Mining for Data Could Help Companies Mine for Gold: Using BI to Manage Heavy Equipment Tires

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Abstract

Heavy equipment tires are one of the largest expenses for mining companies. Many tire manufacturers provide services that help mining companies use their tires more effectively. This value added service frequently results in cost savings for the operations. This teaching case explores the potential for the development of a business intelligence (BI) system that supports both historical decision making and real-time day-to-day operations for a tire manufacturer (using the pseudonym “Western Tire Corporation”). The BI system is intended to help the customers of Western Tire Corporation efficiently and effectively manage their use of tires.

Introduction

Scott Bedwick stood at the window of his office. As the Vice-President for Business Initiatives at Western Tire Corporation (WTC) it was his decision whether to plunge into the software business. WTC manufactures and markets tires used on heavy equipment, specializing in tires for equipment in the mining industry. In the past, most of the business initiatives Scott directed aimed at modifying tire design and creating new manufacturing methods and facilities. The business initiative he now contemplated was different from anything he had evaluated in the past. This initiative came from a business analyst in the Information Technology Department (ITD) who proposed using computer technology to better manage tire usage on a real-time basis. The analyst, Jessica Crandall, said that they could use business intelligence and data mining to help their customers run much more efficiently. While her current proposal focused on using computers to better track and understand tire usage, she felt that providing management information about tires that were currently in use on heavy equipment could actually affect the longevity of a given tire. Jessica believed that WTC’s customers would be willing to pay for a service that produced, analyzed, and displayed tire usage information 24/7. Jessica was convinced that if they decided to pursue this opportunity that the service might become a profit center for WTC.

Scott was interested in using technology to help his customers manage WTC’s products, but he wasn’t certain about the amount of time and effort needed to develop software systems. He had heard horror stories about software projects that took four times as long as the initial estimates and that never generated the paybacks used to justify the projects in the first place. Jessica assured him that there are products available to facilitate this type of software development project and that she could produce a relatively accurate development schedule. Scott wasn’t sure it was worth having Jessica develop a detailed proposal – she said that she needed about 180 hours to put together a detailed plan. Her time for the planning process would be charged to his area and he didn’t want to agree to useless expenses. On the other hand, she was very excited about developing this service and had been adept at helping his area make use of new computer technology. He had also been reading about other manufacturing companies that provided more operational assistance for their customers. He knew that the days of “sell a good product and let the customer decide what to do with it” were over. Nowadays it seemed like you have to know as much about the customer’s business as the customer does. He had promised Jessica an answer tomorrow, so he needed to decide now.

Background about Tires in the Mining Industry

Large off-the-road (OTR) tires represent one of the largest single procurement expenses for a mining operation. One copper mine in Arizona reported that tires represented 18% of their overall procurement expenses in 2008 (Interview with Mine Supervisor, 2009). Barrick Corporation, one of the largest gold producers in the world, spent almost $80 million dollars (US) on tires at their mining operations in 2006 (Barrick 2007, 2008). Prices on these large tires range from $10,000/tire up to $65,000/tire for the largest tires. During a recent tire shortage, the largest tires were sold on the used market for over $300,000/tire (Interview with Executive Vice President, WTC, 2009). Mining operations are willing to pay these prices to keep their haul trucks in operation. While the supply of OTR tires is currently in alignment with demand (Koeth 2010) management in the mining industry continues to keep a close eye on the availability of this critical resource. They also strive to get as much usage as possible out of the life of each tire.

While most people have dealt with tire usage on personal vehicles, it may be difficult to understand the scope and size of this resource for a mining operation. For example, consider a mining operation with 100 haul trucks. 100 trucks represent 600 wheel positions that a tire could be mounted on; six per truck. These tires average 5,500 hours of operation. The mine operates 24 hours a day, 7 days a week. But due to shift changes, the truck may only operate 22 hours out of each day. That is roughly 8,000 hours of operating time per year. If a tire lasts for only 5,500 hours, the mine needs 1.45 tires per wheel position for an entire year. That represents 870 tires for all one hundred trucks. If a radial tire costs $50,000/each, then the mine would need $43,500,000 to purchase all of those tires.

If the mining company could increase the life of these tires by just 10%, the mine would now get 6,050 hours per tire. At 8,000 operating hours per year per wheel position, the mine only needs 1.32 tires per wheel position. The mine now only needs 792 tires per year at a cost of $39,600,000. This is a savings of $3,900,000. In other words, this is a much different scope than purchasing new tires every few years for your Honda Civic.

Mining operations focus their efforts on how much ore they can mine each day. All other activities support this goal. A tire problem can shut down a vehicle from production resulting in lost production time for the mine. Many mines manage their tires themselves, while others look for outside help to ensure that they can keep their fleets running efficiently. The latter type of operation often turns to the tire manufacturers or tire dealers for this critical support.

