Case Study

Condition Based Maintenance – Wireless Crack Propagation Monitoring System Implemented at Canadian Oil Sands Company

The oil sands industry is currently burdened with the task of implementing timely and cost effective maintenance for the haul trucks used in the oil reclamation process. Global Inspections was able to install its Wireless Crack Propagation Monitoring System and wirelessly collect real-time data, effectively monitoring crack propagation without the need for direct visual inspection or costly unscheduled downtime.

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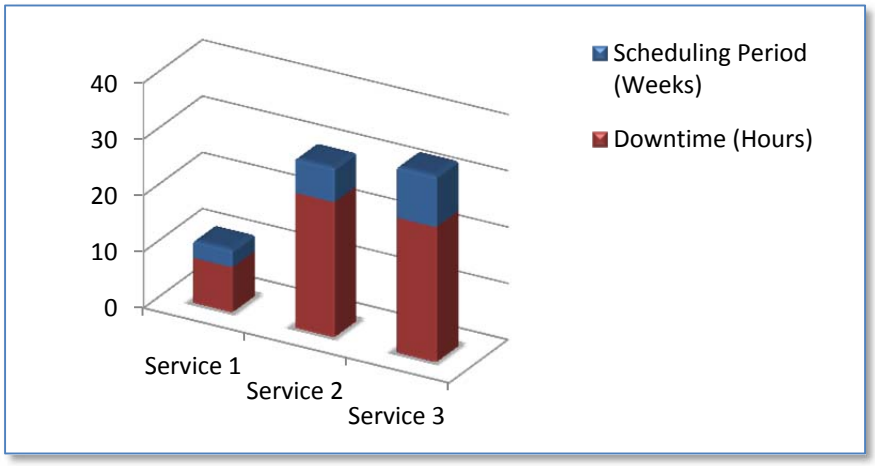
The Challenge

Equipment maintenance is a critical component of *any* industrial operation, but the larger more expensive machinery, found in the mining industry, demands a higher level of importance be placed on optimal maintenance. With an average of about two tonnes of mined oil sands needed to produce just one barrel of synthetic crude oil, these giant haul trucks are placed under tremendous amounts of stress that can cause fatigue cracking. Any failure of these crucial pieces of machinery can ultimately cost the company millions of dollars in downtime and damaged equipment.

Oil Sands maintenance personal generally utilize a preventative maintenance plan which consists of three service levels at varying intervals, with varying maintenance tasks performed at each service level. For example:



- **Service 1** – 8 hours duration every 3rd week
- **Service 2** – 24 hours duration every 6th week
- **Service 3** – 24 hours duration every 9th week

During this scheduled downtime, the haul trucks undergo routine maintenance procedures such as engine and transmission oil changes. A visual inspection is also made to detect any new cracks, which on any given inspection can number 5 – 10 per haul truck. Of those cracks, between 1 – 3 are generally identified as critical, but will not undergo repairs at this time due to maintenance bay scheduling constraints.

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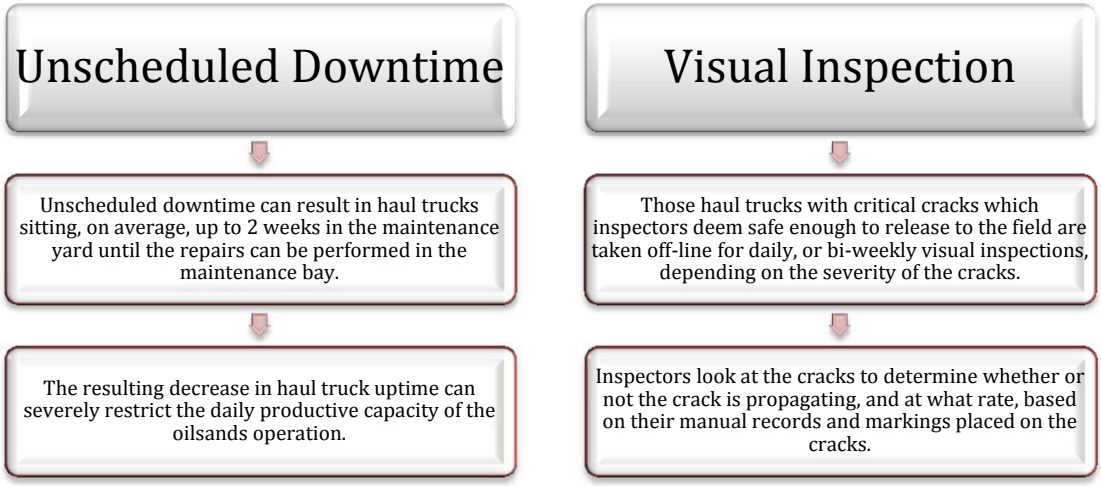
Once a crack has been identified on a haul truck, the maintenance team is currently limited to one of two available options:



Each of these options are not only exceedingly expensive, but are often inadequate in their ability to accurately predict critical failure. In addition, each of the above options reduces the mechanical availability of the haul truck.

