Pipeline Encroachment Monitoring

Accurately identify potential sources of third party mechanical damage along a lengthy pipeline route with minimal need for site visits or overflights.

Summary

Over the past decade and more there has been an ongoing development with C-CORE/via+ to integrate the use of satellite data into encroachment and ground deformation monitoring of pipeline right-of-ways (RoWs). Several developments, pilot programs, and now, operational monitoring programs have been executed.

The main focus for this case study is the use of satellite imagery for the detection of third party mechanical damage threats. Detection accuracies are reaching the thresholds required for this service. False alarms are still a challenge that is being addressed.

Hard numbers on the value or return of this service are not available; however the service provided a significant enhancement to the awareness of the activities adjacent to the pipeline and the potential threats they may pose.

We are looking for ways to cost effectively integrate multiple satellite sensors into this application to expand the number of relevant indicators that can be monitored and reported on.

Background

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Over the period 1984 to 2001, almost $90M in property damage was incurred in the USA over 420 third-party incidents. Third party mechanical damage to pipelines is primarily damage caused by excavations on pipeline RoW.

Mechanical damage is the single largest cause of on-land pipeline incidents with more than 75% of incidents being caused by third parties. More than 90% of mechanical damage induced failures occur immediately upon contact. More than 70% of mechanical damage incidents occur in cases where unauthorized encroachment take place without any prior contact being made with the local First Call organizations. More than 65% of mechanical damage incidents occur on pipelines with some level of signage. This drives the need for more proactive approaches to reducing mechanical damage by identifying threats prior to their potential contact with the pipeline.

Alliance Pipeline has over 1,500 km of pipelines in Canada and over 1,400 km of pipelines in the USA. There is a need for preventative measures that reduces mechanical damage risk and can be cost effectively deployed over the system. This capability must also have a minimal health, safety, and environment (HSE) footprint, and its associated risks.

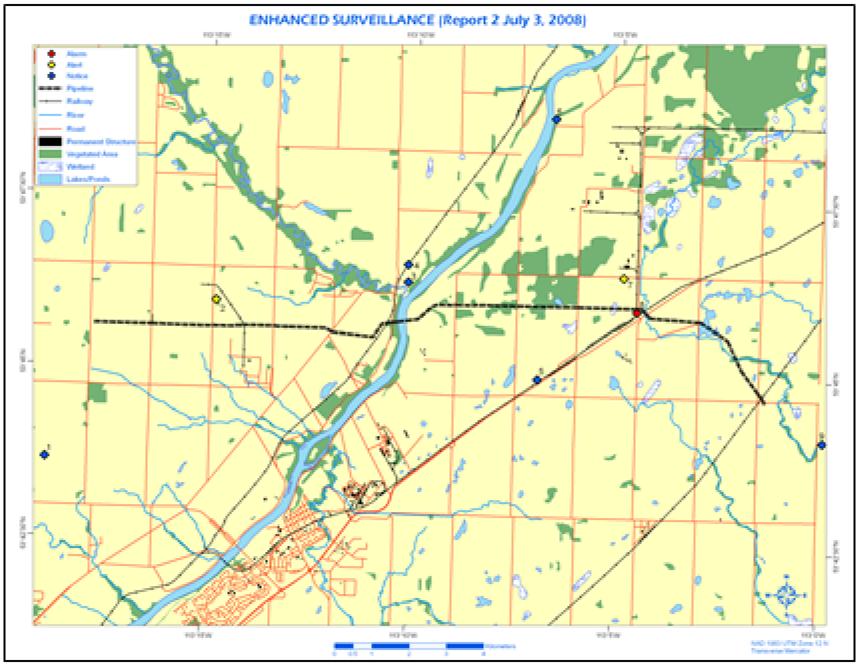
The ideal solution is a ‘visitless’ system that can monitor pipeline RoWs and a buffer of at least 1 km on either side of the pipeline and even up to 5 km on either side. Detected contacts within the buffers are categorized as high priority alarms if they are within 100 m of the pipeline Row, alerts if they are within 500 m, and notifications if they are within 5 km. Ideally these contacts are detected several times a day during busy times (i.e., construction season, day time working hours, etc.). The ‘alarm’ is required as soon as possible after detection (within the hour) with some validation to reduce the false alarms. There is a cost and credibility factor to investigating contacts that result in no activity detected by the operators. The notification of the ‘alert’ depends on the type of activity and the speed at which that activity will approach the RoWs. Same day notification for early day detections or prior to next morning’s business day for evening detections should be adequate.

Activities

Alliance has been monitoring the progress of satellite technology for this monitoring application due to internal corporate interest and support from Pipeline Research Council International (PRCI).

Over $2M has been invested by Alliance and other operators, and organizations such as PRCI in the development of satellite technology to date. The feasibility of the technology was first demonstrated in 2000 and automated in 2001. Developing a near real time capability and integration with Geographic Information System (GIS) was completed in 2002. Several trials took place over the 2002 to 2004 time frame. In 2004 an automated process flow and integration with existing notification services were put in place. There were two levels of service defined in 2006 – a bi-monthly and a bi-weekly service. This was mainly to introduce a satellite based service to get industry comfortable with the technology at a significantly lower price point.

The majority of the detection work was performed using radar. High resolution and very high resolution modes of RADARSAT 1 and COSMO-SkyMed (CSK) have been used. An example of the report is shown in Figure 1 below. Table files are also provided that integrate directly with the GIS.



The trials in the Southeast US demonstrated 75% detection accuracy with a 21% false alarm rate. The trials the following year in Southwest US demonstrated 80-90% detection accuracy with a 1015% false alarm rate. The service was delivered on average about 3.5 hours after the image was acquired. The increase in accuracy was mainly due to the experience gained by the analysts during the first trial. This was a new application and working with pipeline operators to understand better the application domain helped for the second trial.

