4
    Lag 4 (Loading – Blasting): 1
    Lag 5 (Blasting – Mucking): 1

Critical activity:
Development was late. This was due to the unexpected need to remove paste in the overcut because the bulkhead was put in such a place that the developed T in the overcut was filled. The brow of the 65-860-ST caved, forcing the bulkhead to be pulled back.
Based on the design of 65-860-ST, this was a likely scenario. The extra development cause the extra delay for the pyramid link.
**Stope Analysis 66-SL2-ST**

Development end date: **4 June 2010**

**Cablebolt Drilling:**
- Planned days: 10.4
- Actual start date: 1 June 2010
- Actual workdays: 18.0
- Delay: **7.4**

**Cablebolt Installation:**
- Planned days: 8.3
- Actual start date: 18 June 2010
- Actual workdays: 4.0
- Delay: **NO**

**Raisebore:**
- Planned days: 7.3
- Actual start date: 9 June 2010
- Actual workdays: 2.0
- Delay: **NO**

**Drilling:**
- Planned days: 2.4
- Actual start date: 24 June 2010
- Actual workdays: 4.0
- Delay: **1.6**

**Pre-drilling:**
- Designed: 405.7
- Production Drilling: 641.5
- Cleaning: 0.0
- Redrilling: 0.0

**Blasted:**
- First blast
- Location of Raise: Middle of parallel slot

**After blast:**
- Designed: 1168.8
- Production Drilling:
Turnover

<table>
<thead>
<tr>
<th>Previous stope</th>
<th>68-788-ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link type:</td>
<td>VOID</td>
</tr>
<tr>
<td>Fill end date:</td>
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</tr>
<tr>
<td>Turnover days:</td>
<td>12</td>
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<tr>
<td>Drill end date:</td>
<td>27 June 2010</td>
</tr>
<tr>
<td>Load date:</td>
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</tr>
<tr>
<td>Blast date:</td>
<td>2 July 2010</td>
</tr>
<tr>
<td>Muck start:</td>
<td>2 July 2010</td>
</tr>
</tbody>
</table>

Order of activities:
Raiseboring – Cablebolt Installation – Drilling

Lag times:
- Lag 1 (Raiseboring – CB Installing): 7
- Lag 2 (CB Installing – Drilling): 6
- Lag 3 (Drilling – Loading): 4
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 0

Critical activity:
No activity caused such a delay that this caused any problems.

The Block Plan was approved on May 5th. In the overcut, the development needed was the removal of a bulkhead and 5 meters paste removal. In the undercut, a new drift was driven, of 24 meters.

This development was done in less than one month, this is a good result.

The Block Plan was signed off late. This indicates scheduling changes. However, in the 18-month plan the 66-SL2-ST has had a muck start date of June 16 since February but was dragged forward (earlier in time) since November 2009. It takes approximately 12 weeks to do a blockplan, but it can be pushed through faster.

Cause of delay: changes in 18-month plan due to sequence change due to geomechanical concerns, communication of priority to design group.
### Stope Analysis 66-SL11-ST

**Development end date:** 21 February 2010

<table>
<thead>
<tr>
<th>Activity</th>
<th>Planned days</th>
<th>Actual start date</th>
<th>Actual workdays</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cablebolt Drilling</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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<tr>
<td><strong>Cablebolt Installation</strong></td>
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<tr>
<td></td>
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<tr>
<td><strong>Raisebore</strong></td>
<td>7.6</td>
<td>23 February 2010</td>
<td>7</td>
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</tr>
<tr>
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<tr>
<td><strong>Drilling</strong></td>
<td>7.8</td>
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<td>15</td>
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<tr>
<td>Pre-drilling</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Designed:</td>
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<td>Blasted:</td>
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<tr>
<td>First blast Location of Raise</td>
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<td>After blast:</td>
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<tr>
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<tr>
<td>Cleaning:</td>
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<tr>
<td>Redrilling:</td>
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</tbody>
</table>

**Turnover**

- **Previous stope:** 67-SL11-ST
- **Link type:** UP
- **Fill end date:** 21 March 2010
- **Turnover days:** 1
- **Drill end date:** 18 March 2010
- **Load date:** 19 March 2010
- **Blast date:** 22 March 2010
Muck start: 22 March 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 2
- Lag 2 (Raiseboring – Drilling): 1
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 2
- Lag 5 (Blasting – Mucking): 0

Critical activity:
The preceding stope was filled with waste material. No cure time was needed, nor was time needed to remove a paste pipe.

Drilling experienced a significant delay:
- Instructions were to drill slot, R5, R6 and R7. The whole stope was drilled off.
- No drilling, redrilling or cleaning was recorded after the first blast. The stope was drilled off, but in this case this was not a bad decision.

Extra drilling: 4.3 days
Unaccounted delays: 4.7
Set-up & move in delay: 1.6

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site 8</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move 59</td>
</tr>
<tr>
<td>151 B Drilling, Raise bore And Development</td>
<td>No drill plan 10</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure 64</td>
</tr>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time 47</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check 6</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting 4</td>
</tr>
</tbody>
</table>

Delay 65 – Drill failure
Electrical problems, switch cable, needed new parts.
Delay 145 – Drill move
Moving drill in and out of slot.
Delay 151 – No drill plan
Done drilling – no new drill location.
Delay 132 – Prepping drill site
- Setting up drill.
- Checking holes for blast
Stope Analysis 67-863-ST

Development end date: 11 march 2009

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A 
- Actual workdays: 
- Delay: 

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A 
- Actual workdays: 
- Delay: 

Raisebore:
- Planned days: 8.6 
- Actual start date: 19 april 2009 
- Actual workdays: 14 
- Delay: 5.4

Drilling:
- Planned days: 6.8 
- Actual start date: 26 october 2009 
- Actual workdays: 12 
- Delay: 5.2

Pre-drilling:
- Designed: 1161.0 
- Production Drilling: 1837.8 
- Cleaning: 0.0 
- Redrilling: 26.4

Blasted:
- First blast Toes 
- Location of Raise middle of fanned slot 

After blast:
- Designed: 652.3 
- Production Drilling: 0.0 
- Cleaning: 442.88 
- Redrilling: 0.0

Turnover
Previous stope: 66-821-ST
Link type: VOID
Fill end date: 23 October 2009
Turnover days: 17
Drill end date: 6 November 2009
Load date: 6 November 2009
Blast date: 9 November 2009
Muck start: 9 November 2009

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 39
- Lag 2 (Raiseboring – Drilling): 176
- Lag 3 (Drilling – Loading): 0
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 0

Critical activity:
The preceding stope (66-821-ST) had a very high muck rate (1030 t/d). The stope was therefore filled much earlier than anticipated. With normal muck and fill rates, 66-821-ST would have been filled on November 1st.

Drill instructions were to drill slot and ring one. Instead, the whole stope was drilled off. This caused a delay in the pre-drilling, as well as cleaning after the blast. The stope should not have been drilled off completely, since the stope was already slipping (creating a turnover lag) when the drill moved in.

The big lag between raiseboring and drilling is caused by the 18-month plan, the stope was pushed out. This, in itself, should not cause a delay in this stope. By the end of August, the muck start date was scheduled for the end of October 2009. This left more than enough time to schedule the drilling so that a turnover lag would be avoided.

Cause: Drill line-up.
Stope Analysis 67-SL11-ST

Development end date: **24 November 2009**

**Cablebolt Drilling:**
- Planned days: 6.1
- Actual start date: 6 December 2009
- Actual workdays: 9.0
- Delay: **2.9**

**Cablebolt Installation:**
- Planned days: 4.9
- Actual start date: 30 December 2009
- Actual workdays: 4.0
- Delay: **NO**

**Raisebore:**
- Planned days: 8.1
- Actual start date: 8 December 2009
- Actual workdays: 9.0
- Delay: **0.9**

**Drilling:**
- Planned days: 3.0
- Actual start date: 19 December 2009
- Actual workdays: 7.0
- Delay: **4.0**

**Pre-drilling:**

<table>
<thead>
<tr>
<th>Designed</th>
<th>Production Drilling</th>
<th>Cleaning</th>
<th>Redrilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>506.0</td>
<td>1086.2</td>
<td>26.6</td>
<td>0</td>
</tr>
</tbody>
</table>

**Blasted:**

- First blast: Slot Location of Raise: middle of the fanned slot

**After blast:**

<table>
<thead>
<tr>
<th>Designed</th>
<th>Production Drilling</th>
<th>Cleaning</th>
<th>Redrilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>489.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Turnover
Previous stope: 65-SL1-ST
Link type: VOID
Fill end date: 23 January 2010
Turnover days: 2
Drill end date: 25 December 2009
Load date: 22 January 2010
Blast date: 25 January 2010
Muck start: 25 January 2010

Order of activities:
Cablebolt Drilling – Raiseboring – Drilling – Cablebolt Installation

Lag times:
- Lag 1 (CB Drilling – Raiseboring): 0
- Lag 2 (Raiseboring – Drilling): 2
- Lag 3 (Drilling – CB Installing): 3
- Lag 4 (CB Installing – Loading): 20
- Lag 5 (Loading – Blasting): 3
- Lag 6 (Blasting – Mucking): 0

Critical activity:
At the time of the pastefilling of 65-SL1-ST, three stopes competed for the filling. Due to the location of the stopes, the blast of 67-SL11-ST had a high risk of seismic activity. It was absolutely critical that the 65-SL1-ST was completely filled.
The 61-GW1-ST also depended on the fill of 65-SL1-ST. Both 61-GW1-ST and 67-SL11-ST could only be blasted when the 65-SL1-ST was completely filled.

For both stopes high seismic activity and high stress levels on the pillar between SL/GW and main lense, are expected. These stopes can not be blasted at the same time. Since both depend on the same fill-end, one stope will be blasted after the other.
Fill end: Saturday.
Blast 61-GW1-ST: Sunday
Blast 67-SL11-ST: Monday

Root cause: competing stopes.
**Stope Analysis 68-788-ST**

Development end date: **19 February 2010**

**Cablebolt Drilling:**
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

**Cablebolt Installation:**
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

**Raisebore:**
- Planned days: 7.9
- Actual start date: 16 April 2010
- Actual workdays: 6
- Delay: NO

**Drilling:**
- Planned days: 7.2
- Actual start date: 24 April 2010
- Actual workdays: 3
- Delay: NO

**Pre-drilling:**
- Designed: 1240.6
- Production Drilling: 833.7
- Cleaning: 0
- Redrilling: 0

**Blasted:**
- First blast: Slot
- Location of Raise: In the middle of the fanned slot.

**After blast:**
- Designed: 429.4
- Production Drilling: 1630.3
- Cleaning: 20
- Redrilling: 0

Turnover
Previous stope: 66-SL11-ST
Link type: VOID
Fill end date: 1 May 2010
Turnover days: 0
Drill end date: 26 April 2010
Load date: 27 April 2010
Blast date: 28 April 2010
Muck start: 1 May 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 56
- Lag 2 (Raiseboring – Drilling): 2
- Lag 3 (Drilling – Loading): 1
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 3

Critical activity:
Mucking started directly after fill end of predecessor. No turnover lag, and no significant delays. Good stope.
D Mine Block 1

Stope Analysis 69-826-ST

Development end date: **27 april 2010**

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay:

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay:

Raisebore:
- Planned days: 10.9
- Actual start date: 2 may 2010
- Actual workdays: 20
- Delay: **9.1**

Drilling:
- Planned days: 11.2
- Actual start date: 3 june 2010
- Actual workdays: 10
- Delay: **1.2**

Pre-drilling:
- Designed: 1914.0
- Production Drilling: 2082.5
- Cleaning: 69.0
- Redrilling: 0.0

Blasted:
- First blast slot
- Location of Raise: end of drift – fanned

After blast:
- Designed: 1795.8
Turnover

Previous stope: 71-GW5-ST
Link type: VOID
Fill end date: 29 June 2010
Turnover days: 1.0
Drill end date: 12 June 2010
Load date: 29 June 2010
Blast date: 30 June 2010
Muck start: 30 June 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
Lag 1 (Development – Raiseboring): 5
Lag 2 (Raiseboring – Drilling): 12
Lag 3 (Drilling – Loading): 17
Lag 4 (Loading – Blasting): 1
Lag 5 (Blasting – Mucking): 0

Critical activity:
The turnover lag for this stope is 1 day. All activities were done in time, the stope was loaded and ready to go. The first blast had to wait for the filling of the predecessor.
The blast of this stope had a high risk of a seismic event, precautions were necessary in terms of closing off levels. The preparation of these precautions caused the 1 day turnover lag. In this case, this is an acceptable delay.
Stope Analysis 70-826-ST

Development end date: 23 October 2008

Cablebolt Drilling:
- Planned days: 8.6
- Actual start date: 9 December 2008
- Actual workdays: 9.0
- Delay: 0.4

Cablebolt Installation:
- Planned days: 6.9
- Actual start date: 17 December 2008
- Actual workdays: 5.0
- Delay: NO

Raisebore:
- Planned days: 9.7
- Actual start date: 18 December 2009
- Actual workdays: 6.0
- Delay: NO

Drilling:
- Planned days: 5.4
- Actual start date: 10 January 2010
- Actual workdays: 10
- Delay: 4.6

Pre-drilling:
- Designed: 922.2
- Production Drilling: 2485.7
- Cleaning: 32
- Redrilling: 0

Blasted:
- First blast: POSITIVE HOLE
- Location of Raise: middle of the parallel slot

After blast:
- Designed: 1663.7
- Production Drilling: 0
- Cleaning: 200.56
- Redrilling: 0

Turnover
Previous stope: 73-S34-ST
Link type: VOID
Fill end date: 9 April 2010
Turnover days: -65
Drill end date: 19 January 2010
Load date: 30 January 2010
Blast date: 3 February 2010
Muck start: 3 February 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
Lag 1 (CB Drilling – CB Installing): 0
Lag 2 (CB Installing – Raiseboring): 362
Lag 3 (Raiseboring – Drilling): 17
Lag 4 (Drilling – Loading): 11
Lag 5 (Loading – Blasting): 3
Lag 6 (Blasting – Mucking): 0

Critical activity:
In the 18-month plan, it is indicated that 70-826-ST can be blasted when the 73-S34 is 2/3 full. Therefore, the -65 days turnover lag is a valid lag.