General Description of Tire Tracking Programs

Most mines use some sort of system to monitor and track the performance of their large OTR tires. These systems range from simple spreadsheets to complex tire tracking software. The intent of existing systems is to collect and analyze data to make decisions about how to use tires at a specific operation. The purpose of tracking the tires is two-fold. First, tracking systems provide simple inventory control. With these types of systems, mining operations know what tires are installed on which vehicles and what tires are available to use as spares. Second, tracking data can be used to populate business intelligence systems to provide analytics and help managers understand tire performance, identify problems, identify areas for improvement, and identify key indicators that would help extend the life of the tires.

The industry has progressed from tracking tires on 3x5 cards and spreadsheets to complex tire tracking software (examples: EMTrackIII from Goodyear, TreadStat from Bridgestone, and Total Tyre Control from Klinge). These software programs track a tire from cradle to grave. The tire is tracked by a unique serial number on the sidewall that is imprinted during the manufacturing process. While this mechanism makes it relatively easy to track each tire, alternative identification mechanisms such as radio frequency identification tags (RFID) could be developed to assist in the tracking process.

When a tire is installed on a vehicle, that tire is also installed on a virtual vehicle in the tire tracking software. Most software packages will record other items associated with this event, such as: date installed, vehicle hours, vehicle wheel position (e.g. front right or the rear left outside), tread depth, and inflation pressure, etc. Tires are surveyed on a regular basis, primarily to record the tread depth, air pressure, and general condition (this is done through visual inspection). Depending on the mine site or the tire management team, surveys are completed weekly or monthly. Regular surveys provide a way to check the progress of a tire's life and provide a point to visually inspect the tire for potential problems. The data gathered are recorded in a variety of ways (notepad, paper, form, or spreadsheet, etc.). Data are subsequently entered manually into the tire tracking program.

When a tire is removed from a vehicle at the mine it is also removed from the virtual vehicle in the tracking software. Data associated with the event are also entered into the system: date removed, vehicle hours, tread depth, general condition of the tire and reason for removal.

Tires are scrapped and removed from service permanently when they have un-repairable damage or have reached the end of usable tread life. Tracking systems include a field showing the method or location of disposal.

Description of Current Data Input

The tire tracking process begins in the data gathering stage. Paper forms are used to record data points for tire related activities. Examples of “tire related activities” are a change or tire, or a survey of tire wear. A tire technician fills in a form with tire details, vehicle details, and any other data relevant to the activity. A single tire change can require up to twenty five fields of data. (See Appendix 1 for an example of a completed data collection form.) In WTC’s experience, it is easy for technicians to miss something - especially for those technicians who are more concerned with getting the job done quickly than completing the paper work correctly.

Tire technicians receive pressure from the operations staff at the mine to get their work completed in a timely fashion. Pressure is exerted to return vehicles to production as soon as possible. Tire technicians frequently rush to do their jobs; many do not completely fill out tracking forms. Others might scribble out notes or rely on their memory to complete the form at a later time. This tends to result in illegible, incomplete, and/or inaccurate information being recorded.

Once data have been collected, the forms are referenced to enter information into a tire tracking program database. This step may be done either by the tire technician or by a data entry clerk. If the technician knows s/he will be responsible for data entry, s/he might complete less of the form and intend to rely on memory. However, in instances where technicians rely on their memory, they might neglect to fill out the form completely. If their memory fails or they can’t read their own writing, these technicians tend to make up data taking a best guess at the content of the data. Such actions introduce errors and inaccuracies in the system. Some technicians have been known to make up data in order to make data points match what they think it should be.

When the data entry falls onto a data entry clerk (instead of the tire technician) there are fewer data entry errors, but other problems occur. Data entry clerks are not usually knowledgeable about tire usage in mining operations. They may not be familiar with all terminology and the correct units of measure, so they may make validation mistakes.

Data entry is generally completed at a centralized location for several mine sites. This practice adds further sources of error to the data recording process. Since the forms are filled out in the field, they are usually dirty and/or wet because tire technicians usually don’t have clean hands or a clean place to complete the form. There is also a time lag from the time the tire activity is completed until the time the paper work is filled out and submitted to the data entry clerk. This delay can be due to work load and related time constraints that sometimes contribute to paper work being forgotten. Data entry clerks must contact tire technicians for clarification when a form is unreadable. This communication between the data entry clerk and tire technician usually occurs via phone or email. When email is involved more time delays occur, but the accuracy of the information improves. This might be attributed to e-mail being less time sensitive. Technicians have more time to check figures without feeling the additional time pressure from mining managers.

Data collected in the field is time sensitive. Each data point must include the date the data were gathered along with the hours of operation for the tire. These two items are the backbone of all data gathered and used in creating information for management decision making. It is critical for software systems to enter tire activity in chronological order. If paper work is delayed or omitted for one activity, other tire changing activities on that same vehicle can get out of order creating problems in the tire tracking program. Corrections require someone to undo previous work until the point when the paper work should have been entered. Activity data is then re-entered for all other tire activities. This is generally limited to the activities on one specific vehicle.