Alliance moved into a monitoring phase in 2008. This included a control site where various pieces of equipment were staged and imaged by several different satellite sensors. The results were as high as 95% accuracy for detection of contacts.

The service was initially deployed operationally for Alliance in Alberta. The challenge was fully understanding how the service would be integrated operationally into Alliance's operations, and demonstrating that over a site that was easily accessible by Alliance personnel to carry out validation activities. The area also needed to have some reasonable activity levels. The initial area was a known area of high activity. Then there was a planned expansion of a nearby railway yard and construction of an energy plant in relatively close proximity to the RoWs.

The existing monitoring program consists of One Call reporting, field visits by crews, periodic drives along the line, and aircraft monitoring monthly, etc. Mitigation measures included signage, communications with the companies planning the expansion and construction, and maintaining a GIS system that identifies landowners adjacent to the RoWs.

The application of satellite monitoring in this area as a pilot site with real operational requirements was ideal. It provided Alliance with information on the level of management oversight that was involved, some modifications or effort for integrating into the company GIS systems, and if/how to include a new data stream into reporting requirements. There were minimal integration costs as Alliance had a fully operational GIS system already that readily accepted the new inputs. However the main incremental activity for Alliance was the investigations into the contact alarms identified by satellites. This was performed by field staff and this additional task had to be budgeted on top of existing duties. Once the additional contact information became available from satellites there was a responsibility to follow up on each alarm even though this was a pilot project. So there was additional cost incurred.

In order to get 'buy-in' within the organization, especially from the operational personnel, several briefings to introduce the technology and the service aspects were conducted. These briefings were presented by a combination of Alliance personnel and service provider personnel. Also, circulating the acquisition schedule in advance to provide a schedule of expected contact reports from the new data stream was implemented, which helped the operational personnel with their planning.

In 2012 the service was deployed in the USA. The challenge here was the high development activity in the pipeline RoW area. The development was primarily urban sprawl with new subdivisions and shopping centres planned for the area. There was a local Alliance office that made the alert/alarm investigation/follow up task operationally viable.

Outcomes

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Operationally this service presents additional information over existing approaches on the potential for third party mechanical damage. The prevention of that damage can be estimated as many millions of dollars in savings. However quantifying the impact of this service to actually prevent a 'line strike' contact event is difficult. Fortunately, Alliance has not had a Third party line strike to date.

The main benefit is the additional information provided to enhance oversight on the activities in the areas adjacent to the pipeline and therefore the ability to better anticipate potential encroachments outside the typical corridor.

This service does not present any operational cost savings compared to the current approach to monitoring pipeline RoWs for third party mechanical damage threats. Current approaches include aircraft surveillance and driving the RoW, and are likely to continue operationally. There is an increased cost for field investigations of the alerts/alarms, however this is not seen as a deterrent to using satellite data.

There could be value in the analytics of a continuous data set over one to two years that is generated from satellites. The analytics could support third party mechanical damage risk evaluations. The locations of the contacts and their timing (e.g., seasonality, length of time on-site, timelines for activity to reach the RoW, etc.) could help determine areas of high risk and mitigation plans for those areas. Using analytics a pipeline operator could determine hotspots, (i.e., when/where the risk is either high or low), and adjust their monitoring resources accordingly to more cost effectively deploy them. The operator may deal with the hotspot through various mitigation measures (i.e., increased signage, outreach, patrols, etc.).

Also there is a growing social license pressure on companies to operate in an environmentally friendly manner to employ the best possible efforts to mitigating the risk of environmental damage. Satellite monitoring, although not fully deployed today, could be the best approach to monitoring expansive pipeline networks for mechanical threats. It also demonstrates publically that a pipeline operator is proactively monitoring the risk to the pipeline from above ground threats.

Lessons Learned

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Initially there were challenges related to ensuring a continuous and reliable data supply. However, this has been addressed with the constellation of satellites in orbit today that are capable of detecting contacts. The ability of the satellites to reliably detect targets has improved greatly over the past decade, and accuracy rates are now acceptable. The cost of the service is relatively high to deploy over long sections of pipelines (several 100s or 1000s of km). This service cost appears to be very dependent on satellite data costs. If that changes in the future, there should be more widespread use. The service integration cost due to field validations is also high. As detection accuracies are demonstrated to be consistently high, the confidence in the service will improve.

But the remaining challenge is the high rate of false alarms where investigations by field staff into satellite detected alerts and alarms that result in ‘no activity found’ or ‘no threat contact’ create credibility concerns among field staff on the value or ability of satellites to support this application. In many cases there is no easy access to locations along the pipeline RoW to investigate the detected threat. ‘Sight’ inspections from the road do not provide adequate confirmation in all cases. So a high confidence is required that the alarm is real before accessing the RoW over farm properties or other landowners with concerns.

There have been successful demonstrations with One Call operators that reviewed a cost sharing approach to the service in areas where multiple companies operate in the same satellite service area. This is an interesting model to explore, but not something that Alliance would pursue. Service providers and others should explore how to make this happen.

There is a ramp-up period for new sites as analysts become familiar with no-threat targets such as small infrastructure that shows up intermittently.

Classification remains a challenge and there is a need to differentiate construction equipment (threats) from farming equipment or campers (non-threats). However, pipeline encroachment monitoring has improved significantly over the past decade and is expected to improve with the new satellite systems.

The potential for satellite monitoring to become part of monthly or periodic reporting requirements has some potential.

References

References

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