KONGSBERG EXTRA DETECTIONS SUPPORTING PIPELINE INSPECTION SURVEYS

Introduction

A Kongsberg EM2040 was installed in the moon pool of the newly built Fugro Pioneer geophysical survey vessel in late 2014. During various high detail pipeline inspections in early 2015, it became clear that the Kongsberg EM2040 had difficulties in detecting large diameter pipeline freespans at water depths beyond ±30 meters, resulting in unacceptable loss of critical asset information leading to various clients questioning the validity of MBES data collected by Fugro.

The primary scope for pipeline inspections is to collect high detailed survey data of the pipeline and the surrounding seabed and to report on observed anomalies. Amongst these anomalies are freespans, sections of the pipeline which are disconnected from the seabed over a certain length. Freespans pose a serious threat to the pipeline integrity as the pipeline can break if a critical length is reached. The freespan detection issues are of such a magnitude that the top of pipeline (TOP) is not detected at all, the residual suggested detections being the actual seabed underneath the pipeline. Figure 1 illustrates the pipeline detection failure and residual ‘seabed’ detections on two freespan sections observed on a 36 inch pipeline.

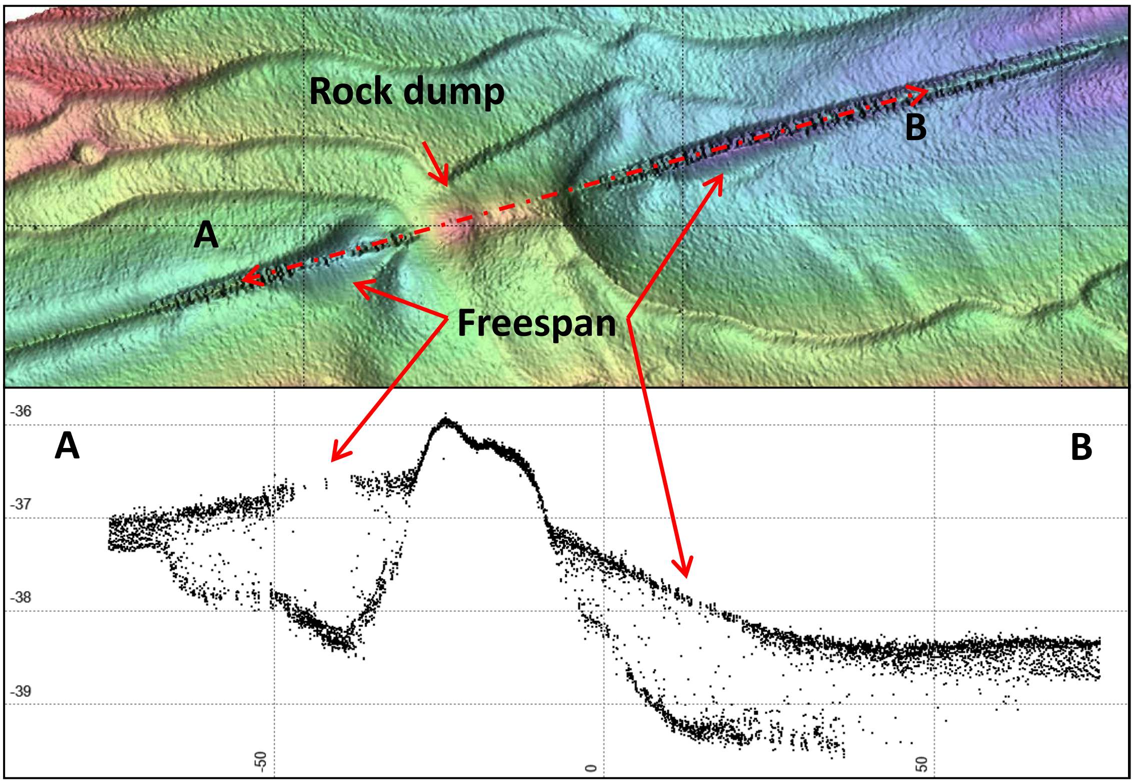

Figure 1: Freespan detection failure on a 36 inch pipeline (0.25 m grid)