At the time of the blast, 73-S34-ST was filled for 59%; given the restriction of 2/3, this stope could not have been blasted earlier. The 73-S34-ST is filled with waste, this is happening at a low rate, even for waste-filling. Filling started at December 29th, 16 days after the muck end; at a rate of 500 t/d, this stope could have been 60% filled on January 20, 2010. Drilling was ready in time.
### Stope Analysis 70-902-ST

**Development end date:** 25 January 2010

**Cablebolt Drilling:**
- Planned days: 8.9
- Actual start date: 24 January 2010
- Actual workdays: 18
- Delay: 9.1

**Cablebolt Installation:**
- Planned days: 7.1
- Actual start date: 15 March 2010
- Actual workdays: 5
- Delay: NO

**Raisebore:**
- Planned days: 10.1
- Actual start date: 23 April 2010
- Actual workdays: 5
- Delay: NO

**Drilling:**
- Planned days: 6
- Actual start date: 10 May 2010
- Actual workdays: 14
- Delay: 8.0

**Pre-drilling:**
- Designed: 1033.3
- Production Drilling: 2084.6
- Cleaning: 42.0
- Redrilling: 12.0

**Blasted:**
- First blast
- Location of Raise: Right side of the fanned T slot.

**After blast:**
- Designed: 1917.1
- Production Drilling: 1152.59
- Cleaning: 352.96
- Redrilling: 0

**Turnover**
Previous stope: 71-901-ST
Link type: UP
Fill end date: 31 May 2010
Turnover days: 1
Drill end date: 23 May 2010
Load date: 29 May 2010
Blast date: 1 June 2010
Muck start: 1 June 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): 6
- Lag 2 (CB Installing – Raiseboring): 34
- Lag 3 (Raiseboring – Drilling): 12
- Lag 4 (Drilling – Loading): 6
- Lag 5 (Loading – Blasting): 3
- Lag 6 (Blasting – Mucking): 0

Critical activity: Load to Blast
It appears that this stope had a one day lag. Everything was ready and the stope was loaded in time.
However, there were significant delays in Cablebolt drilling and Production Drilling.

**Load to Blast:** 1 day
Filling was done at 3 am on June 1st. Did not have enough time to set up blast.

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>CB Dr</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
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<tr>
<td>Prepping drill site</td>
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<td>144 B Drilling, Raise bore And Development</td>
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<td>Ground conditions</td>
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<td>145 B Drilling, Raise bore And Development</td>
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<td>Drill move</td>
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<td>148 B Drilling, Raise bore And Development</td>
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<td>Other process in stope</td>
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<td>149 B Drilling, Raise bore And Development</td>
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<tr>
<td>No driller available</td>
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<td>150 B Drilling, Raise bore And Development</td>
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<tr>
<td>Down for Maintenance/Repair</td>
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<td>151 B Drilling, Raise bore And Development</td>
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<td>138 E Planning And Communication</td>
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<tr>
<td>Poor line up/planning</td>
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<tr>
<td>19 E Planning And Communication</td>
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<tr>
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<tr>
<td>Surveyors</td>
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<td>2.0</td>
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</tbody>
</table>
Cablebolt drilling
Delay 148 – Other process in stope
  - Other drill moving in and setting up
  - Paste filling preceding stope underneath
  - Mucking on same level
  - Next worksite not ready, no place to go

Delay 145 – Drill Move
Drill moved in and out three times.

Delay 19 – Worksite not ready
Site is not ready to move into.

Delay 132 – Prepping drill site
Clean up, setting up.

Delay 138 – Poor line up / planning
Licensed driller was lined up for other drill with lower priority.

Delay 150 – Down for Maintenance / Repair / Drill failure
Maintenance

Delay 149 – No driller available
Driller had vacation day

Delay 151 – No Drill plan
Unknown where drill is to go next, in the mean time occupying workplace.

Delay 6 – Training
Training other guy on raise bore.

Delay 1 – LHB / Gas Check
Gas check.
Drilling

Extra drilling: 7.4 days
Drill set up & move in delay: 1 day
Unaccounted delays: 4.5 days

Delay 120 – Seismicity
Seismic events. Level closed.

Delay 1 – LHB / Gas Check
Gas check.

Delay 150 – Down for Maintenance / Repairs / Drill Failure
Drill failure.

Delay 148 – Other process in stope
Paste filling stope next door.

Delay 149 – No Driller available
No driller available for this drill.

Delay 117 – Flood
Level flooded all shift.
Stope Analysis 71-901-ST

Development end date: 8 april 2009

Cablebolt Drilling:
- Planned days: 12
- Actual start date: 19 may 2009
- Actual workdays: 14
- Delay: 2

Cablebolt Installation:
- Planned days: 9.6
- Actual start date: 1 june 2009
- Actual workdays: 11
- Delay: 1.4

Raisebore:
- Planned days: 10.1
- Actual start date: 28 december 2009
- Actual workdays: 11
- Delay: 0.9

Drilling:
- Planned days: 6.0
- Actual start date: 13 february 2010
- Actual workdays: 28
- Delay: 22

Pre-drilling:
- Designed: 1029.3
- Production Drilling: 1078.08
- Cleaning: 1542.49
- Redrilling: 270.9

Blasted:
- First blast
- Location of Raise: Left side of T slot parallel holes - not far enough to the left for positive hole

After blast:
- Designed: 656.7
- Production Drilling: 0
- Cleaning: 1188.97
- Redrilling: 152.4

Turnover
Previous stope: 73-943-ST
Link type: VOID
Fill end date: 8 March 2010
Turnover days: 8
Drill end date: 12 March 2010
Load date: 15 March 2010
Blast date: 16 March 2010
Muck start: 16 March 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): 0
- Lag 2 (CB Installing – Raiseboring): 200
- Lag 3 (Raiseboring – Drilling): 35
- Lag 4 (Drilling – Loading): 3
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 1

Critical activity:
Cablebolting and development were finished well in advance and do not influence the turnover lag at all. Raiseboring is started on time and does not suffer a delay.

Drilling is started well in time, but due to the immense delay, drilling the cause of the 8 day turnover lag.
Next drill to move in: 464 Solo. Was in 46 SHOP, moved to 64-767-ST for remote drilling.

Extra drilling: 12.4 days
Move in & set up: no delay
Unaccounted delay: 13.7 days

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<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
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<td>Material availability</td>
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<td>1 F Ventilation &amp; Blasting</td>
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<td>51 B Drilling, Raise bore And Development</td>
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<td>144 B Drilling, Raise bore And Development</td>
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<tr>
<td>47</td>
<td>Drilling, Raise bore And Development</td>
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<td>65</td>
<td>Drilling, Raise bore And Development</td>
</tr>
<tr>
<td>2</td>
<td>Manpower</td>
</tr>
</tbody>
</table>

Delay 81 – Material availability
No drill available to move to worksite.

Delay 145 – Drill move
Moving in and out twice.

Delay 132 – Prepping drill site
Clean up with scoop. Checking holes with blasters.

Delay 150 – Down for maintenance / Repair
Drill overheating, broken hose, changing boom.

Delay 148 – Other process in stope
Construction crew installing vent.
Stope Analysis 71-GWS-ST

Development end date: 12 November 2008

Cablebolt Drilling:
  Planned days: 
  Actual start date: N/A
  Actual workdays: 
  Delay: 

Cablebolt Installation:
  Planned days: 
  Actual start date: N/A
  Actual workdays: 
  Delay: 

Raisebore:
  Planned days: 10.5
  Actual start date: 16 November 2009
  Actual workdays: 10
  Delay: NO

Drilling:
  Planned days: 6.2
  Actual start date: 15 April 2010
  Actual workdays: 13
  Delay: 6.8

Pre-drilling:
  Designed: 1058.0
  Production Drilling: 1440.4
  Cleaning: 39.0
  Redrilling: 0.0

Blasted:
  First blast Toes
  Location of Raise Left side of the T slot

After blast:
  Designed: 571.0
  Production Drilling: 1089.77
  Cleaning: 769.5
  Redrilling: 95.85

Turnover
  Previous stope 70-826-ST
Link type: VOID
Fill end date: 27 April 2010
Turnover days: 6
Drill end date: 27 April 2010
Load date: 1 May 2010
Blast date: 2 May 2010
Muck start: 3 May 2010

Order of activities:
Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): N/A
- Lag 2 (CB Installing – Raiseboring): N/A
- Lag 3 (Raiseboring – Drilling): 137
- Lag 4 (Drilling – Loading): 4
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 1

Critical activity:
Drilling was the critical activity. If the drilling hadn’t suffered a delay, it would have been ready in time and be loaded in time to blast right at the end of filling. However, the drilling did suffer a delay, therefore causing a turnover lag of six days.
The main problems with drilling were scheduling problems which could have been predicted.
Given the excessive raisebore-to-drill lag of 137 days, it might have been wise to move the drill in a couple of days earlier to allow enough time for other activities in the stope.

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
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<tbody>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stope</td>
</tr>
<tr>
<td>3 E Planning And Communication</td>
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<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
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<tr>
<td>149 B Drilling, Raise bore And Development</td>
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<tr>
<td>150 B Drilling, Raise bore And Development</td>
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</tr>
<tr>
<td>2 I Manpower</td>
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</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
</tr>
</tbody>
</table>

The first blast was a toe-shot therefore cleaning of ring 1 and some slot holes was required.
Extra drilling: 2.8 days
Set up & Move in delay: 1.5
Unaccounted delay: 5.3
Delay 148 – Other process in stope
Construction crew was building a wall next door, took cable, vent, air and water.

Delay 145 – Drill move
Moving drill in, moving drill out, drill moving back in for some final drilling and cleaning.

Delay 150 – Down for Maintenance / Repair / Drill failure
Problems with rods handler

Delay 132 – Prepping drill site
Installing cable, hanging vent, getting mark up, mucking out drill site.

Delay 149 – No driller available
Driller is on vacation.

Delay 1 – LHB / Gas Check
Gas check.

Delay 51 – Stuck Rods
Rods are stuck.

Delay 2 - Meeting
Safety meeting.
**Stope Analysis 73-846-ST**

Development end date: **24 march 2010**

**Cablebolt Drilling:**
- Planned days: 14.9
- Actual start date: 24 January 2010
- Actual workdays: 21
- Delay: 6

**Cablebolt Installation:**
- Planned days: 11.9
- Actual start date: 23 February 2010
- Actual workdays: 2
- Delay: NO

**Raisebore:**
- Planned days: 9.6
- Actual start date: 28 March 2010
- Actual workdays: 5
- Delay: NO

**Drilling:**
- Planned days: 6.6
- Actual start date: 14 April 2010
- Actual workdays: 10
- Delay: 3.4

**Pre-drilling:**
- Designed: 1127.5
- Production Drilling: 1432.2
- Cleaning: 133.5
- Redrilling: 34

**Blasted:**
- Toes / no toes: TOES
- Location of Raise: In the middle of the fanned slot

**After blast:**
- Designed: 566.7
- Production Drilling: 783.24
- Cleaning: 1897.9
- Redrilling: 276.29
Previous stope: 70-826-ST
Link type: VOID
Fill end date: 27 April 2010
Turnover days: -1
Drill end date: 23 April 2010
Load date: 24 April 2010
Blast date: 25 April 2010
Muck start: 26 April 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
Lag 1 (CB Drilling – CB Installing): 10
Lag 2 (CB Installing – Raiseboring): 32
Lag 3 (Raiseboring – Drilling): 12
Lag 4 (Drilling – Loading): 1
Lag 5 (Loading – Blasting): 1
Lag 6 (Blasting – Mucking): 1

Critical activity:
The turnover was -1 day. This is a very good result for a Void link.
There were small delays in Cablebolt Drilling and Production Drilling activities. The biggest impact was due to the lag times between activities. All in all did this not result in stope slippage.