The Solution

Global Inspections has a unique wireless crack propagation monitoring system that can be used to detect, monitor and report cracks in metallic objects. The crack sensors are spot welded in place, and then typically covered with special protective materials to protect the electronics from the harsh environments found in the oil sands and mining industries. The wireless data acquisition module (called a “Mote”) can also be spot welded close to the sensors since it is battery powered and designed for use in harsh environments. Once in place, the data from the crack sensors are monitored electronically and stored in the Mote. Data log files from these Motes can then be transmitted via a 900MHz wireless connection to a PC or via a cellular modem gateway to a remote server.

Wireless Crack Monitoring via PC

The crack propagation monitoring system is installed on the haule previously identified as having critical cracks. Data downloading takes place during shift changes (***scheduled* downtime**), which typically occur every 12 hours.

The average shift change is completed in 20 minutes. This leaves sufficient time for an operator to safely stand near the haul truck and download the crack propagation data using a laptop computer for analysis.

Wireless Crack Monitoring via Cellular Modem

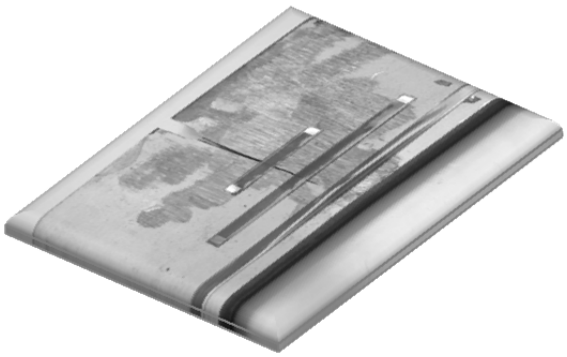
The crack propagation sensor system is installed on the hauler previously identified as having critical cracks. A cellular modem gateway is installed in the driver's cab. The gateway is then able to download crack propagation data on an hourly basis and wirelessly transmit it to a remote server.

The user can view the data online from a secure website or download the data for further analysis. The server software is capable of sending alarms, email messages, or voicemails to alert the operator to impending failures.

This program was commissioned by the preventative maintenance division of an oil sands company to install and monitor crack propagation on one of their haul trucks, which had previously been identified as having critical cracks. The prospect of monitoring cracks electronically, without the need for constant visual inspections, was of great value to the preventive maintenance team.
Four cracks identified on a Komatsu 930E haul truck were chosen for wireless crack propagation monitoring based on crack size and severity. The locations were as follows:

1. Rear of H-frame, behind the hydraulic tank
2. Rear of H-frame, beside the hydraulic tank
3. Right front, upper horse collar
4. Left front, upper horse collar

The crack sensor installation procedure was very time efficient; with an average of 1.5 hours spent per individual crack.
The installation procedure involves mounting a series of three separate sensor gauges of increasing length, placed parallel to one another in a staggered configuration.
The first step in the procedure is critical, and involves surface preparation to ensure all traces of mud, oil, grease, and other organic contaminants are removed. Once cleaned, a grinder is used to remove any loosely bonded adherents (scale, rust, paint, coatings, etc.).