High-tech pipeline integrity models are used to assess the status of seabed infrastructure and to determine if remedial action is required. These models rely heavily on accurate MBES point cloud data. The absence of reliable top of pipeline (TOP) detections and questionable ‘seabed’ detections from underneath the pipeline seriously limited freespan length assessments. An excellent example of these difficulties is provided in Figure 2 were TOP detections are absent and the residual seabed detections suggest that the pipeline is supported by the seabed in one location, thus reducing the reported freepan length. Such reduction in freespan length could mean the difference between identifying the need for costly remedial action or not. The unacceptable loss of critical asset information resulted in numerous discussions with various clients questioning the validity of the MBES data collected by the Fugro Pioneer using the Kongsberg EM2040. The primary questions which required answering were:

- Why is the pipeline not detected?
- Is the seabed underneath the pipeline real and if so, is the freespan not actually supported based on the point cloud?

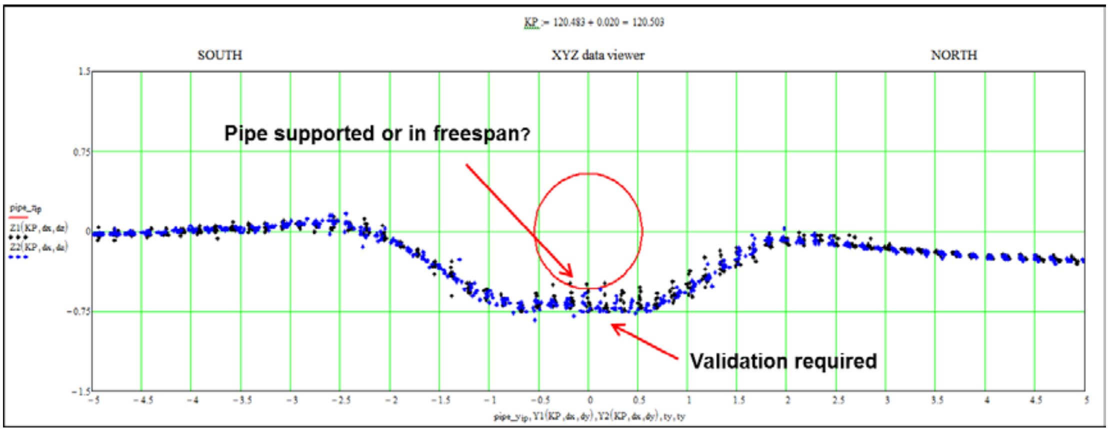

Figure 2: Potential supported freespan within point cloud

Fugro worked with Kongsberg to explain this phenomenon, collecting various datasets using a wide variety of acquisition settings without significant improvements. During the summer of 2015, Kongsberg released a new feature called *Extra Detections* which was expected to possibly detect the TOP when the main detections fail. Normally, the MBES establishes a single valid return per beam (main detection) based on several criteria by which scores are assigned to the various returns within the beam. The return with the highest score is selected and collected by the acquisition software and the other potential candidates discarded (except when water column data is enabled). The *Extra Detections* functionality divides the water column into separate classes based on depth and enables the user to register multiple solutions within a beam. The *Extra Detections* feature was not specifically designed for resolving pipeline detection issues, but the idea was this feature could potentially restore the missing TOP detections.

Extra Detection Trial

Due to the schedule of the Fugro Pioneer, the *Extra Detection* functionality could not be installed and tested until October 2015. With technical assistance from Kongsberg, the Fugro proprietary Starfix® processing software was one of the first in the world to be made compatible to the *Extra Detections* datagram. The trial location was established based on survey data collected earlier in the year and included two freespans of a 36 inch pipeline at such a depth that detection failure of the mean beams would be guaranteed. The survey plan was tailored around the location and included the classic pipeline inspection approach with a centreline (directly on top of the pipeline) and wing line to each side with 35 metre offset. During the course of 2015, it was noticed that crosslines seemed to perform better on detecting the TOP within the main detection. However, this theory was not fully proven and therefore cross and diagonal lines were added to the line plan of the Extra Detection trial. Water column data was also logged to aid data analysis by both Fugro and Kongsberg.