There was a delay in the Cablebolt drilling, but since this was done well in advance, this did not influence the muck start date of the stope.
### Stope Analysis 73-943-ST

**Development end date:** 25 October 2009

#### Cablebolt Drilling:
- **Planned days:** 2.6
- **Actual start date:** 4 November 2009
- **Actual workdays:** 9.0
- **Delay:** 6.4

#### Cablebolt Installation:
- **Planned days:** 2.1
- **Actual start date:** 12 December 2009
- **Actual workdays:** 5.0
- **Delay:** 2.9

#### Raisebore:
- **Planned days:** 9.7
- **Actual start date:** 23 November 2009
- **Actual workdays:** 9.0
- **Delay:** NO

#### Drilling:
- **Planned days:** 4.9
- **Actual start date:** 7 December 2009
- **Actual workdays:** 41.0
- **Delay:** 36.1

#### Pre-drilling:
- **Designed:** 845.3
- **Production Drilling:** 2090.1
- **Cleaning:** 34.75
- **Redrilling:** 0.0

#### Blasted:
- **First blast** SLOT
- **Location of Raise** in the middle of the parallel slot
- **After blast**
  - **Designed:** 1213.1
  - **Production Drilling:** 0.0
  - **Cleaning:** 952.03
  - **Redrilling:** 0.0

### Turnover

![Xstrata Copper](image-url)
Previous stope: 75-917-ST
Link type: VOID
Fill end date: 26 January 2010
Turnover days: 2
Drill end date: 15 December 2010
Load date: 16 January 2010
Blast date: 27 January 2010
Muck start: 28 January 2010

Order of activities:
Cablebolt Drilling – Raiseboring – Drilling – Cablebolt Installation - Drilling

Lag times:
- Lag 1 (CB Drilling – Raiseboring): 11
- Lag 2 (Raiseboring – Drilling): 5
- Lag 3 (Raiseboring – CB Installing): 10
- Lag 4 (Drilling – Loading): 32
- Lag 5 (Loading – Blasting): 6
- Lag 6 (Blasting – Mucking): 1

Critical activity:
Drilling encountered a 36.1 day delay. This could have easily caused a delay in the turnover lag. The filling of the predecessor started 13 days after the end of mucking, this lag pushed the turnover lag down.

Load to Blast:
Loading took three days. Loading was done on January 22. This was a Friday, on Monday January 25th the filling was complete, blast had to wait for cablebolt installation.

There was no competing stope link.
Stope Analysis 73-S34-ST

Development end date: **19 augustus 2009**

Cablebolt Drilling:
- Planned days: 12.1
- Actual start date: 20 may 2008
- Actual workdays: 8.0
- Delay: NO

Cablebolt Installation:
- Planned days: 9.7
- Actual start date: 13 june 2008
- Actual workdays: 6.0
- Delay: NO

Raisebore:
- Planned days: 9.8
- Actual start date: 4 october 2009
- Actual workdays: 9.0
- Delay: NO

Drilling:
- Planned days: 5.1
- Actual start date: 23 october 2009
- Actual workdays: 10.0
- Delay: **4.9**

Pre-drilling:
- Designed: 877.5
- Production Drilling: 2133.0
- Cleaning: 42.5
- Redrilling: 0.0

Blasted:
- First blast
- Location of Raise: middle of slot

After blast:
- Designed: 886.9
- Production Drilling: 0.0
- Cleaning: 670.56
- Redrilling: 133.51

Turnover
Previous stope: 70-867-ST
Link type: VOID
Fill end date: 16 September 2009
Turnover days: 52
Drill end date: 1 November 2009
Load date: 3 November 2009
Blast date: 5 November 2009
Muck start: 7 November 2009

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 46
- Lag 2 (Raiseboring – Drilling): 10
- Lag 3 (Drilling – Loading): 2
- Lag 4 (Loading – Blasting): 2
- Lag 5 (Blasting – Mucking): 2

Critical activity:
Drillbook asked to drill slot, and blast toes. The whole slot was drilled off, causing a delay in drilling as well as significant cleaning and redrilling after the first blast. All the extra drilling accounts for the delays in drilling.

The 52 day turnover lag is caused by:
1. Drill delay: 4 days
2. Raiseboring – Drilling lag: 10 days = 7 day delay
3. Development – Raiseboring lag: 46 days = 43 days delay.

The late move-in date of the raisebore causes the turnover lag.
The raisebore was moved in late because extensive rehab was to be done on 73 level, in the 01S and in 73-S30 XC. The need of this rehab was caused by the rockburst in January. A Seisic study was conducted to come up with the best plan for rehabilitation.
Rehab on 73 level started in July and was done on November 4th. The blast had to wait for the finish of rehab and the installation of enhanced support in the intersections in the 73-01 S. From the end of July until the first blast, the work continued non stop. 1202 hours during 116 days were spent on the installation of enhanced support.

Remote drilling was required for some holes, this stopped the other activities on the level. Due to the high level of activities happening on this level, some shifts there was not enough power for all activities.
This delay is mainly driven by the need to install enhanced support in the intersections in the 01.
Stope Analysis 75-917-ST

Development end date: 4 October 2009

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Raisebore:
- Planned days: 10.4
- Actual start date: 10 September 2009
- Actual workdays: 8.0
- Delay: NO

Drilling:
- Planned days: 7.2
- Actual start date: 12 October 2009
- Actual workdays: 57.0
- Delay: 49.8

Pre-drilling:
- Designed: 1232.7
- Production Drilling: 1892.1
- Cleaning: 1140.23
- Redrilling: 0.0

Blasted:
- First blast Toes
- Location of Raise middle of fanned slot

After blast:
- Designed: 531.4
- Production Drilling: 0.0
- Cleaning: 526.39
- Redrilling: 0.0

Turnover
- Previous stope 77-917-ST
- Link type: VOID
- Fill end date: 1 September 2009
- Turnover days: 100
- Drill end date: 7 December 2009
- Load date: 7 December 2009
<table>
<thead>
<tr>
<th>Blast date:</th>
<th>9 December 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muck start:</td>
<td>10 December 2009</td>
</tr>
</tbody>
</table>

Order of activities:
Rehab – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 17
- Lag 2 (Raiseboring – Drilling): 24
- Lag 3 (Drilling – Loading): 0
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 1

Critical activity:
The turnover lag is solely caused by the rockburst in June. Significant rehab needed to be done on 75 level, which made the stope inaccessible. In August, a driving layout was issued to create a new drawpoint (7505 FR). This 7505 FR was driven from September 9 to September 25 and the last slash was taken October 4. The Rehab on 75 level took place in from the June rockburst on to after the first blast, spreading out the drilling due to conflicts of activities on level. Development of the overcut was finished by August 24, this pushed out the move in date of the raisebore.

Cause: late development / rehab due to rockburst.

(June 2008) First driving layout: extension of 75-93 XC to 75-91 XC (same drift, different name). Drive 75-917 SL off to the SE.
(May 2009) Blockplan: 75-90a XC off 75-90 XC since 75-917 SL off 75-91 XC is not accessible for scoop.
(June 15th 2009) Rockburst: Nuttli 3.1 event in 75-01S.
(June 26 2009) New driving layout: drive 75-95 off of 75-97 XC
(July 28, 2009) Drift progressed till 75-95 XC “start”: 24 meters.
(Aug 28 2009) Drift progressed till start of 7505 FR: 22 m
(27 sept 2009) 7505 FR done till last round before BT: 22 m
(4 oct 2009) last round BT.
(7 oct 2009) support in wall needed before mining stope

Several intersections on 75 level had to be rehabbed and enhanced support had to be installed. This was originally linked to the blast of the 75-956-ST but due to ground control considerations, it was decided that this needed to be in place for the blast of 75-917-ST. Rehab in the 75-90 XC, 7505 FR, 75 Level Access, 7501 N, 7501 S, 75-95 XC, 74-92 XC and 74 Level Access took place every day, starting after the June rock burst, and continued after the first blast in 75-917-ST. This rehab delayed the blast date of the stope, which was reason to move the drill out and back in 20 days later. By the time the drill moved back in, the holes were squeezing, extensive cleaning and redrilling was required.
This delay is completely driven by the need to install enhanced support in the intersections in the 01.
**Stope Analysis 75-956-ST**

Development end date: **22 January 2010**

**Cablebolt Drilling:**
- Planned days: 9.3
- Actual start date: 22 November 2009
- Actual workdays: 5
- Delay: NO

**Cablebolt Installation:**
- Planned days: 7.4
- Actual start date: 23 February 2010
- Actual workdays: 2
- Delay: NO

**Raisebore:**
- Planned days: 11.2
- Actual start date: 8 February 2010
- Actual workdays: 13
- Delay: 1.8

**Drilling:**
- Planned days: 11
- Actual start date: 16 March 2010
- Actual workdays: 41
- Delay: **29.7**

**Pre-drilling:**
- Designed: 1939.8
- Production Drilling: 1823.38
- Cleaning: 184.7
- Redrilling: 325.08

**Blasted:**
- First blast: Upholes from UC
- Location of Raise: In the middle of the fanned slot
- 1 ring behind slot.

**After blast:**
- Designed: 437.3
- Production Drilling: 756.84
- Cleaning: 639.76
- Redrilling: 240.78

Turnover
Previous stope: 78-957-ST
Link type: VOID
Fill end date: 17 April 2010
Turnover days: 13
Drill end date: 26 April 2010
Load date: 28 April 2010
Blast date: 29 April 2010
Muck start: 30 April 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – Raiseboring): 74
- Lag 2 (Raiseboring – CB Installing): 2
- Lag 3 (CB Installing – Drilling): 20
- Lag 4 (Drilling – Loading): 2
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 1

Critical activity:
Drilling is the critical activity with a delay of almost 30 days.
Cablebolting of the overcut and raiseboring was finished well in time for the drill to move in.
Drill moved in at a reasonable date. Bad ground (a fault) caused lots of problems while drilling the slot. The drill (a solo) was moved out and left idle for five days. Another drill (also a solo) moved back in for another try at drilling. The problems with bad ground still existed.
The decision was made to drill upholes from the undercut as to avoid the fault. The undercut was not safe enough for drilling, cablebolts had to be installed. This cause a significant delay in the drilling.

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<th>DRILL (hrs)</th>
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</thead>
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<td>Other process in stope</td>
</tr>
<tr>
<td>138 E Planning And Communication</td>
<td>Poor line up/planning</td>
</tr>
<tr>
<td>150 B Drilling, Raise bore And Development</td>
<td>Down for Maintenance/Repair</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods</td>
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<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
</tr>
<tr>
<td>144 B Drilling, Raise bore And Development</td>
<td>Ground conditions</td>
</tr>
<tr>
<td>19 E Planning And Communication</td>
<td>Work Site Not Ready</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
<tr>
<td>151 B Drilling, Raise bore And Development</td>
<td>No drill plan</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting</td>
</tr>
</tbody>
</table>
Delay 148 – Other process in stope
Rehabbing stope undercut. Rehab involved cablebolting, which had to be done because upholes where drilled in stope.

Delay 138 – Poor line up / planning
Stope was idle for 5 days. Can not find any explanation or other activities. Stope disappeared from drilling-priority list.

Delay 150 – Down for Maintenance / Repair / Drill failure
Broken and missing bolts, ripped off rubbers, rod arm adjustment, compressor belt

Delay 145 – Drill move
Move drill in and out. Three times.

Delay 51 – Stuck rods
Rods stuck in holes.

Delay 132 – Prepping drill site
Setting up drill, cleaning up slot, reroute drill cable.

Delay 144 – Ground conditions
Bad ground.

Delay 19 – Work site not ready
Site needed cleanup but no scoop available for cleanup.

Delay 1 – LHB / Gas Check
Gas checks.

Delay 151 – No drill plan
Problems drilling holes to full length. Waiting for new plan.

Delay 2 - Meeting
Crew meeting.

Delay 2 – Other blasting
Blasting Orepass on level.

Delay 29 – Poor ventilation
Heavy dust on level.
## D Mine Block 2

### Stope Analysis 78-957-ST

<table>
<thead>
<tr>
<th>Process</th>
<th>Planned days</th>
<th>Actual start date</th>
<th>Actual workdays</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development</td>
<td></td>
<td>7 january 2009</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Cablebolt Drilling</td>
<td>10.2</td>
<td>24 February 2009</td>
<td>31</td>
<td>20.9</td>
</tr>
<tr>
<td>Cablebolt Installation</td>
<td>8.1</td>
<td>10 April 2009</td>
<td>5</td>
<td>NO</td>
</tr>
<tr>
<td>Raisebore</td>
<td>9.2</td>
<td>4 September 2009</td>
<td>8</td>
<td>NO</td>
</tr>
<tr>
<td>Drilling</td>
<td>4.5</td>
<td>1 December 2009</td>
<td>72</td>
<td>67.5</td>
</tr>
</tbody>
</table>

### Pre-drilling:

- Designed: 779.7
- Production Drilling: 1342.22
- Cleaning: 621.95
- Redrilling: 106.07

### Blasted:

- First blast: Upholes from UC
- Location of Raise: Middle of fanned slot

### After blast:

- Designed: 839.1
- Production Drilling: 510.6
Cleaning: 454.78
Redrilling: 438.29

Turnover

Previous stope: 75-917-ST
Link type: VOID
Fill end date: 26 January 2010
Turnover days: 18
Drill end date: 10 February 2010
Load date: 12 February 2010
Blast date: 12 February 2010
Muck start: 13 February 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:

- Lag 1 (CB Drilling – CB Installing): 15
- Lag 2 (CB Installing – Raiseboring): 143
- Lag 3 (Raiseboring – Drilling): 80
- Lag 4 (Drilling – Loading): 2
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
Drilling started on December 2nd, 2009. Drilled for three days, problems with can-cable and hydraulic hose. Drill moved to 75 shop on December 5th. On December 6th, drill moved to 73-943-ST. 78-957-ST disappeared from drill-list.
On December 25th, 78-957-ST suddenly appears again on drill-list (production line-up), on priority 1. MR7 moves in, is ready to drill but there is crew working below.