Data entry clerks typically follow a relatively strict regimen when entering data in order to ensure the information is recorded correctly. For example, tire removal or wear conditions make use of a predetermined list of conditions. If a tire technician use the condition “Junk” as the reason a tire was removed but that condition does not exist on the predetermined list, the clerk would need to find out why the tire was scrapped so s/he can enter the appropriate condition.

Data entry for tire tracking is time-consuming and prone to error for many mining operations.

Description of Current Data Analysis

The information generated from existing tire tracking systems is generally based on historical data. Historical data is crucial to understanding future patterns for tire use and inventory planning. Systems generate reports on a weekly or monthly basis to assist with tire oversight, but there is little real-time data available due to the delayed methods of data input described in the previous section. Data analysis is usually conducted using:

- Tire Life (Total hours of use)
- Cost per hour (total cost / total hours runtime)
- Hours per tread unit used (total hours / amount of tread used)
- Reason and condition of the tire being removed from service

Most of the pre-built reports summarize data after a tire is scrapped. Historical views provide a representation of tire performance over the life of the tire, giving both detailed and summarized insight into the status of an individual scrapped tire and whole categories of scrapped tires.

In WTC's experience, mining management teams review the reports once a month. Report usage often varies from site to site, and sometimes from person to person at the same mine site. Reports are used primarily to make inventory-related decisions about how a given company's tires are performing, or how they are going to forecast needs for the next defined period of time.

The tire tracking programs allow reports to be run at any time, but most sites receive them or use them only once a month. This could be because the information does not help management make decisions that will affect the longevity of a given tire. The information in the reports shows primarily historical data from scrapped tires - not from tires currently in circulation. This is to show the tires that were removed from service and provide a summary of their performance. While reports can show how the tire is currently performing while installed, reports **summarize** lifetime use only. Longitudinal data is saved for when a tire is removed from service rather than used for a tire currently in service. This skews the data if you are trying to analyze the performance of a tire on a specific vehicle, since it is quite possible that tire was previously installed on different vehicles.

Not enough tires are removed from service each month to provide adequate change in the historical reports. In some instances, too few data points are generated for real time data analysis. A data point is generated every time a tire is changed or surveyed. For the mines that only do monthly surveys, these types of reports are not useful until the survey information is recorded in the system.

Issues with Current Systems

There are several shortcomings to the way tires are currently tracked. These arise from the methods used to collect data, critical data that is not collected at all, and the limitations of the data analysis within the tire tracking systems. These shortcomings create a business environment where it is difficult, if not impossible, to construct a comprehensive view of overall tire performance.

Data collection and entry is essentially a manual process. Data collection is dependent upon the availability and effectiveness of the tire technicians. The data entry process tries to reconcile errors and uncertainties before performance reports are generated each month. In many instances, these issues are not resolved by the time the reports are scheduled to be produced and sent out. Once the issues are resolved, the reports are generated, but the information is no longer timely.

Existing tire tracking systems do not take into account other factors that affect the life and performance of tires. These are important items that generally go overlooked, as far as data gathering, and are not correlated to specific tires in existing systems. The major factors that affect tire life are:

- Air Pressure and Temperature
- Cycle Distance and Time
- Payload
- Vehicle Maintenance
- Road Conditions and Design
- Weather

- Operators

Many of these factors can also serve as key indicators to serve as warning or action items for further investigation during the life of a tire, and not after it has been scrapped. These data points should be collected and associated with the specific tires to help create data points for further analysis. This would help to create real time or more timely information.

Of these factors, air pressure and temperature are perhaps most significant. Proper air pressure is critical to maximizing tire life. Mine sites that get the most out of their tires check air pressures at regular intervals. Air pressure inside the tire is what actually carries the load - not the rubberized tire itself. A flat tire does not have any air pressure and cannot carry a load. When a tire has too much air pressure it causes problems with how the tire performs. One main function of a tire is to absorb road hazards such as rocks. If a tire has too much air pressure, the tire could be punctured by a rock instead of enveloping it. An overinflated tire will also wear down the center portion of the tread faster than the outside parts.

Tires are designed to operate best within a range of temperatures. When a tire overheats the rubber reverts to its natural state (i.e., pre-vulcanization). This effect causes different layers of rubber to separate. Examples of this phenomenon are scattered across highways. Most commercial truck tires that come apart are the result of carrying incorrect air pressure for the load. If a tire does not have enough air pressure, it overheats which can lead to the situation described. In addition to improper air pressure, a tire can heat up for a variety of other reasons. A tire generates its own heat as it flexes during it normal operation. When it is underinflated, it generates more heat. Heat is also introduced to the tire through the wheel, hub, and brake assemblies. Heat from the road or other surfaces is transferred as well. Finally, ambient temperature can affect the tire temperature.

A tire comes with a manufacturer rating, which is an expression of the working capacity of a tire, called Ton Mile Per Hour (TMPH). This rating tells how much the tire can carry at specified speeds and air pressures. If this rating is exceeded the tire builds up too much heat and the different rubber layers will separate; just as illustrated by the above example of commercial truck tires.