Results

The trial location proved to be a good spot as the main detections from the Kongsberg EM2040 failed to detect the TOP on both freespans, detecting the seabed underneath the pipeline instead. Gaps in main detections on the TOP stand out in the upper part of Figure 3. Over 95% of the failing main detections on the TOP could be restored with Extra Detection. This is well illustrated in the lower part of Figure 3 (*Extra Detections* in green). The quality of the extra detection is similar to the quality of the main detections. Thus, main and *Extra Detections* in the outer beams of the swath are of less quality compared to nadir beam detections. The centre line data revealed that the main detections on the TOP failed less quickly when the pipeline generated the first return. To be more precise: when the pipeline was situated above the first powerful seabed return. Main detections from the cross line proved to be very successful in detecting the TOP and no significant detection failure was observed. The file size of the .all file is increased roughly by 30% – 40%, depending in part on how much was picked up within the water column. Surveys in 2016 confirmed that a 45 minute session .all file of 800 – 900 MB would become around a 1.3 GB. No major limitations were experienced when processing this data in Fugro proprietary Starfix® processing software.

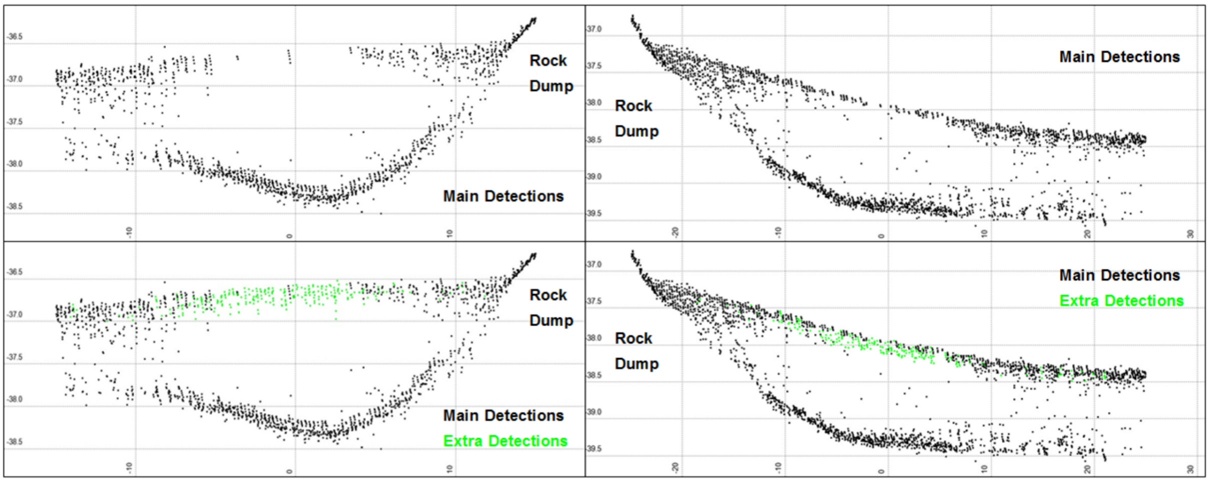

Figure 3: Extra Detections fill TOP gap

Clarification

The answer of both primary questions lies within the detection algorithm which is used by the Kongsberg EM2040. Candidates selected by the bottom detection algorithm are weighted by its strength, distance from previous bottom detection, etc. In this situation, the ‘nice’ continuous strong return from the seabed adjacent to the pipeline gets a higher ‘score’ than the weaker return from the TOP. The main detection for each beam is determined from the return with the highest score within the -10 dB limitation. This - 10 dB limit depends on frequency, beam width, beam angle (relative to nadir) beam spacing, beam steering angle and the water depth. The sensitivity in the mainlobe, following the example of Figure 4, is above -10 dB limit for ± 3 beam spacing which is equal to approximately 53 cm to both sides from the centre of the beam. The main detection (white circles following the seabed) of the beam presented in Figure 4 will be generated from the return with the highest score within the indicated blue boundaries. The strongest return comes from the seabed on the left side of the pipe (red circle) which is projected at the centre of the beam (green circle). Thus, the return received from underneath the pipeline must be from the part of the mainlobe that hits the seabed adjacent to the pipeline. It should be noted that the -10 dB limitations are very dynamic as they depend on a large number of parameters. The depth factor is the major reason that the main detection failure occurs more often at greater depths (taking into account that some parameters are depth dependent). *Extra Detections* are presented as well in Figure 4 by the small yellow circles on the TOP. Following the above explanation, seabed detections underneath the pipeline (due to main detection failure) should be classified as invalid as they do not represent the seabed below the pipeline.