The ground is broken up and “crumbling”, a new drill plan is made: upholes from undercut. Undercut needs to be Rehabbed. Drill is moved to undercut, upholes are drilled and blasted as toes of stope. Stope is primary abutment stope in hangingwall, there is a major fault running through the slot. The available resources were not applied in the most efficient way.

Rehab taking place in undercut from January 26 to February 3 and on February 20.
(Jan 26; 27; 28; 29; Feb 1; 2; 3; 20)

Extra drilling: 8.5 days
Move in & set up delay: none
Unaccounted delays: 57.4 days
Delay 151 – No drill plan
- Drill broke down, stope disappeared from priority list (20 days).
- MR7 drill cannot drill holes. Decision made to drill upholes. Waiting for decision, design and new print.

Delay 148 – Other process in stope
Undercut needed rehab before drilling upholes.

Delay 145 – Drill move
Drill moved in, broke down, moved out, drill moved in, couldn’t drill, moved out of overcut, moved in to undercut. Three drill moves.

Delay 144 – Ground conditions
Broken ground, “crumbling” ground, very hard to drill.

Delay 132 – Prepping drill site
Changing to 6” holes, needed 6” casing, rods, hammer. Scaling and mucking out after rehab.

Delay 81 - Material availability
Availability of drill rods, hammer, casing
**Stope Analysis 78-GW8-ST**

**Development end date:** 11 November 2008

**Cablebolt Drilling:**
- **Planned days:** 8.4
- **Actual start date:** 21 April 2009
- **Actual workdays:** 22.0
- **Delay:** 13.6 days

**Cablebolt Installation:**
- **Planned days:** 6.7
- **Actual start date:** 14 June 2009
- **Actual workdays:** 11.0
- **Delay:** 4.3 days

**Raisebore:**
- **Planned days:** 9.8
- **Actual start date:** 18 September 2009
- **Actual workdays:** 7.0
- **Delay:** NO

**Drilling:**
- **Planned days:** 22.0
- **Actual start date:** 27 September 2009
- **Actual workdays:** 8.0
- **Delay:** NO

**Pre-drilling:**
- **Designed:** 1146.3
- **Production Drilling:** 1395.2
- **Cleaning:** 40.0
- **Redrilling:** 0.0

**Blasted:**
- **First blast Location of Raise Slot**
- **Middle of fanned slot.**

**After blast:**
- **Designed:** 574.7
- **Production Drilling:** 431.29
- **Cleaning:** 224.04
- **Redrilling:** 0.0
Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): 11
- Lag 2 (CB Installing – Raiseboring): 4
- Lag 3 (Raiseboring – Drilling): 2
- Lag 4 (Drilling – Loading): 3
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
A 5 day turnover for a void link is more than necessary.
The lags between activities from CB Installation onwards are reasonable lags for the activities concerned. Drilling nor raiseboring suffered a delay. The muck rate and the fill rate of the preceding stope are both as scheduled.

There is a big lag between CB Drilling and CB Installing; also, both CB Drilling and CB Installation are done in phases, with significant gaps in between the workdays. These gaps are caused by conflicting activities between the cablebolt activities and the development and rehab on the 7700 level. Cablebolting moved on and off GF log several times. This was caused by a shortage in cablebolt capacity. We did not have enough equipment and not enough manpower to meet the requested amount of cablebolting. Machine Roger had only one drill on site. The delay in Cablebolt Drilling is caused by scheduling conflicts in cablebolt drilling and rehab. On top of that, the capacity was tight since both enhanced support and the start of block 4 required cablebolt drilling.

Rehab / enhanced support was linked to a location, in this case the 78-GW8-ST and accordingly prioritized in the production schedule. No signs of diamond drilling in 77 pillar interfering with cablebolting.

CAUSE: Rehab / Development & Cablebolt Capacity
Stope Analysis 79-994-ST

Development end date: 3 December 2008

Cablebolt Drilling:
- Planned days: 6.8
- Actual start date: 19 January 2010
- Actual workdays: 6
- Delay: NO

Cablebolt Installation:
- Planned days: 5.4
- Actual start date: 16 February 2010
- Actual workdays: 3
- Delay: NO

Raisebore:
- Planned days: 9.7
- Actual start date: 18 December 2009
- Actual workdays: 11
- Delay: 1.3

Drilling:
- Planned days: 8.6
- Actual start date: 27 March 2010
- Actual workdays: 38
- Delay: 30.6

Pre-drilling:
- Designed: 1474.1
- Production Drilling: 1763.25
- Cleaning: 1617.99
- Redrilling: 1132.24

Blasted:
- First blast
- Location of Raise
- Toes of slot
- Middle of fanned slot
- 3 rings behind slot

After blast:
- Designed: 583.0
- Production Drilling: 1096.07
- Cleaning: 1023.83
- Redrilling: 32.92

Turnover
Previous stope: 78-957-ST  
Link type: VOID  
Fill end date: 17 April 2010  
Turnover days: 20  
Drill end date: 3 May 2010  
Load date: 5 May 2010  
Blast date: 6 May 2010  
Muck start: 7 May 2010

Order of activities: Raiseboring - Cablebolt Drilling – Cablebolt Installation – Drilling

Lag times:
- Lag 1 (Raiseboring - CB Drilling): 21
- Lag 2 (CB Drilling – CB Installing): 23
- Lag 3 (CB Installing – Drilling): 35
- Lag 4 (Drilling – Loading): 2
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 1

Critical activity:
Both Raiseboring as well as Production Drilling suffered delays. Also, big lag times can be observed.
The real problem however, is the delay in production drilling, since the drilling started well in time for the stope to be ready on time, but the drill delays prevented that and created a turnover lag of 20 days.

Drilling:
Extra drilling: 20.3 days
Move in and set up delays: 0.5 days
Unaccounted delays: 16.8 days

Stope design:
Raise was in middle of drift, three rings behind the slot. The raise was placed there, because the undercut had a (already developed) T slot in place. The decision was made not to take slashes in the undercut, but to put the raise in the middle of the stope, and take a toe shot.
Ground control had warned for high stresses in the abutment.

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Planning And Communication</td>
<td>117.0</td>
</tr>
<tr>
<td>150 Drilling, Raise bore And Development</td>
<td>60.5</td>
</tr>
<tr>
<td>138 Planning And Communication</td>
<td>50.0</td>
</tr>
<tr>
<td>51 Drilling, Raise bore And Development</td>
<td>37.0</td>
</tr>
<tr>
<td>144 Drilling, Raise bore And Development</td>
<td>32.0</td>
</tr>
</tbody>
</table>
Delay 132 - Prepping drill site
setting up drill, cutting grading, repairing hoses

Delay 144 – Ground conditions
Bad, broken ground, looks like gravel. Makes it harder to drill, you need to be more careful when drilling.

Delay 145 – Drill move
Drill (Solo) moved in, drilled, holes were checked by blasters, drill moved out, stope sat idle for three days, no blast, another drill (ITH) moved back in, drilled, then drill moved out and toes of slot were blasted.

Delay 148 – Other process in stope
Blasters checking holes to see if the holes are good enough to load.

Delay 150 – Down for maintenance / Repair / Drill failure
Problems with hydraulic hoses.

Delay 47 – Drilling conflicts
Trying to unplug the raise while men were working on the vent in the undercut.

Delay 51 – Stuck Rods
Bad ground causing rods to get stuck. Ground is squeezing.

Delay 79 – Water problem
No water available.

Delay 81 – Material availability
Needed bull hose.

Delay 138 – Poor line up / Planning
Stope sat idle for three days because there was no drill available. Was priority 5, drill came back in as priority 1 (on drill priority list).

Delay 1 – LHB / Gas Check
Gas checks. Almost every day 1 hour.

Delay 93 – Repair ventilation
Repairing vent.

Delay 117 – Flood
Level was flooded.

Delay 119 – Repair of workplace
Pipes in 01 were damaged, needed to repair these.

Delay 120 – Seismicity
Seismic bump on 74 level.

Delay 2 - Meeting
Safety meeting.
Stope Analysis 79-GW7-ST

Development end date: 27 December 2009

Cablebolt Drilling:
  Planned days: 79
  Actual start date: N/A
  Actual workdays: N/A
  Delay: 0

Cablebolt Installation:
  Planned days: GW7-ST
  Actual start date: N/A
  Actual workdays: N/A
  Delay: 0

Raisebore:
  Planned days: 10.4
  Actual start date: 9 January 2010
  Actual workdays: 7.0
  Delay: NO

Drilling:
  Planned days: 12.9
  Actual start date: 16 January 2010
  Actual workdays: 14
  Delay: 1.1

Pre-drilling:
  Designed: 2210.0
  Production Drilling: 2205.2
  Cleaning: 2.0
  Redrilling: 19.0

Blasted:
  First blast: Toes
  Location of Raise: At the right side in the T.

After blast:
  Designed: 0.0
  Production Drilling: 0.0
  Cleaning: 962.65
  Redrilling: 0.0

Turnover
Previous stope: 78-GW8-ST
Link type: PYRAMID
Fill end date: 13 December 2009
Turnover days: 54
Drill end date: 29 January 2010
Load date: 1 February 2010
Blast date: 4 February 2010
Muck start: 5 February 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development– Raiseboring): 13
- Lag 2 (Raiseboring – Drilling): 0
- Lag 3 (Drilling – Loading): 3
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 1

Critical activity:
This is a pyramid link. All activities are in the critical path. Development through paste started on December 17, fairly soon after the end of filling since the paste needs 2 to 3 days cure time before development can start. In 18 days, 19 meters of development were achieved. This is a good rate for development.

On January 4 2010, the development was done and the raisebore pad could be poured. The raisebore moved in on January 9th, leaving 4 days to mark up and pour the pad. This is a reasonable “delay”.

The next stope in the sequence could only be developed after the installation of the culvert. Therefore this stope did not have high priority since the culvert was in the critical path.
Stope Analysis 80-031-ST

Development end date: **23 december 2008**

**Cablebolt Drilling:**
- Planned days: 9.9
- Actual start date: 1 february 2009
- Actual workdays: 10.0
- Delay: NO

**Cablebolt Installation:**
- Planned days: 7.9
- Actual start date: 18 march 2009
- Actual workdays: 12.0
- Delay: 4.1

**Raisebore:**
- Planned days: 10.6
- Actual start date: 22 february 2009
- Actual workdays: 7.0
- Delay: NO

**Drilling:**
- Planned days: 6.3
- Actual start date: 10 october 2009
- Actual workdays: 15.0
- Delay: 8.7

**Pre-drilling:**
- Designed: 1087.6
- Production Drilling: 2077.4
- Cleaning: 40.5
- Redrilling: 0.0

**Blasted:**
- First blast slot
- Location of Raise in middle of slot

**After blast:**
- Designed: 645.9
- Production Drilling: 0.0
- Cleaning: 929.03
- Redrilling: 0.0

Turnover
Previous stope: 80-011-ST
Link type: VOID
Fill end date: 6 October 2009
Turnover days: 23
Drill end date: 24 October 2009
Load date: 26 October 2009
Blast date: 29 October 2009
Muck start: 29 October 2009

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
Lag 1 (CB Drilling – Raiseboring): 12
Lag 2 (Raiseboring – CB Installing): 17
Lag 3 (CB Installing – Drilling): 195
Lag 4 (Drilling – Loading): 2
Lag 5 (Loading – Blasting): 2
Lag 6 (Blasting – Mucking): 0

Critical activity:
A 20 day void link is excessive. Drilling suffered a 8.7 day delay. Even without this, the drill was moved in late, while the rest of the activities were done well in advance.

The 80-011-ST was filled with waste. The haul route for the trucks interfered with the drill location of the 80-031-ST. The drill could not possible move in before the waste filling was done. Drilling became part of the critical path. Therefore the delay in drilling is the only delay influencing the turnover lag.

Drilling:
Extra drilling: 6.9 days
Delays accounted for in drill rate: 1.3 days
Delays in SIMS: 8.5 days

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>149 B Drilling, Raise bore And Development</td>
<td>No driller available 60,0</td>
</tr>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time 33,5</td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stope 30,0</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure 23,0</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site 15,5</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting 3,0</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods 1,5</td>
</tr>
<tr>
<td>6 I Manpower</td>
<td>Training 1,5</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check 1,0</td>
</tr>
</tbody>
</table>
Delay 149 – No driller available
Driller is on vacation.

Delay 3 – Travel time
Travelling from and to worksite, lunch, calling in for working alone.

Delay 148 – Other process in stope
No power on level – drill cable was blasted

Delay 65 – Drill failure
Hydraulic hose broke twice, pito jaws, splash guard

Delay 132 – Prepping drill site
Changing grating, changing vent, checking holes
**Stope Analysis 80-072-ST**

Development end date: **5 march 2010**

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay: 

Raisebore:
- Planned days: 10.4
- Actual start date: 21 march 2010
- Actual workdays: 9.0
- Delay: NO

Drilling:
- Planned days: 5.4
- Actual start date: 29 march 2010
- Actual workdays: 12
- Delay: 6.6

Pre-drilling:
- Designed: 929.2
- Production Drilling: 988.4
- Cleaning: 36.4
- Redrilling: 62.5

Blasted:
- First blast
- Location of Raise

After blast:
- Designed: 986.7
- Production Drilling: 903.6
- Cleaning: 284.3
- Redrilling: 0

Turnover
Previous stope: 82-072-ST
Link type: UP
Fill end date: 27 March 2010
Turnover days: 17
Drill end date: 9 April 2010
Load date: 12 April 2010
Blast date: 13 April 2010
Muck start: 13 April 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
- Lag 1 (Development – Raiseboring): 16
- Lag 2 (Raiseboring – Drilling): 1
- Lag 3 (Drilling – Loading): 3
- Lag 4 (Loading – Blasting): 1
- Lag 5 (Blasting – Mucking): 0

Critical activity:
Raisebore pad was poured on March 19 Night Shift.
Ground Control instrumentation was installed in slot, this took one week after the end of development.
On March 18, worksite was ready to pour pad. Previous inspection was before the installing of ground control instruments. Installation of ground control instrumentation took one week.
There are delays in hand-over from development to ground control and from ground control to raiseboring.