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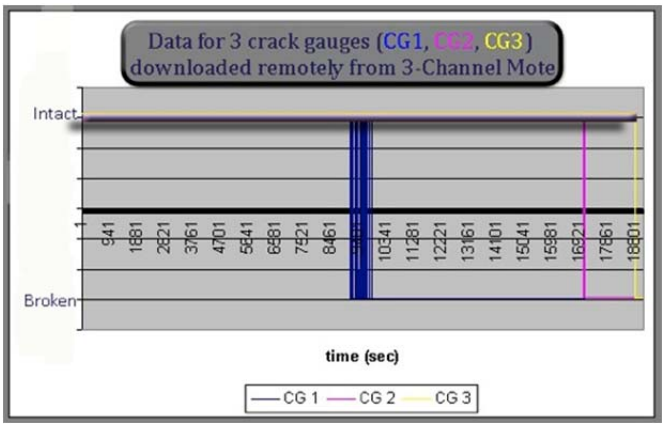
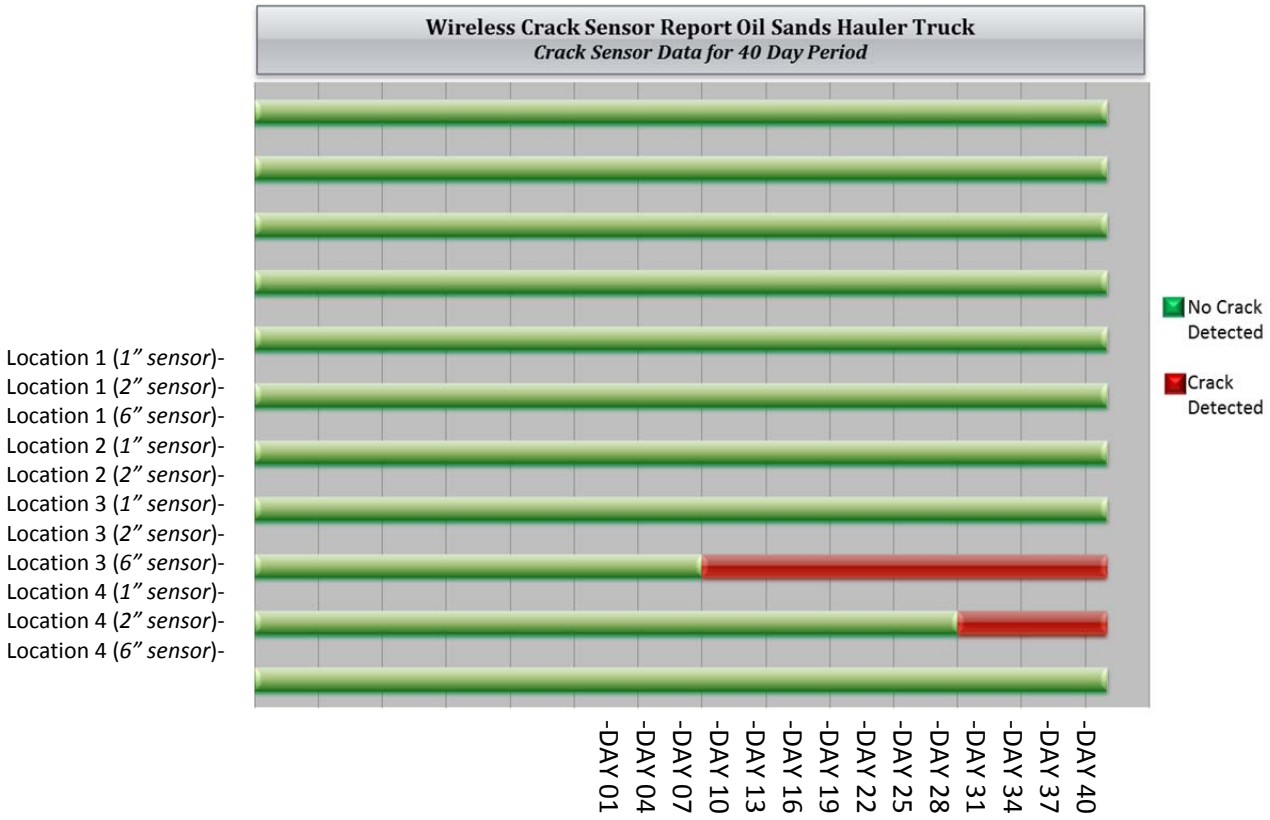
The three gauges, measuring 1, 2, and 6 inches, are then aligned with 1 inch spacing between the parallel-placed gauges. A spot welder was used to mount the gauges to the areas of concern. Once mounted, a protective layer of Teflon tape was applied over the gauges, followed by a coating of rubber sealant. Lead-wires were then attached to the gauges, followed by another layer of rubber, and lastly aluminum tape.
The last step in the process is to spot weld the Mote in close proximity to the three gauges.

The Data



The following figure shows wireless crack propagation data collected over a period of approximately 5 hours during an accelerated test. The crack gauge sensors, CG1, CG2, and CG3, coloured blue, pink, and yellow respectively, were placed strategically so that CG1 was situated immediately at the end of the crack, CG2 was one inch away from CG1, and CG3 was placed one inch away from CG2.
The X axis represents the time it took for the integrity of each of the gauges to be breeched-indicating a propagation of the crack at that exact point in time and distance. The Y axis units have been simplified, for illustrative purposes, to indicate the two possible states that the crack gauges can exist in (open or closed circuit) for any meaningful period of time. As you can see from the figure, the first crack gauge was breeched at approximately 2.5 hours, the second at 4.7 hours, and the last at 5.2 hours.

HAUL TRUCK DATA
Motes with Crack Sensors were installed on a haul truck at a major Oil Sands production facility. Crack propagation data was taken at 10 minute intervals, with data being transmitted to a laptop computer. Global Inspections server uploaded the data every 3 days
The Crack Propagation Data was then analyzed by the technicians, and the results represented in the following bar chart format.



The Benefits

A careful analysis of data collected indicated that with the implementation of Global Inspections wireless crack propagation monitoring system, there is the potential for a 335% return on investment for a fleet of 130 haul trucks. The total annual savings that can be realized would translate into $35,000.00 per haul truck. Condition based monitoring of cracks also increases the uptime (mechanical availability) of the haul trucks by 3%, and the oil sands company is able to reduce their fleet by 4 haul trucks - saving over $4 million in operating costs annually. In addition, the capital cost savings is over $20 million, based on 4 haul trucks with a value of approximately $5 million per unit.

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