Payload and the vehicle empty weight make up the carrying weight. Since the empty vehicle weight is relatively constant, the payload is an important factor. As discussed previously, mining operations try to maximize payload in order to achieve production goals. Haul trucks are designed to distribute the weight evenly across all tires, while carrying its payload. However, a truck loaded to the limits of its carrying capacity creates several problems. If the load is not correctly placed in the truck, it will create an imbalance on the weight distribution. A truck traveling on uneven grades can cause weight distributions to be pushed out of their balanced state. With these conditions, some tires may become loaded beyond manufacturer ratings.

The vehicle on which the tires are mounted also impacts the way a tire performs and lasts. A vehicle that is not maintained properly can affect a tire's tread wear pattern, unbalanced loading of all tires, excessive heat generation, or the ability to react to road issues.

Poor road design and maintenance can also impact tire performance. A tight curve without a banked and elevated turn can cause excessive lateral forces in the tire and cause a separation of the different components of the tire and higher wear rate. Most tire and mine vehicle manufacturers recommend that the grade of any road should not exceed ten percent. This transfers more of the load from the uphill tires to the downhill tires, potentially creating an overloaded situation on the downhill tires. Road maintenance includes camber of the road, materials in the road base, spills, undulations, drainage, and frequency of use. Tires are more susceptible to cuts when they are wet. Proper drainage of the roads and working areas help to ensure tires are not easily damaged. An undulation causes the truck to bounce creating instantaneous overload on the tires and truck components. This can also cause material to spill out of the back of a truck and following trucks must cope with driving over the items, or navigating around them.

Operators/Drivers of these large machines also play a major role into the lifespan of the tires. A driver's bad habits can lead to a number of problems with tires. These include speeding, hard acceleration and braking, turning too tightly, or turning the steering wheel while the vehicle is stopped.

Weather is one of the last major factors affecting a tire's TMPH. Since tires build up heat, the lower the ambient temperature, the faster tires will expel heat. But when the ambient temperature exceeds 100 degrees Fahrenheit, tires have a much harder time cooling off and will reach their TMPH limit faster. Precipitation also affects the life of a tire. Water acts like a lubricant to cut rubber. If you have a site with heavy precipitation or excess water on the roads and working areas, the tires are much more prone to cuts and damages.

While current tire tracking systems provide useful information for mining operations, they are far from complete BI (business intelligence) systems in several ways. They basically report the current status of tires. The data can be summarized in several different ways, but does not use longitudinal data to give a detailed look into the operation. These systems provide information that is relatively low on the level of competitive advantage and degree of intelligence it provides (Davenport and Harris 2007). WTC has an opportunity to incorporate more data and better data collection techniques to create a true real-time BI system and leverage the system to create business value for the company.

Real-Time Business Intelligence for Tire Tracking

Many tire dealers offer additional consulting services to help a mining operation get the most performance from their tires. Some manufacturers will place a consultant (tire account manager) on site to help manage the use of this valuable resource. This value added service frequently results in cost savings for the operation and better use of resources. One Nevada mine saw tire life increase 45% in their largest size tires after employing a tire dealer's program (Tattersall and Johnson 2004). Another gold mine in northeast Nevada reported reductions in per hour costs by 60%-70% after they implemented a dealer's tire tracking service (Berndtson 2008).

WTC places a tire account manager at each customer site that does a certain threshold of business with the company. The tire tracking program used by WTC is relatively rudimentary – it provides historical information to help the tire account manager control tire inventory for the company. Jessica Crandall of WTC believes that there is an opportunity to apply BI to tire tracking to either assist the tire account manager, or possibly allow managers to provide service remotely for multiple sites.

Improving Data Collection Methods

The first issue to address in the development of a real-time BI system is the use of paper forms for data collection. While this method is an inexpensive way to collect data, current technologies can make use of electronic means to help gather and record data directly into a tire tracking database. Reducing data entry performed by humans will likely reduce the number of errors in the data store as well.

Some tire software packages offer a compact database on a handheld device. Tire technicians could use the handset in the field for data collection and tire changing activities. This device can synchronize data records with a centralized database. This application provides timely data entry and improves data integrity but still leaves open a point of error because the tire technician is still entering data into the system.

Creation of an automated system would start with the identification of the tire. Each tire has a unique serial number used to identify it in the database. Tire IDs are manually entered or selected from a list in current systems. Ideally the tire's serial number would be entered electronically or scanned into the system. Mechanisms to capture tire identification data could be automated by using a tag embedded in or on the tire. Tags could use Radio Frequency Identification (RFID) or Near Field Communication (NFC). Either method would send information about the tire to a receiver on the handheld device. These mechanisms could provide for more accurate entry of the serial number in the appropriate field needed in the database. Additional electronic devices can be used to automatically capture other data used to monitor tire performance. Such devices include PSI gauges, temperature probes, and tread depth gauges. Current systems expect the tire technician to enter this data manually through the handheld device. If automated, data would be captured and recorded on the handheld device using radio frequency or a cable connection. The use of these devices could also increase the frequency of data input and allow for quicker analysis.