Causes: other activities in stope.

Development of the overcut slot was late, because the development of the overcut drift was late. Driving this (new) crosscut started in November 2009. The stope first appeared in the 18-month plan in September 2009. It was then pulled forward, leaving less time for development.

Root cause: changes in schedule and planning.

18-month plan
9-Jan-09: no 80-072-ST.
19-Mar-09: 80-071-ST is out of plan. 80-073-ST muck start 1-Apr-10. Dev start 7-Dec-09; dev end 7-Jan-10.
14-Apr-09: 80-071-ST still out of plan. 80-073-ST muck start 1-Apr-10. Dev start 22-Nov-09; dev end 29-Dec-09.

Monthly plan: first appearances December Month Plan (nov 22 2009).

EPS Schedule:
November: 80-072-ST development start: 1 nov; end 28 dec 2009.
Stope Analysis 82-072-ST

Development end date: 12 October 2009

Cablebolt Drilling:
  Planned days: 82-ST
  Actual start date: N/A
  Actual workdays: Delay:

Cablebolt Installation:
  Planned days: 82-ST
  Actual start date: N/A
  Actual workdays: Delay:

Raisebore:
  Planned days: 10.2
  Actual start date: 14 November 2009
  Actual workdays: 5.0
  Delay: NO

Drilling:
  Planned days: 9.4
  Actual start date: 30 November 2009
  Actual workdays: 9.0
  Delay: NO

Pre-drilling:
  Designed: 1607.2
  Production Drilling: 2339.1
  Cleaning: 0.0
  Redrilling: 0.0

Blasted:
  First blast TOES
  Location of Raise Middle of fanned slot

After blast:
  Designed: 733.9
  Production Drilling: 0.0
  Cleaning: 702.5
  Redrilling: 438.0

Turnover
  Previous stope 80-031-ST
Order of activities:
Development – Raiseboring – Drilling

Lag times:

<table>
<thead>
<tr>
<th>Lag</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag 1 (Development – Raiseboring)</td>
<td>33</td>
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<tr>
<td>Lag 2 (Raiseboring – Drilling)</td>
<td>11</td>
</tr>
<tr>
<td>Lag 3 (Drilling – Loading)</td>
<td>1</td>
</tr>
<tr>
<td>Lag 4 (Loading – Blasting)</td>
<td>2</td>
</tr>
<tr>
<td>Lag 5 (Blasting – Mucking)</td>
<td>0</td>
</tr>
</tbody>
</table>

Critical activity:
Since both raiseboring and drilling did not suffer a delay in the activity itself, the turnover lag is caused by the lags between activities.

These lags indicate poor scheduling, the next activity wasn’t ready to move in right away because it was occupied elsewhere.


The raisebore-drilling lag is 11 days, indicating that no drill was available to move in there earlier. The stope appears on the production line-up directly after the raisebore is done (November 20). Comment made that 3 lengths of each pipe need to be taken down.

The development-raisebore lag is 33 days, this indicates that the development was not the driving problem. On November 5th, the comment was made that the site needed preparation. It takes 9 days to do this and start moving in the raisebore.

GF log:
October 20: 483 next move 82-072-ST.
October 27: 483 next move 82-072-ST.
October 28: 483 next move 65-SL1-ST

65-SL1-ST had earlier muck start date than 82-072-ST and is therefore higher on priority list.
There is no other raisebore available to move in earlier. There is no raisebore print available for mark-ups and pouring pad.

Changes in earlier start date cause conflict in prioritizing the stopes as well as the prints being ready. The change in muck start date is caused by Block Plan discussions for the 82-073-ST. This Block Plan discussion took place so late, that it caused impossible tight scheduling for the 82-072-ST.

Since these revisions were done in October, and the anticipated development end date was the beginning of September, it is obvious that delays could have been anticipated here. 7 days turnover is not too bad considering the big changes in the 18-month plan.

Root cause: late scheduling change due to Block Plan discussions.
Stope Analysis 82-073-ST

Development end date: **26 February 2010**

Cablebolt Drilling:
- Planned days: 5.2
- Actual start date: 23 Augustus 2009
- Actual workdays: 10.0
- Delay: 4.8

Cablebolt Installation:
- Planned days: 4.2
- Actual start date: 7 September 2009
- Actual workdays: 5.0
- Delay: 0.8

Raisebore:
- Planned days: 10.3
- Actual start date: 29 May 2010
- Actual workdays: 12.0
- Delay: 1.7

Drilling:
- Planned days: 6.0
- Actual start date: 21 June 2010
- Actual workdays: 7.0
- Delay: 1.0

Pre-drilling:
- Designed: 1034.6
- Production Drilling: 1069.4
- Cleaning: 42.0
- Redrilling: 0.0

Blasted:
- First blast Slot
- Location of Raise middle of fanned slot

After blast:
- Designed: 2143.2
- Production Drilling:
- Cleaning:
- Redrilling:
Previous stope  80-072-ST
Link type:  PYRAMID
Fill end date:  27 may 2010
Turnover days:  35
Drill end date:  27 June 2010
Load date:  30 June 2010
Blast date:  1 July 2010
Muck start:  1 July 2010

Order of activities:
Development – Raiseboring – Drilling

Lag times:
   Lag 1 (Development – Raiseboring):  92
   Lag 2 (Raiseboring – Drilling):  11
   Lag 3 (Drilling – Loading):  3
   Lag 4 (Loading – Blasting):  1
   Lag 5 (Blasting – Mucking):  0

Critical activity:
A 35 day turnover lag for a pyramid link would be considered a good link, however, in most situations this would include development.
For the 80-072-ST, the bulkhead was placed in the designed location and no rehab or development was needed for the 80-107 xc.

The 35 day turnover lag was driven by the undercut slash that had to be taken for void concerns.
Three days after the raisebore was done, the development crews moved in to prepare the undercut slash. The drill started drilling the day after the undercut slash was taken.

Stope was high priority in drilling, but drill was drilling 90-965-ST which took long time to drill. Turnover could have been shorter if drill prioritizing had been done differently.

A 35 day turnover lag is a good result.
### Stope Analysis 82-934-ST

**Development end date:** 3 September 2009

#### Cablebolt Drilling:
- **Planned days:** 16.8
- **Actual start date:** 3 September 2009
- **Actual workdays:** 22.0
- **Delay:** 5.2

#### Cablebolt Installation:
- **Planned days:** 13.5
- **Actual start date:** 25 September 2009
- **Actual workdays:** 7.0
- **Delay:** NO

#### Raisebore:
- **Planned days:** 9.6
- **Actual start date:** 16 October 2009
- **Actual workdays:** 6.0
- **Delay:** NO

#### Drilling:
- **Planned days:** 22.0
- **Actual start date:** 1 November 2009
- **Actual workdays:** 5.0
- **Delay:** NO

#### Pre-drilling:
- **Designed:** 835.4
- **Production Drilling:** 860.8
- **Cleaning:** 0.0
- **Redrilling:** 0.0

**Blasted:**
- **First blast:** Toes
- **Location of Raise:** Middle of fanned slot

**After blast:**
- **Designed:** 725.4
- **Production Drilling:** 667.1
- **Cleaning:** 248.1
- **Redrilling:** 0.0

#### Turnover
- **Previous stope:** 83-947-ST
- **Link type:** UP
- **Fill end date:** 2 November 2009
- **Turnover days:** 6
- **Drill end date:** 5 November 2009
- **Load date:** 5 November 2009
Blast date: 8 November 2009  
Muck start: 8 November 2009

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 0 (Development – CB Drilling): 0
- Lag 1 (CB Drilling – CB Installing): 1
- Lag 2 (CB Installing – Raiseboring): 15
- Lag 3 (Raiseboring – Drilling): 10
- Lag 4 (Drilling – Loading): 0
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
Only Cablebolt Drilling suffers a delay of 5.2 days.
There is a 15 day lag time between CB installing and Raiseboring, this could be done in 3 days, this is a 12 day delay.
Raiseboring to drilling takes 10 days, this could be 1 day, this is a 9 day delay.

Development of the 80-93 XC was done in a tightly manner, this was a new drift, reason of it being so tight is that it only shows up in the 18-month plan in May 2009. Therefore, every activity including development is in the critical path. Mining of this stope is bound to the copper price, it was put out of plan when the prices went down, but got back into the plan when prices went up. It was mined because it could provide extra muck in the time where the mine was recovering from the rockburst.

Delay in lag 2 and lag 3 are caused by poor drilling line up. Mine wide there was enough capacity in raise bores and drills, but still the drills cannot move in on time. There is not extremely much redrilling and cleaning going on (mine wide) therefore drills should have been available.

18-month plan muck start / dev start / dev end
November: 1 Nov 2009 /
October: 6 Nov 2009 / 16 Sep 09 / 17 Sep 09
September: 25 October 2009 / 31 Aug 09 / 5 Sep 09
Augustus: 25 October 2009 / 2 Aug 09 / 5 Sep 09
July: 2 October 2009 / 7 Jun 09 / 13 Aug 09
June: 2 October 2009 / 7 Jun 09 / 12 Aug 09
May: 12 Sept 2009 / 26 April 09 / 24 Jul 09
April: OUT OF PLAN
D Mine Block 3

Stope Analysis 83-987-ST

Development end date: 8 January 2010

Cablebolt Drilling:
- Planned days: 4.7
- Actual start date: 18 November 2009
- Actual workdays: 5.0
- Delay: 0.3

Cablebolt Installation:
- Planned days: 3.8
- Actual start date: 23 December 2009
- Actual workdays: 3.0
- Delay: 0.8

Raisebore:
- Planned days: 10.2
- Actual start date: 20 January 2010
- Actual workdays: 17.0
- Delay: 6.8

Drilling:
- Planned days: 4.3
- Actual start date: 30 January 2010
- Actual workdays: 7.0
- Delay: 2.7

Pre-drilling:
- Designed: 745.5
- Production Drilling: 900.0
- Cleaning: 73.0
- Redrilling: 70.0

Blasted:
- First blast
- Location of Raise: Far left in T slot

After blast:
- Designed: 508.4
- Production Drilling: 330.7
Cleaning: 440.5
Redrilling: 338.5

Turnover

Previous stope: 84-986-ST
Link type: VOID
Fill end date: 16 February 2010
Turnover days: 4.0
Drill end date: 5 February 2010
Load date: 18 February 2010
Blast date: 20 February 2010
Muck start: 20 February 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:

<table>
<thead>
<tr>
<th>Lag</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag 1</td>
<td>31</td>
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<tr>
<td>Lag 2</td>
<td>16</td>
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<tr>
<td>Lag 3</td>
<td>8</td>
</tr>
<tr>
<td>Lag 4</td>
<td>13</td>
</tr>
<tr>
<td>Lag 5</td>
<td>2</td>
</tr>
<tr>
<td>Lag 6</td>
<td>0</td>
</tr>
</tbody>
</table>

Critical activity:
Even though all activities suffered a delay, the 4 day void link as a turnover, is caused by the lag between drilling and loading. The drilling was finished well in advance.

There is a 5-day gap in the filling of the predecessor, caused by other priorities in the paste filling.
The pasteline for the 84-986-ST was in the way so the scoop could not get to the 83-987-ST to muck out the cuttings from the raisebore (needed for void), blasting could not take place before the pasteline was removed since the drawpoint was unaccessible for the scoop.