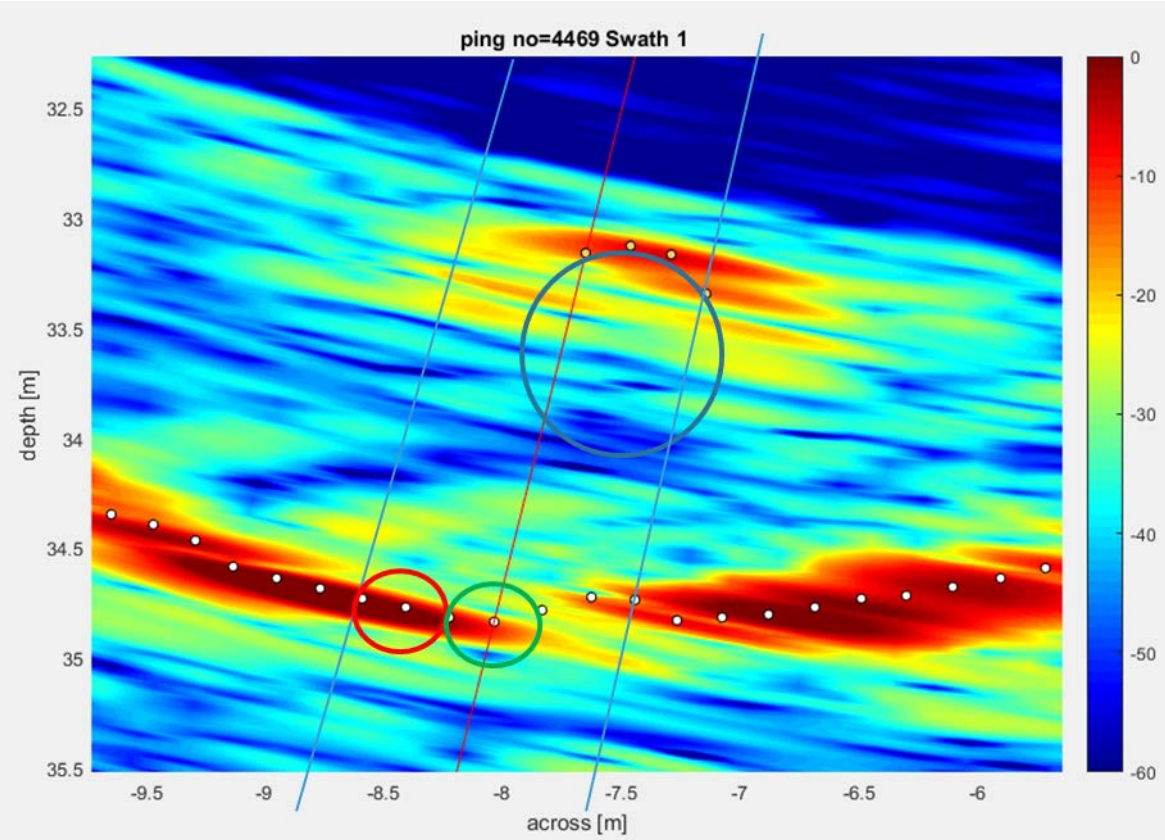

Figure 4: Beam example, blue lines indicating -10 dB points

Conclusion:

The requirements of detailed pipeline inspection challenged the capabilities of the hull mounted Kongsberg EM2040 on the Fugro Pioneer. This resulted in the system not being able to properly detect the top of pipe on freespans situated in water depths deeper than ± 30 m. The Kongsberg *Extra Detections* functionality enables Fugro to successfully restore over 95 % of the initial failing main detections on the TOP. Alternatives are water column data (increased data volumes) or cross lines over the anomaly. Settings in the online MBES setup do little to influence detection failure of the main beams.

Seabed detections underneath the pipeline (due to main detection failure) should be classified as invalid. It is the powerful return of the seabed adjacent to the pipeline, projected to the centre of the beam covering the area underneath the pipeline.

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