The use of these types of devices not only helps ensure the accuracy of the data but also frees up time for tire technicians and data entry clerks. They allow for more efficient data entry and a better focus on report production. Time saved by automating the data collection mechanisms could be allocated to other tasks. In addition, costly delays associated with data capture, data transmittal, and clarification communications between technicians and clerks are reduced if not eliminated. Reports would be generated in a more timely fashion.

Improving Data Collected

Using automated data collection methods provides the opportunity to also improve the type and quantity of data collected. Examples of additional data that could be collected and integrated are discussed in the following sub-sections.

Air Pressure

Air pressure can be tracked in a variety of ways. This is currently done for WTC's customers by taking surveys manually on a regular basis and tracking these measurements in an Excel spreadsheet or a small Access database. This can be slow and difficult, especially if there is a large fleet.

A better solution is to use a system that can constantly monitor the air pressure of tires. Two of the leading monitoring systems are Michelin's MEMS and Rimex's TyreSense (Interview with mining company Tireshop Supervisor, 2009). These TPMS (Tire Pressure Monitoring System) systems can continuously monitor the pressure from a small device that is either attached to the inside sidewall of a tire or mounted onto the wheel assembly. They use a close range radio frequency to communicate to a module (mounted on the truck) that can then record the information and transmit it back to a central database, usually hosted by the system's manufacturer. Data are transmitted via radio transmitter or cell phone module. These devices not only record air pressure but also record the internal air chamber temperature, which can be correlated to how the tire is performing. Many of these systems have a small display system mounted in the cab for the driver to observe the reading or have warnings displayed for further immediate action.

Data can be viewed in real time or near real time. This would be a great asset to monitoring how a tire is working. The heat buildup can be tracked for any abnormal spikes in temperature, which would indicate a problem for investigation. The air pressure itself can also be monitored for spikes or rapid loss of pressure. If a spike occurs, then the tire has run over or hit some obstacle that could potentially cause harm to the tire. Alerts are sent when a pressure or temperature is outside preset control limits. These alerts are sent by email, text message, or an alert on a computer system.

If a truck runs over a rock, the tire takes the impact of that rock. At the same time the tire hits the rock, there would be a spike in air pressure as the tire absorbs the impact. This might be a cause for further investigation of the tire. If the rock is large or the impact is hard, it can break some of the steel cables in the tire. This can cause a loss of air at another time. This loss of air could be a slow leak or rapidly blowing a hole through the tire, and creating a safety hazard.

If a monitoring system were set up, this spike could be measured. Then an alert or warning could be sent out notifying the appropriate personnel of the issue. The tire should be inspected before a safety hazard occurs, or sent to repair before so much damage occurs that the tire must be scrapped.

If a tire has a rapid loss of air pressure, the driver should be notified to stop immediately. This relatively simple warning mechanism could prevent a driver from ruining a $50,000 tire. A tire cannot be repaired if it has been driven while flat. Real-time data is absolutely critical in this situation. The driver could be radioed to stop driving immediately. At the same time, an alert warning message could be sent to the tire technicians who would be dispatched to repair the flat. This is a case where immediate action must be taken to save an expensive tire. This tire may have lost its air pressure from a broken air stem, a cracked wheel, or something else. It can be repaired and there would be no need to sacrifice a tire. In the long run, immediate action of this type could also decrease truck downtime.

An additional benefit to using an air pressure monitoring system is that it could constantly monitor the tires. There is no need to stop a vehicle to check the air pressure and temperature in the tires. This helps to keep the vehicles moving without costly downtime.

Vehicles

Large mining vehicle manufacturers built an array of electronic sensors on new trucks in recent years. The on-board electronics are used to monitor several aspects of the trucks' run-time operations. Data are captured and recorded for every haul cycle the truck completes. Data recorded by the vehicle (example vehicle manufactured by Komatsu) for one cycle include:

- date and time cycle was started
- total time to complete the cycle
- empty running time – how long the truck operated with no load
- loaded running time - how long the truck operated with a payload
- time to load the vehicle
- time to dump the load
- cycle distance traveled - loaded, and empty
- average speed - loaded and empty
- maximum speed attained - loaded and empty
- strut pressure of all four struts
- calculated payload - based off strut pressure
- actual time of loading started
- actual time dumping started
- actual time of Max speed (both for loaded and empty)

Data can be transmitted via radio link or cell link to a centralized database, or are downloaded manually into a laptop. Vehicle operators also have a display in the cab to monitor performance measures such as payload. The truck can also be programmed to respond to input from truck sensors. For example, if the payload calculations are over a set limit, the truck can be programmed to prevent an operator from traveling predetermined distances or exceeding predetermined speeds until the load is dumped. Such precautions help ensure that payloads exceeding the carry capacity of the truck do not damage the truck or its tires.