This is an inevitable delay.
### Stope Analysis 84-986-ST / 84-966-NIR

<table>
<thead>
<tr>
<th>Development end date:</th>
<th>10 May 2009</th>
<th>27 Sep 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2009</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Cablebolt Drilling:</strong></td>
<td></td>
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<tr>
<td>Planned days:</td>
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<tr>
<td>Actual start date:</td>
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<td>Delay:</td>
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<tr>
<td><strong>Cablebolt Installation:</strong></td>
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<tr>
<td>Planned days:</td>
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<td>Delay:</td>
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<tr>
<td><strong>Raisebore:</strong></td>
<td></td>
<td>(014)</td>
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<tr>
<td>Planned days:</td>
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<td>(464)</td>
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<td>&amp; (MR9)</td>
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<td>Planned days:</td>
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<td>Actual start date:</td>
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<tr>
<td>Actual workdays:</td>
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<tr>
<td>Delay:</td>
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<td><strong>9.1</strong></td>
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<tr>
<td><strong>Pre-drilling:</strong></td>
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<td></td>
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<tr>
<td>Designed:</td>
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<td>848.3</td>
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<tr>
<td>Production Drilling:</td>
<td>1810.5</td>
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<td>Cleaning:</td>
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<td><strong>Blasted:</strong></td>
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<tr>
<td>First blast Location of Raise:</td>
<td></td>
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<tr>
<td>Right side of slot</td>
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<tr>
<td><strong>After blast:</strong></td>
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<tr>
<td>Designed:</td>
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<tr>
<td>Production Drilling:</td>
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</table>
## Turnover

<table>
<thead>
<tr>
<th>Previous stope</th>
<th>83-947-ST</th>
<th>83-947-ST</th>
</tr>
</thead>
</table>

| Link type: | VOID | VOID |
| Fill end date: | 2 november 2009 | 2 nov |

| Turnover days: | 31 | 31 |
| Drill end date: | 1 december 2009 | 28 nov |

| Load date: | 2 december 2009 | 2 dec |
| Blast date: | 3 december 2009 | 3 dec |

| Muck start: | 3 december 2009 | N/A |

## Order of activities:

- Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

### Lag times:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Lag</th>
<th>Activity</th>
<th>Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB Drilling – Raiseboring</td>
<td>6</td>
<td>Dev – RB</td>
<td>12</td>
</tr>
<tr>
<td>Raiseboring – CB Install</td>
<td>5</td>
<td>RB – Drill</td>
<td>18</td>
</tr>
<tr>
<td>CB Install – Drilling</td>
<td>98</td>
<td>Drill – Load</td>
<td>4</td>
</tr>
<tr>
<td>Drilling – Loading</td>
<td>1</td>
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<tr>
<td>Loading – Blasting</td>
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<td></td>
</tr>
<tr>
<td>Blasting – Mucking</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Combined Critical Path

<table>
<thead>
<tr>
<th>Activity</th>
<th>Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dev start – Dev end</td>
<td>79</td>
</tr>
<tr>
<td>Dev OC – RB NIR</td>
<td>12</td>
</tr>
<tr>
<td>RB NIR – Drill ST</td>
<td>7</td>
</tr>
<tr>
<td>Drill ST – Loading</td>
<td>1</td>
</tr>
<tr>
<td>Load – Blast</td>
<td>1</td>
</tr>
<tr>
<td>Blast – MUCK</td>
<td>0</td>
</tr>
</tbody>
</table>

## Critical activity:

The 84-986-ST has a strong relation to the 84-966-NIR, a stope which is blasted as a distress stope. The 84-986-ST and the 84-966-NIR are blasted with the same blast, therefore all preparations for the 84-966-NIR have to be ready in time for the 84-986-ST blast. Due to this strong interconnection and the fact that the two stopes are literally blasted together (one blast letter, one capping), these stopes are considered to be one big project.
The 84-986-ST suffered a 31 day turnover from the 83-947-ST. The 83-947-ST was mucked and filled at the planned rates, this stope was not the cause of the turnover lag.

The drill end date for the 84-966-NIR is November 28. The drill end date for the 84-986-ST is December 1. Even though these dates are very close together and the drill moved back and forth between the 84-966-NIR and 84-986-ST, the drilling driving the blast date, is the drilling of the 84-986-ST. For the 84-966-NIR, the holes were just drilled, no cleaning or redrilling or extensive production drilling was needed.

The decision to use the 84-966-NIR as a distress stope, is made in July 2009. Development needed for the 84-966-NIR is 37 meters in the UC and 45 meters in the OC. The development of the overcut is started on July 10th and finished on September 27th. The development of the undercut is started on August 20 and finished on September 19th.

This means that the site (UC) was available for the raisebore on September 27th. If the raisebore would have moved in on this date, with the actual dates, the 84-966-NIR could have been ready for blasting on November 4th if no activity would be interrupted by the drilling of 84-986-ST.

The worksite on 83 level (drill-location for the 84-986-ST) was ready well in advance. The raisebore was done in June and is out of the critical path. The drill could have started drilling on September 19th, when the development in the undercut was done and no man had to be present. However, the activities on 82 level, 83 level and 84 level were conflicting and could not all take place simultaneously.

The turnover lag is caused by
- the slow development on 82 level. 52 meters in 79 days is too slow for a high priority, straight drift.
- Drilling problems in 84-986-ST:
  o Instructions from drillbook ignored: instructed to drill off complete stope:
    ▪ 911 m drilled in 12 days on ring 1 and 2: had to be redrilled after blast
  o Wrong mark-up of rings:
    ▪ 4 days delayed
  o Inexperienced drillers: no idea what they are doing, couldn’t recognize problems with drilling
  o High stress: very high hole deviation; squeezing holes
  o Bad decision: stick to trying to get whole slot even though positive hole was possible (eventually first blast was positive hole)

Development:
52 meters could have been taken in (52/1.3)=40 days. This is a 39 day delay.

Lags:
Dev OC – RB NIR : 12 days
RB NIR – Drill ST: 7
Total: **19 days**

Combined drilling:
Downholes NIR (82 level) simultaneously with ST holes (83 level).
Upholes NIR (84 level) caused gap in drilling for ST.
Drilling optimal: 3.9 days (ST) + 4.9/2 (NIR) = 6.5 days
Days drilled: 35

**Delay: 28.5 days**
Extra drilling ST: 16.8 days
(the extra drilling in the NIR happened during the simultaneous drilling so doesn’t count for delay)
Moving in and out: 4 days
Accounted for delays (in drill rate): 1.8 days

Unexplained: 12.2 days
Hours recorded add up to 16.7 days. There is 4.5 day “mysterious” delay.
Considering that everything in the critical path is drilled with a Cubex, the planned days should have been more and the delay would have been even less (making the mysterious delay even bigger).

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
</tr>
<tr>
<td>149 B Drilling, Raise bore And Development</td>
<td>No driller available</td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stope</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
</tr>
<tr>
<td>79 D Material &amp; Services</td>
<td>Water problem</td>
</tr>
<tr>
<td>138 E Planning And Communication</td>
<td>Poor line up/planning</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods</td>
</tr>
<tr>
<td>19 E Planning And Communication</td>
<td>Work Site Not Ready</td>
</tr>
<tr>
<td>93 F Ventilation &amp; Blasting</td>
<td>Repair ventilation</td>
</tr>
<tr>
<td>6 I Manpower</td>
<td>Training</td>
</tr>
<tr>
<td>25 E Planning And Communication</td>
<td>Surveyors</td>
</tr>
<tr>
<td>81 D Material &amp; Services</td>
<td>Material availability</td>
</tr>
<tr>
<td>116 H Safety &amp; General Conditions</td>
<td>Accident/incident investigation</td>
</tr>
<tr>
<td>29 F Ventilation &amp; Blasting</td>
<td>Poor ventilation</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting</td>
</tr>
<tr>
<td>139 F Ventilation &amp; Blasting</td>
<td>Central blast/gas check</td>
</tr>
<tr>
<td>47 B Drilling, Raise bore And Development</td>
<td>Drilling conflicts</td>
</tr>
</tbody>
</table>

Delay 3 – Travel Time
Traveling to and from worksite, lunch, calling in for working alone.
Delay 65 – Drill failure
Electrical problems, changed compressor and fixed drill.

Delay 132 – Prepping drill site
Drill moving around, for wrong mark-up, for face to shoot and shotcrete.
Delay 149 – No driller available
Driller is sick.

Delay 148 – Other process in stope
Installing raisecover, shooting face, shotcreting face

Delay 79 – Water problem
No water on level

Delay 138 – Poor line up / planning
Wrong print, Break through not where they should be.

Delay 1 – LHB / Gas Check
Gas checks.

Delay 51 – Stuck Rods
Rods stuck, squeezing ground

Delay 19 – Work site not ready
Work site not ready to move in drill (back to 84-986-ST)

Delay 93 – Repair ventilation
Repair vent, on 82, 83 and 84.
Stope Analysis 86-005-ST

Development end date: **14 March 2010**

Cablebolt Drilling:
- Planned days: 10.5
- Actual start date: 16 March 2010
- Actual workdays: 7
- Delay: NO

Cablebolt Installation:
- Planned days: 8.4
- Actual start date: 29 March 2010
- Actual workdays: 5
- Delay: NO

Raisebore:
- Planned days: 10.3
- Actual start date: 25 March 2010
- Actual workdays: 28
- Delay: **17.7**

Drilling:
- Planned days: 6.8
- Actual start date: 25 April 2010
- Actual workdays: 17
- Delay: **10.2**

Pre-drilling:
- Designed: 1162.3
- Production Drilling: 519.38
- Cleaning: 669.68
- Redrilling: 126.8

Blasted:
- First blast: Toes around the raise
- Location of Raise: Middle of fanned slot

After blast:
- Designed: 2111.7
- Production Drilling: 489.51
- Cleaning: 1154.9
- Redrilling: 135.94

Turnover
- Previous stope: 83-987-ST
Link type: VOID
Fill end date: 19 May 2010
Turnover days: 0
Drill end date: 11 May 2010
Load date: 12 May 2010
Blast date: 12 May 2010
Muck start: 19 May 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:

- Lag 1 (CB Drilling – CB Installing): 7
- Lag 2 (CB Installing – Raiseboring): 7
- Lag 3 (Raiseboring – Drilling): 2
- Lag 4 (Drilling – Loading): 1
- Lag 5 (Loading – Blasting): 0
- Lag 6 (Blasting – Mucking): 7

Critical activity: Raiseboring and Drilling both suffered significant delays. Still the stope does not have a turnover delay. This is mainly due to the fact that the predecessor suffered a delay in muck to fill lag. This because a scoop got buried and the decision was made to paste over the scoop.

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>RB</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td></td>
<td></td>
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<tr>
<td>19 E Planning And Communication</td>
<td></td>
<td></td>
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<tr>
<td>132 B Drilling, Raise bore And Development</td>
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<td>143 B Drilling, Raise bore And Development</td>
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<td>149 B Drilling, Raise bore And Development</td>
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<td></td>
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<td>144 B Drilling, Raise bore And Development</td>
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<td></td>
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<tr>
<td>150 B Drilling, Raise bore And Development</td>
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<td></td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
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<td></td>
</tr>
<tr>
<td>79 D Material &amp; Services</td>
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<td>2 I Manpower</td>
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<td>68 C Mobile Equipment</td>
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<td>51 B Drilling, Raise bore And Development</td>
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<td>12 H Safety &amp; General Conditions</td>
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<tr>
<td>81 D Material &amp; Services</td>
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<td></td>
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<tr>
<td>151 B Drilling, Raise bore And Development</td>
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<td></td>
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<tr>
<td>120 H Safety &amp; General Conditions</td>
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</tbody>
</table>
Raiseboring:
Delay 145 – Drill move
Move raisebore in and out of stope. Moved in, problems with ground support, moving out, Dumas rehabbing, moving back in.

Delay 148 – Other process in stope
Rehad and extra cablebolting.

Delay 19 – Work site not ready
More screen and cablebolts were required.

Delay 132 – Prepping drill site
Setting up drill, repair air, water, vent, electric cable, leveling muckpad, tighten baseplates

Delay 143 – Installing reamer
Install reamer on rods to start reaming.

Delay 149 – No driller available
Driller was needed to help move other drill.

Delay 144 – Ground conditions
Raise got plugged. Needed to clean raise.

Delay 150 – Down for Maintenance / Repair
Drill is down.

Delay 1 – LHB / Gas check
Gas check.

Delay 79 – Water problem
No water available.

Delay 2 – Meeting
Safety meeting

Delay 68 – Scoop failure
Scoop broke down in drift while helping move the drill.

Drilling:

Extra drilling: 1 day
Move in & set up: no delay
Accounted delays: 10.2 days
Delay 51 – Stuck rods
Holes squeeze, rods got stuck.

Delay 148 – Other process in stope
Rehad needed.

Delay 144 – Ground conditions
Holes are squeezing.

Delay 145 – Drill move
Drill moved in and out.

Delay 12 – Unsafe condition
Face plates popping, need ground control to check heading.

Delay 81 – Material availability
Need casing for holes, no casing available on site, have to order casing.

Delay 150 – Down for Maintenance / Repair
Electrical problems on drill.

Delay 151 – No drill plan
Holes keep squeezing, cannot keep open. Need new plan as to what to do.

Delay 1 – LHB / Gas check
Gas check.

Delay 132 – Prepping drill site
Setting up drill after it had to move for rehab.

Delay 120 – Seismicity
Seismic bump on 74 level.
Stope Analysis 86-947-ST

Development end date: **15 April 2010** - OC slot

Cablebolt Drilling:
- Planned days: 4.4
- Actual start date: 22 October 2007
- Actual workdays: 6
- Delay: **1.6**

Cablebolt Installation:
- Planned days: 3.5
- Actual start date: 18 August 2008
- Actual workdays: 3
- Delay: **NO**

Raisebore:
- Planned days: 9.9
- Actual start date: 12 April 2010
- Actual workdays: 25
- Delay: **15.1**

Drilling:
- Planned days: 5.7
- Actual start date: 8 May 2010
- Actual workdays: 11
- Delay: **5.3**

Pre-drilling:
- Designed: 972.5
- Production Drilling: 830.6
- Cleaning: 34.5
- Redrilling: 90.5

Blasted:
- First blast (Part of) Slot
- Location of Raise middle of stope, accessible
- From both sides.