Truck sensors are also able to determine whether or not a payload is correctly centered on a truck. For illustrative purposes, imagine a weight lifter hoisting a bar that has twice as much weight on one side. The lifter will struggle to lift the bar because of the unbalanced load. These situations are not uncommon when loading haul trucks. Unbalanced loads generate excessive weight on some of the tires and cause harm to the struts, the haul bed, and the overall support structure of the truck.

Data related to truck operations that is not automatically transmitted to a central database is downloaded at irregular intervals. While the data is useful in *post hoc* performance analysis, real time data could be more useful. If truck and tire performance data were to be transmitted from the truck using radio signals in real time, the data could be used to identify potential problems and alert operators to the problems. Performance guidelines could be fed into a system that monitors actual performance and compares it with predetermined limits. Warning alerts would signal some action to be taken when performance measures don’t align with guidelines.

Road Conditions, Design, Maintenance, and Vehicle Operations

There are several GPS devices on the market that major mining operations use for their dispatch systems. Dispatch systems use a GPS receiver that is mounted on every vehicle to keep track of their location, production and logistics. A GPS unit can record its location at set intervals, even down to multiple times per second. By utilizing the GPS location to track vehicle movements, the BI system could allow a TMPH calculation to help dispatch personnel with their logistics. An alert, based on past data, can be established to occur when TMPH rating is approaching or exceeding limitations. Then dispatch can re-route the vehicle to tasks that would allow the vehicle to come back within the control limits.

These dispatch systems do keep a record of everything that occurs, even the track each vehicle creates during its day to day operations. It is possible to look up a vehicle and see where it went, how fast, the loads it carried, etc. for as long as the history is kept in storage.

Currently, there are no configurations able to use this GPS data. Yet this is a vast data store to tie into for further analysis of haul routes for other conditions as previously stated. An analysis of the GPS tracks might reveal much about how the mine roads are designed and also reveal other operator habits that can cause damage to the tires. This would help to identify problems with the haul road design or haul lengths by identifying grades or curves that exceeded recommendations. Poor road design can have a huge impact on the tires as previously noted.

This data can be used to track the way drivers handle the vehicles. Drivers' habits can lead to a number of problems with tires. These include speeding, hard acceleration and braking, turning too tightly, or turning while the vehicle is stopped. By analyzing the GPS data, all of these destructive habits can be identified.

Another advantage of collecting data from this system would be to analyze road maintenance. This would include changes to the haul roads, water trucks performing dust suppression, graders maintaining the roads, etc. The traffic of support equipment and the tasks assigned by dispatch could be analyzed for problematic spots that might require further investigation from the haul road engineers.

Road maintenance is another important factor to helping tire life. These factors can include chamber of the road, materials in the road base, spills, undulations, drainage, and frequency of use. Most of these items would have to be captured by maintenance records or a visual inspection scorecard type of system. This could be very useful when there is a trend of tires that are being damaged in a certain area of the mine.

Data from the many and varied sources related to truck operation, tire performance, dispatch and environmental variables could be brought together in a data warehouse that could be leveraged for real time decision environments and provide business intelligence that could greatly benefit overall performance.

Improving Data Analysis and Visualization

WTC's Tire Account Manager and the mining company's dispatcher play vital roles in day to day decision making - especially decisions that need real time data for their duties. As discussed in the previous section, their decisions ensure that there is an immediate response to reduce further damage to these costly assets.

The Tire Account Manager also uses the information to create action items that must be taken care of on a daily, weekly, or monthly basis. A majority of these decisions are based on the logistics of maintaining the tire inventory and minimizing down time for the mine. If they can pull off a damaged tire during scheduled haul truck maintenance, they can reduce or eliminate unscheduled downtime due to that tire. The damaged tire can be sent to repair, greatly extending the life of the tire.

Real time reporting can be presented as on demand reports. These reports would allow the Tire Account Manager and other decision makers to get the information they need when they need it. This can take several forms. An online reporting site connected back to the data warehouse would allow decision makers to generate the information when they need it. For example, a Tire Account Manager could log onto the BI portal first thing in the morning. One part of the BI portal could be dedicated to performance monitoring as shown in Appendix 2. The Tire Account Manager could have the system generate a list of items that need to be checked that day due to items that have flagged a warning or are possibly out of their control limits, based on an analysis of past data and applied to the existing tire configuration and environment. The Tire Account Manager could take action immediately to affect the longevity of the tires.

Another stakeholder that would be interested in combining historical and real-time data is the manager of the mine. A Mine Manager is primarily concerned about the ore production at the mining operation. With this system, a model could be built to answer several of his/her "what if" questions. Let's assume the Mine Manager wants to see what would happen if they increased the payload of the trucks by 10%. By pulling data from the data warehouse into a model, the system could return further information about how it might affect the life of the tires. A cost benefit analysis should be a part of this model, to see what affect each decision would make on expenses and profits. One of the possible outcomes of a question like this could have negative outcomes for the tires, but positive outcomes for the overall mining operations. For example, if this question of overloading the trucks by 10% were analyzed, the results may show that tire life is reduced by 20% and costs are increased an extra $2 million. But the mine may produce more ore that results in a $10 million profit. In this case, the tires would be sacrificed to achieve more profit.

Many of the analytical processes are simple mathematical calculations. These would include TMPH, Hours per 32nds, and Cost per Hour. These can be determined by inserting data into these preset formulas. However, mining operations could be facilitated by more complex forms of data mining. Some of the transformations need to include pattern matching, clustering, regression analysis, mapping of GPS locations, and predictive modeling.

The data being collected is extremely varied. One of the main results from this data gathering is to eventually create a predictive model for tire life. One main tool to create this model is regression analysis. With the variety of factors that affect tire life, a multiple regression model could be defined to predict the dependent variable of hours per tread unit utilized.

The gathered data needs to correlate against the hours per tread unit utilized to find out which input variables have the greatest impact (George, Rowlands and Price 2005). Not only what has the biggest impact, but how much they affect the results and in what way. This will assist in creating the predictive model by using the best combination of variables that result in the most accurate predictive results.

Delivering BI as a Service

Jessica Crandall believes that WTC should deliver BI as an application service. She envisions developing a comprehensive BI solution for tire management that will help provide competitive advantage for WTC's customers. Large OTR tires represent one of the largest single procurement expenses of a mining operation. Mining operations need to get as much time possible out of the life of each tire without impacting their production of ore. Even though there are several tire tracking systems readily available off the shelf, they do little to provide business intelligence that assists a mining operation maintain or increase competitive advantage. This shortcoming is due to the variety of factors that affect the life of a tire, but that are not tracked in these software packages. However, a mining company already gathers and records data points from a variety of disparate systems that can provide valuable data if integrated within a business intelligence system.

By mining and analyzing data from these separate systems, a mining company can make better informed decisions. These decisions can help the mine to use tires more efficiently, keep their fleets running while reducing their expenses, and achieve a competitive advantage in their market. Jessica believes that an individual mining company doesn't have the resources or overall knowledge of tire management to create this type of system. She also believes that if WTC does not provide this level of information for its customers, then another vendor will. Competitive vendors could use their BI systems to edge out WTC for future tire business.

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Appendix 1

THE MINE

Tire Change Card

Date: 13 Aug 2010

Vehicle Number/ID: HT - 23 | Vehicle Hours: 24,589 | Foreman/Leadman: Fred | Tire Changed By: Mike

Tires Coming OFF

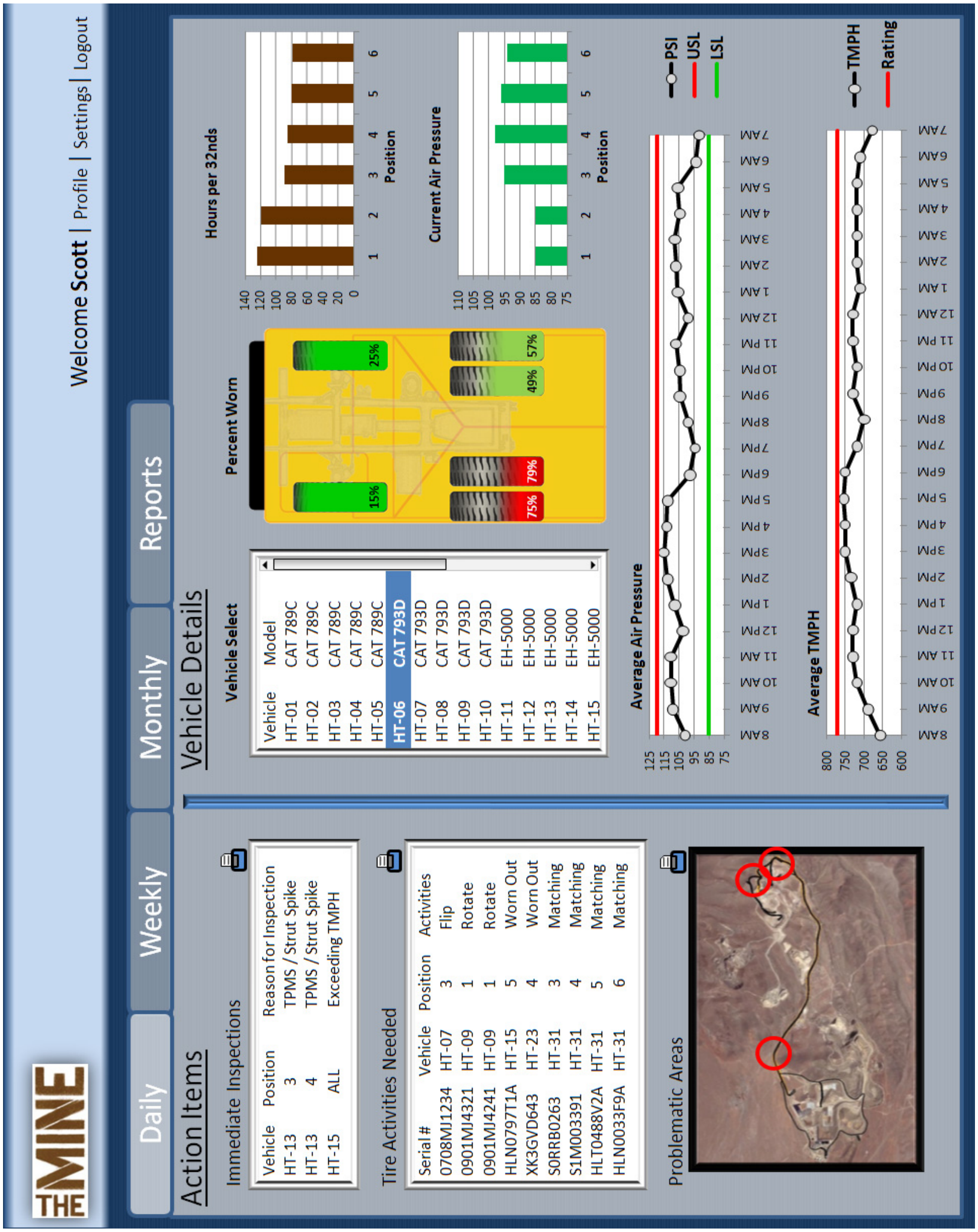
Location on Vehicle	Tire Brand #	Tire Serial #	Remaining Tread Depth (32nds) O	Remaining Tread Depth (32nds) I	Removal Reason (Check One): Maintenance	Worn Out	Damaged	Tire Condition (Where is it damaged?): Tread	Sidewall	Other	Why was the tire removed? (Please use EMTrack Wear Conditions & other comments)	DISPOSITION (Where is the tire going?): SPARE	ON HOLD	SCRAP	REPAIR	RETREAD
1																
3	TM-8013	0705MJ2611	5	8	X						Spare	X				
4	TM-7313	TLM1609T2C	2	0		X					Worn Out – Belt packages			X		
5	TM-8159	TLM1807T1C	25	29			X	X			Impact Break - Tread		X			
6	TM-8204	TLM1909F2C	32	33			X		X		Section Failure - Sidewall				X	
2																