After blast:
- Designed: 1324.1
- Production Drilling: 1679.2
- Cleaning: 617.4
- Redrilling: 6.0
Turnover

- Previous stope: 83-987-ST
- Link type: VOID
- Fill end date: 19 May 2010
- Turnover days: 3
- Drill end date: 18 May 2010
- Load date: 20 May 2010
- Blast date: 21 May 2010
- Muck start: 22 May 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): 296
- Lag 2 (CB Installing – Raiseboring): 600
- Lag 3 (Raiseboring – Drilling): 0
- Lag 4 (Drilling – Loading): 2
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 1

Critical activity: Raiseboring and drilling both suffered a delay, but the raisebore delay is significant larger than the drilling delay, therefore the raisebore delay is the critical delay.

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>RB</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>145</td>
<td>B</td>
<td>Drill move</td>
</tr>
<tr>
<td>148</td>
<td>B</td>
<td>Other process in stope</td>
</tr>
<tr>
<td>65</td>
<td>B</td>
<td>Drill failure</td>
</tr>
<tr>
<td>132</td>
<td>B</td>
<td>Prepping drill site</td>
</tr>
<tr>
<td>149</td>
<td>B</td>
<td>No driller available</td>
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<td>6</td>
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<td>LHB / Gas Check</td>
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<tr>
<td>120</td>
<td>H</td>
<td>Seismicity</td>
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<tr>
<td>51</td>
<td>B</td>
<td>Stuck Rods</td>
</tr>
<tr>
<td>144</td>
<td>B</td>
<td>Ground conditions</td>
</tr>
</tbody>
</table>

Raiseboring:
Delay 145 - Drill move
The pad was not poured on bedrock and had to be re-done. This was only discovered after the drill had moved in and drilled a test hole. When the new pad was poured, the drill moved back in but wouldn’t power up, so the drill had to move back out and was replaced by another drill.

Delay 148 – Other process in stope
The pad was poured on paste, had to be ripped out and poured again. When the raisebore was drilling, another crew needed the vent, shutting down the raisebore (1 hrs).

Delay 65 – Drill failure
Drill wouldn’t power up.

Delay 132 – Prepping drill site:
Installing hangman, checking for bedrock so pad can be poured in right place. Tightening baseplates, cutting rebar. Repairing and moving the ventilation.

Delay 149 – No driller available
1 shift: Therefore not enough men to operate all raisebores.
1 shift: guy was sick

Delay 6 – Training
Worker was trained on 6 yrd scoop.

Delay 4 – Changing location
Driller assigned to stope, but couldn’t drill because drill was down. Had to go to different worksite.

Delay 1 – Gas check
Gas check after blast.

Delay 120 – Seismicity
Seismic bump on 74 level on May 5th 2010.

Drilling:

Extra drilling: 0 days
Move in & set up: NO
Accounted delays: 5.2 days

Delay 51 – Stuck rods
Rods stuck in hole, need extra time to get them out.

Delay 65 – Drill failure
Problems with pito jaws and striking bars.

Delay 149 – no driller available
Not enough licensed drillers to operate all drills.

Delay 145 – Drill move
Moving drill in and out of stope, setting up.

Delay 6 – Training
Driller training on 6 yrd.

Delay 1 – Gas check
Gas check after blast.

Delay 148 – other processes in stope
Construction crew is building muckpads in crosscut next door, using 2 scoops, not enough vent on level.

Delay 132 – Prepping drill site
Hooking up air and water. Moving trailer closer to worksite.

Delay 144 – Ground conditions
Rods got stuck, had to change drill bit.
Stope Analysis 86-988-ST

Development end date: 25 June 2009

Cablebolt Drilling:
  Planned days: 8.9
  Actual start date: 28 June 2009
  Actual workdays: 11
  Delay: 2.1

Cablebolt Installation:
  Planned days: 7.2
  Actual start date: 19 September 2009
  Actual workdays: 4
  Delay: NO

Raisebore:
  Planned days: 11.2
  Actual start date: 23 July 2009
  Actual workdays: 6
  Delay: NO

Drilling:
  Planned days: 7.3
  Actual start date: 1 February 2010
  Actual workdays: 20
  Delay: 12.7

Pre-drilling:
  Designed: 1246.0
  Production Drilling: 1794.8
  Cleaning: 728.2
  Redrilling: 37.0

Blasted:
  First blast
  Location of Raise
  Toes
  Fanned slot at the end of drift.

After blast:
  Designed: 1125.8
  Production Drilling: 550.51
  Cleaning: 1617.11
  Redrilling: 199.65

Turnover
Previous stope: 84-986-ST
Link type: VOID
Fill end date: 16 February 2010
Turnover days: 6
Drill end date: 21 February 2010
Load date: 21 February 2010
Blast date: 22 February 2010
Muck start: 22 February 2010

Order of activities:
Cablebolt Drilling – Raiseboring – Cablebolt Installation – Drilling

Lag times:
- Lag 1 (CB Drilling – Raiseboring): 15
- Lag 2 (Raiseboring – CB Installing): 52
- Lag 3 (CB Installing – Drilling): 132
- Lag 4 (Drilling – Loading): 0
- Lag 5 (Loading – Blasting): 1
- Lag 6 (Blasting – Mucking): 0

Critical activity:
The turnover lag of six days is caused by the delay in drilling. The drill was moved in after the pre-decessing stope was completely mucked out. Had there not been delays in the muck-to-fill lag and the filling itself, the turnover lag would have been larger.

The delays in drilling can be explained by:

Extra drilling: 8.8 days
Move in & set up delays: NO delay
Unaccounted delays: 6.9 days

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 B Drilling, Raise bore And Development</td>
<td>Down for Maintenance/Repair</td>
</tr>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
</tr>
<tr>
<td>120 H Safety &amp; General Conditions</td>
<td>Seismicity</td>
</tr>
<tr>
<td>144 B Drilling, Raise bore And Development</td>
<td>Ground conditions</td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stope</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
</tr>
</tbody>
</table>
Delay 150 – Down for Maintenance / Repair / Drill failure
Problems with water & hydraulic hoses.

Delay 3 – Travel Time
Travel to worksite, calling in when working alone, lunchtime.

Delay 51 – Stuck Rods
Rods stuck in hole.

Delay 1 – LHB / Gas check
Gas check.

Delay 132 – Prepping drill site
Checking holes for blasters.

Delay 120 – Seismicity
Seismicity.

Delay 144 – Ground conditions
Bad ground

Delay 148 – Other process in stope
Borehole survey
Stope Analysis 88-026-ST

Development end date: 2 January 2008

Cablebolt Drilling:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay:

Cablebolt Installation:
- Planned days: 
- Actual start date: N/A
- Actual workdays: 
- Delay:

Raisebore:
- Planned days: 8.5
- Actual start date: 26 January 2010
- Actual workdays: 9
- Delay: 0.5

Drilling:
- Planned days: 19
- Actual start date: 9 April 2010
- Actual workdays: 12
- Delay: NO

Pre-drilling [meters]
- Designed: 752.2
- Production Drilling: 979.02
- Cleaning: 38.4
- Redrilling: 110.96

Blasted:
- First blast SLOT
- Location of Raise In the middle of the fanned slot

After blast [meters]
- Designed: 803.7
- Production Drilling: 822.04
- Cleaning: 0
- Redrilling: 305.43

Turnover
Previous stope       88-083-ST
Link type:          VOID
Fill end date:      14 May 2010
Turnover days:      -7
Drill end date:     21 April 2010
Load date:          22 April 2010
Blast date:         4 May 2010
Muck start:         7 May 2010

Order of activities:
Raiseboring – Drilling

Lag times:
  Lag 1 (CB Drilling – CB Installing): N/A
  Lag 2 (CB Installing – Raiseboring): N/A
  Lag 3 (Raiseboring – Drilling):      64
  Lag 4 (Drilling – Loading):          1
  Lag 5 (Loading – Blasting):          12
  Lag 6 (Blasting – Mucking):          3

Critical activity:
This stope was held up by its predecessor.
Excessive lag times are recorded in lag 3, 5 and 6. No delay in turnover.
Stope Analysis 88-083-ST

Development end date: 31 July 2009

Cablebolt Drilling:
Planned days: 10.1
Actual start date: 21 October 2009
Actual workdays: 13.0
Delay: 2.9

Cablebolt Installation:
Planned days: 8.0
Actual start date: 7 November 2009
Actual workdays: 6.0
Delay: NO

Raisebore:
Planned days: 10.4
Actual start date: 21 September 2009
Actual workdays: 12.0
Delay: 1.6

Drilling:
Planned days: 11.1
Actual start date: 6 January 2010
Actual workdays: 14.0
Delay: 2.9

Pre-drilling:
Designed: 1899.10
Production Drilling: 1457.25
Cleaning: 336.2
Redrilling: 0

Blasted:
First blast: Slot
Location of Raise: end of drift – fanned slot

After blast:
Designed: 254.0
Production Drilling: 812.1
Cleaning: 36.5
Redrilling: 0

Turnover
Previous stope: 87-033-ST
Link type: VOID
Fill end date: 10 February 2010
Turnover days: 0
Drill end date: 19 January 2010
Load date: 5 February 2010
Blast date: 10 February 2010
Muck start: 10 February 2010

Order of activities:
Raiseboring – Cablebolt Drilling – Cablebolt Installation – Drilling

Lag times:
<table>
<thead>
<tr>
<th>Lag</th>
<th>Activity Sequence</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raiseboring – CB Drilling</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>CB Drilling – CB Installing</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>CB Installing – Drilling</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>Drilling – Loading</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>Loading – Blasting</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Blasting – Mucking</td>
<td>0</td>
</tr>
</tbody>
</table>

Critical activity:
The turnover lag for this stope is 0 days. This is a perfect result. Even though small delays were encountered in the different activities, the activities were all done well in time and no turnover delay was encountered. The 87-033-ST was very steadily rockfilled at normal rate.

The excessive lag times are partly caused by the interference from activities of the 88-042-NIR and the preparation of the undercut slash. Due to the steady fill rate for 87-033-ST, this did not lead to a delay.
Stope Analysis 88-9410-ST

Development end date: **4 October 2009**

**Cablebolt Drilling:**
- Planned days: 7.4
- Actual start date: 3 October 2009
- Actual workdays: 13.0
- Delay: **5.6**

**Cablebolt Installation:**
- Planned days: 5.9
- Actual start date: 18 October 2009
- Actual workdays: 2.0
- Delay: NO

**Raisebore:**
- Planned days: 10.7
- Actual start date: 23 October 2009
- Actual workdays: 11.0
- Delay: NO

**Drilling:**
- Planned days: 3.5
- Actual start date: 5 November 2009
- Actual workdays: 13.0
- Delay: **9.5**

**Pre-drilling:**
- Designed: 692.9
- Production Drilling: 1373.3
- Cleaning: 0.0
- Redrilling: 0.0

**Blasted:**
- First blast Slot
  - Location of Raise left side of semi-fanned slot

**After blast:**
- Designed: 744.6
- Production Drilling: 588.6
- Cleaning: 335.3
- Redrilling: 0.0
Turnover

<table>
<thead>
<tr>
<th>Turnover</th>
<th>88-989-ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous stope</td>
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<tr>
<td>Link type:</td>
<td>VOID</td>
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<tr>
<td>Fill end date:</td>
<td>27 October 2009</td>
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<tr>
<td>Turnover days:</td>
<td>26</td>
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<tr>
<td>Drill end date:</td>
<td>17 November 2009</td>
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<tr>
<td>Load date:</td>
<td>17 November 2009</td>
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<tr>
<td>Blast date:</td>
<td>21 November 2009</td>
</tr>
<tr>
<td>Muck start:</td>
<td>22 November 2009</td>
</tr>
</tbody>
</table>

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:

<table>
<thead>
<tr>
<th>Lag</th>
<th>Description</th>
<th>Days</th>
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<tbody>
<tr>
<td>0</td>
<td>Development – CB Drilling</td>
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<tr>
<td>3</td>
<td>CB Drilling – CB Installing</td>
<td>3</td>
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<tr>
<td>4</td>
<td>CB Installing – Raiseboring</td>
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</tr>
<tr>
<td>2</td>
<td>Raiseboring – Drilling</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>Drilling – Loading</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Loading – Blasting</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Blasting – Mucking</td>
<td>1</td>
</tr>
</tbody>
</table>

Critical activity:
No significant lags between activities are recoded. Drilling had a delay of 9.5 days. Cablebolt drilling had a delay of 5.6 days.

Development was late (causing the remaining 9 days delay).
June: OUT of plan
July: muck start 8 Sep 09; dev start 15 May 09; dev end 7 Jun 09
Aug: muck start 21 Oct 09; dev start 8 Aug 09; dev end 31 Aug 09
Sep: muck start 21 Oct 09; dev start 21 Aug 09; dev end 13 Sep 09

In 18-mnth plan, development is high priority since it is in the critical path.

Month Plan
September: priority 2 (87) and spare 2 (87)
Augustus: priority 4 (88) and 10 (87)
July: priority 11 (88)

Priority in Production Engineering Month Schedule does not represent the high priority of this development. This allows the development to be late. Development for the 88-9410-ST competed with the development for 88-989-ST. Also, the UfT project on Pastefilling caused delays in the development, cables from the paste-monitoring were path of the 88-9410-ST mucking and had to be re-routed. 88-947-ST end of filling: 29 July 2008. This leaves plenty of
time to move those cables. The problem of the late development is caused by the prioritizing by production engineering.

Cablebolt Drilling

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>CB Dr</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure</td>
</tr>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time</td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stope</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
</tr>
<tr>
<td>47 B Drilling, Raise bore And Development</td>
<td>Drilling conflicts</td>
</tr>
<tr>
<td>100 H Safety &amp; General Conditions</td>
<td>Heat Stress</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting</td>
</tr>
<tr>
<td>150 B Drilling, Raise bore And Development</td>
<td>Down for Maintenance/Repair</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
</tbody>
</table>

Delay 65 – Drill Failure

Undefined failure

Delay 3 – travel time
Travel to and from worksite, lunch, calling in for working alone

Delay 148 – Other process in stope
Dumas rehabbing on N/S

Drilling:
Slot prints were wrong, it took 3 days to get new prints. 4.5 days for the extra drilling that was done.

Extra drilling: 4.5 days
Accounted delays: 0.7 days
Unaccounted delays: 6.0 days
Explained in delays: 6.7 days

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
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</tr>
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<tbody>
<tr>
<td>3 E Planning And Communication</td>
<td>Travel Time</td>
</tr>
<tr>
<td>65 B Drilling, Raise bore And Development</td>
<td>Drill failure</td>
</tr>
<tr>
<td>132 B Drilling, Raise bore And Development</td>
<td>Prepping drill site</td>
</tr>
<tr>
<td>51 B Drilling, Raise bore And Development</td>
<td>Stuck Rods</td>
</tr>
<tr>
<td>1 F Ventilation &amp; Blasting</td>
<td>LHB / Gas Check</td>
</tr>
<tr>
<td>116 H Safety &amp; General Conditions</td>
<td>Accident/incident investigation</td>
</tr>
<tr>
<td>145 B Drilling, Raise bore And Development</td>
<td>Drill move</td>
</tr>
<tr>
<td>25 E Planning And Communication</td>
<td>Surveyors</td>
</tr>
<tr>
<td>2 I Manpower</td>
<td>Meeting</td>
</tr>
<tr>
<td>148 B Drilling, Raise bore And Development</td>
<td>Other process in stope</td>
</tr>
<tr>
<td>47</td>
<td>B</td>
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<tr>
<td>120</td>
<td>H</td>
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</tbody>
</table>

Delay 3 – Travel Time
Travel to and from worksite, lunch, calling in for working alone

Delay 65 – Drill Failure
No percussion on drill

Delay 132 – Prepping Drill site
Waiting for prints, repairing vent, measuring holes, setting up remote

Delay 51 – Stuck Rods
Stuck rods.

Delay 1 – LHB / Gas Check
Gas check.

Delay 116 – Accident / incident investigation
Accident / incident investigation.

Delay 145 – Drill move
Moving drill from slot to ring 2 and back, moving in and out for surveyors.

Delay 25 – Surveyors
Mark up rings
Stope Analysis 88-S44-ST

Development end date: 4 mar 2010 (undercut) / 2 mar 2008 (overcut)

Cablebolt Drilling:
- Planned days: 11.6
- Actual start date: 14 dec 2009
- Actual workdays: 8
- Delay: NO

Cablebolt Installation:
- Planned days: 9.3
- Actual start date: 5 mar 2010
- Actual workdays: 7
- Delay: NO

Raisebore:
- Planned days: 10.1
- Actual start date: 15 mar 2010
- Actual workdays: 13
- Delay: 2.9

Drilling:
- Planned days: 3.1
- Actual start date: 29 mar 2010
- Actual workdays: 10
- Delay: 6.9

Pre-drilling:
- Designed: 531.2
- Production Drilling: 721.44
- Cleaning: 0
- Redrilling: 66.75

Blasted:
- Toes / no toes
- Location of Raise

After blast:
- Designed: 1339.1
- Production Drilling: 1621.3
- Cleaning: 0
- Redrilling: 21

Turnover
- Previous stope: 88-9410-ST
- Link type: VOID
- Fill end date: 28 feb 2010
- Turnover days: 61
- Drill end date: 7 apr 2010
- Load date: 8 apr 2010
- Blast date: 28 apr 2010
Muck start: 30 April 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): 74
- Lag 2 (CB Installing – Raiseboring): 4
- Lag 3 (Raiseboring – Drilling): 1
- Lag 4 (Drilling – Loading): 1
- Lag 5 (Loading – Blasting): 19
- Lag 6 (Blasting – Mucking): 2

Critical activity: The dump slash of the 88-9410-ST was not done correctly, therefore forcing the scoop to dump via the 88-S04 xc. This delayed the cablebolting in the stope, pushing out all other activities. On top of this, the cablebolting of the 88-01S at the intersection with the 88-S04 xc, ore haulage acc and #1 O/P Acc were delayed and installation of these cablebolts was critical to blasting this stope.

Cablebolting of these intersections began at April 7, 2010 and was completed on April 28, 2010. Cablebolt layouts were issued on January 27, 2010.

As a result of this delay, the explosives sat in the holes for 19 days, causing the emulsion to settle down in the holes. The poor distribution of the explosives caused a bench in the slot. Since the extend of the bench was unknown, the A-fence was put up in front of ring 1, making ring 1 un-accessible. Four dumped rings had to be drilled in order to recover the material in the benched area.


Unsuccessfull dump-slash:
Design: was okay. Two rings for dump slash, because slide was going around the corner.
Slash – ring 1: 2.8 m; 4.7 m; 6.3 m
Slash – ring 2: 1.7 m; 3.1 m

Superintendent instructs to “drill as per print, check ring 4 and make sure the floor slash is complete”
Supervisor comments: “Need to markup floor slash, surveyors did not show up…. All short holes, easy lay out”.

December 2, 2009, N/S: Driller drills all dump slash holes to 6.3 meters. According to driller, supervisor instructed him to “drill all holes to the length of the longest one. 6.4 or 6.5 meter or something”.
There clearly is noise in the communication.
Loading print instructs to load all dump slash holes from 6.3 meter to 1.5 meter. Blast-designers fails to notice that this will lead to a bench.
Dump slash is blasted and turns out to be a bench instead of a slide.

Root Cause: COMMUNICATION
D Mine Block 4a

**Stope Analysis 90-965-ST**

**Development end date:** **28 April 2010**

**Cablebolt Drilling:**
- Planned days: 12.3
- Actual start date: 4 March 2010
- Actual workdays: 18
- Delay: **6.3**

**Cablebolt Installation:**
- Planned days: 9.9
- Actual start date: 26 March 2010
- Actual workdays: 8
- Delay: **NO**

**Raisebore:**
- Planned days: 10.9
- Actual start date: 4 February 2010
- Actual workdays: 17
- Delay: **6.1**

**Drilling:**
- Planned days: 17.8
- Actual start date: 28 May 2010
- Actual workdays: 25
- Delay: **7.2**

**Pre-drilling:**
- Designed: 3057
- Production Drilling: 1355.8
- Cleaning: 581.3
- Redrilling: 137.5

**Blasted:**
- First blast  
  - Location of Raise: **SLOT**
  - Middle of semi-fanned slot

**After blast:**
- Designed: 0
- Production Drilling: 0
Cleaning: 84
Redrilling: 155.57

Turnover

Previous stope: 91-923-ST
Link type: VOID
Fill end date: 15 June 2010
Turnover days: 8
Drill end date: 21 June 2010
Load date: 22 June 2010
Blast date: 23 June 2010
Muck start: 23 June 2010

Order of activities:
Raiseboring – Cablebolt Drilling – Cablebolt Installation – Drilling

Lag times:
Lag 1 (Raiseboring – CB Drilling): 11
Lag 2 (CB Drilling – CB Installing): 5
Lag 3 (CB Installing – Drilling): 26
Lag 4 (Drilling – Loading): 1
Lag 5 (Loading – Blasting): 1
Lag 6 (Blasting – Mucking): 1

Critical activity:
With 24 days, the lag between the end of cablebolt installation and the start of drilling is excessive. The muck-to-fill lag in the preceding stope was 7 days, this is artificially reducing the turnover lag.
There was no drill available to move in earlier (No resources available).

Delays in the drilling itself contributed to the delay.

Extra drilling: NO contribution
Move in & set up delay: 2 days
Unaccounted delay: 10.2 days

<table>
<thead>
<tr>
<th>DELAYS BREAKDOWN</th>
<th>DRILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3          E</td>
<td>Planning And Communication</td>
</tr>
<tr>
<td>79         D</td>
<td>Material &amp; Services</td>
</tr>
<tr>
<td>51         B</td>
<td>Drilling, Raise bore And Development</td>
</tr>
<tr>
<td>149        B</td>
<td>Drilling, Raise bore And Development</td>
</tr>
<tr>
<td>145        B</td>
<td>Drilling, Raise bore And Development</td>
</tr>
<tr>
<td>150        B</td>
<td>Drilling, Raise bore And Development</td>
</tr>
<tr>
<td>144        B</td>
<td>Drilling, Raise bore And Development</td>
</tr>
<tr>
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<td>Manpower</td>
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<td>Ventilation &amp; Blasting</td>
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<td>47 B</td>
<td>Drilling, Raise bore And Development</td>
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</tr>
<tr>
<td>25 E</td>
<td>Planning And Communication</td>
</tr>
<tr>
<td>39 J</td>
<td>Fixed Equipment / Infrastructure</td>
</tr>
</tbody>
</table>

Delay 79 – Water problem
There was a water leak that affected all levels from 84 level down. It took a couple of days to find the problem and fix it.

Delay 51 – Stuck Rods
Rods were stuck, holes were squeezing, tough ground to drill in.

Delay 145 – Drill move
Moving drill in and out.

Delay 149 – No driller available
Driller is sick. Driller is on vacation.

Delay 150 – Down for maintenance/Repair
Problems with striking bar and hoses.

Delay 132 – Prepping drill site
Need to clean up, need cable, had to reinstall raisecover because it got damaged by the drill.

Delay 144 – Ground conditions
Holes were squeezing, problems with fault running through slot.
**Stope Analysis 91-923-ST**

Development end date: **1 september 2009**

**Cablebolt Drilling:**
- Planned days: 12.1
- Actual start date: 3 november 2009
- Actual workdays: 15
- Delay: **2.9**

**Cablebolt Installation:**
- Planned days: 9.7
- Actual start date: 26 november 2009
- Actual workdays: 11
- Delay: **1.3**

**Raisebore:**
- Planned days: 10.1
- Actual start date: 3 december 2009
- Actual workdays: 14
- Delay: **3.9**

**Drilling:**
- Planned days: 3
- Actual start date: 17 january 2010
- Actual workdays: 68
- Delay: **65**

**Pre-drilling:**
- Designed: 539.8
- Production Drilling: 1542.9
- Cleaning: 1497.78
- Redrilling: 662.62

**Blasted:**
- First blast: Toes
- Location of Raise: Left side of slot

**After blast:**
- Designed: 876.1
- Production Drilling: 0
- Cleaning: 1073.2
- Redrilling: 580.04

**Turnover**
- Previous stope: 91-965-ST
- Link type: VOID
- Fill end date: 1 march 2010
- Turnover days: 27
- Drill end date: 25 march 2010
- Load date: 27 march 2010
- Blast date: 28 march 2010
Muck start: 28 March 2010

Order of activities:
Cablebolt Drilling – Cablebolt Installation – Raiseboring – Drilling

Lag times:
- Lag 1 (CB Drilling – CB Installing): 9
- Lag 2 (CB Installing – Raiseboring): 1
- Lag 3 (Raiseboring – CB Installing): 20
- Lag 3 (CB Installing – Drilling): 6
- Lag 4 (Drilling – Loading): 2
- Lag 5 (Loading – Blasting): 0
- Lag 6 (Blasting – Mucking): 0

Critical activity: Drilling was causing the delay in the turnover lag.

Part 1 - On January 16, 2010, the Cubex 7 moved in. As instructed, they drilled off the whole stope, were done on February 4, 2010. The drill was moved out. Could not blast since the critical predecessor (91-965-ST) was not filled yet.


Part 3 – 438 drill moved in on February 28, 2010. Drilled easers. Tried to blast toes of slot. Holes were squeezing and couldn’t be loaded, so toes of positive hole were blasted. This blast counts as the first production blast.

The second blast was a toe-shot of the whole stope. This was blasted on March 28. Mucking started this day.

Extra drilling: 21.1 days
Move in & set up: NO
Unaccounted delays: 26.8 days

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<th>DRILL</th>
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Delay 150 – Down for Maintenance / Repair / Drill down
Compressor on MR7 broke, had to be replaced. Problems with the hoses.

Delay 145 – Drill move
Drill moved in and out of worksite three times.

Delay 132 – Prepping drill site
Repair vent, need mark up, clean up with scoop, reamer was still in slot.

Delay 149 – No driller available
Driller needed to help move drills.

Delay 19 – Work site not ready
Dumas was using drill cable.

Delays count for: 20.1 days
Days idle: 14 days

Instructed pre-drilling drillbook: Slot (row A and C).
Instructed pre-drilling superintendent: drill slot and rings.

Extra production drilling (more then drillbook pre-drill instructions):
- 1003.1 [m] @ 100 m/d = 10 [days]
- Cleaning: 1497.78 [m] @ 100 m/d = 15 [days]
- Redrilling: 662.62 [m] @ 100 m/d = 6.6 [days]
Total: 31.6 [days]

Causes of delay: stope design. Early move in date of drill.

Root cause: Design.

Drill wasn’t really moved in early, the filling of the 91-965-ST started way later than planned due to problems with the pastefill plant.