Tires Going ON

Please complete a full survey of vehicle below

Location on Vehicle	Tire Brand #	Tire Serial #	Tire Description & Other Comments (e.g. 33.00R51 XDR B4 **)	Remaining Tread Depth (32nds) O	Remaining Tread Depth (32nds) I	Flipped	PSI	Temperature	Aired to: NEW TIRE	From ?: SPARE TIRE
1	TM-8099	TLM0812F5C	40.00R57 XDR B4 **	100	100		98	88		
3	TM-8412	0812MJ0411	40.00R57 RL-4B ** Goodyear 4SL E-4 $42,356	108	108		95	86	X	
4	TM-8413	0812MJ0410	40.00R57 RL-4B ** Goodyear 4SL E-4 $42,356	108	108		95	86	X	
5	TM-8160	TLM1807T1C	40.00R57 XDR B4 **	87	92		95	89		X
6	TM-8289	TLM1909F2C	40.00R57 XDR B4 **	91	90		95	87		X
2	TM-8098	TLM0812F5C	40.00R57 XDR B4 **	95	98		99	89		

Appendix 2


THE MINE
Welcome Scott | Profile | Settings | Logout
Daily
Weekly
Monthly
Reports
Action Items
Immediate Inspections
Vehicle Position Reason for Inspection
HT-13 3 TPMS / Strut Spike
HT-13 4 TPMS / Strut Spike
HT-15 ALL Exceeding TMPH
Tire Activities Needed
Serial # Vehicle Position Activities
0708MJ1234 HT-07 3 Flip
0901MJ4321 HT-09 1 Rotate
0901MJ4241 HT-09 1 Rotate
HLN0797T1A HT-15 5 Worn Out
XK3GVD643 HT-23 4 Worn Out
S0RRB0263 HT-31 3 Matching
S1M003391 HT-31 4 Matching
HLT0488V2A HT-31 5 Matching
HLN0033F9A HT-31 6 Matching
Problematic Areas
Vehicle Details
Vehicle Select
Vehicle Model
HT-01 CAT 789C
HT-02 CAT 789C
HT-03 CAT 789C
HT-04 CAT 789C
HT-05 CAT 789C
HT-06 CAT 793D
HT-07 CAT 793D
HT-08 CAT 793D
HT-09 CAT 793D
HT-10 CAT 793D
HT-11 EH-5000
HT-12 EH-5000
HT-13 EH-5000
HT-14 EH-5000
HT-15 EH-5000
Percent Worn
15%
25%
75%
79%
49%
57%
Hours per 32nds
Position
Current Air Pressure
Position
Average Air Pressure
PSI
USL
LSL
Average TMPH
TMPH
Rating