PROTECTING SUBSEA ASSETS USING AIS

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Abstract: AIS can be used by owners of subsea assets to provide proactive protection from external aggression, react to incidents that have caused damage and provide information to improve the routing of new systems. The increase in system reliability and potential reduction in costs from decreased repair times, and cost recovery from the guilty party, can more than pay for any monitoring system put in place. Such systems can vary significantly; from DIY collections of free web resources through to dedicated paid-for software with the AIS information originating from self-owned networks or purchased commercial data. Protection can extend to a single landing, a multi-national consortium system or a geographical region.

This paper explains what AIS is, how AIS data can be received and looks at the types of software available which can help monitor and protect subsea assets.

1. INTRODUCTION

The ship Automatic Identification System (AIS) is a tracking system for identifying and locating vessels via a VHF broadcast from the vessel concerned. It was initially devised to help prevent collisions at sea. The periodic transmission includes the ships position, course, speed, and navigational status amongst other information. It is broadcast every 2 to 10 seconds for large vessels underway, to every 3 minutes for vessels at anchor. The International Maritime Organization's (IMO) International Convention for the Safety of Life at Sea (SOLAS) [1] requires AIS to be fitted aboard international voyaging ships with gross tonnage of 300 or more tons, and all passenger ships regardless of size. National or regional legislation can extend this coverage, for example all EU fishing vessels over 15m will need to be equipped by 2014 [2].
Owners of subsea assets can make use of AIS information to help protect their subsea infrastructure, but have several choices to make in how they obtain the data and then process it.

2. RECEIVING AIS INFORMATION

In order to make use of AIS data, it must first be obtained in some form.
Excluding data specifically obtained by satellite, all AIS data, whether via a free website, a paid-for commercial service or a wholly owned network, will originate from one or more land-based receivers. These receivers pick up AIS data from vessels within VHF radio-range, which is fundamentally dependent on the height above sea-level of the aerial, the height of the vessels' aerials, and any prevailing weather and atmospheric conditions. This immediately restricts useful AIS coverage to areas of sea inherently close to land, although for the cable owner, these areas, with their typically shallow water depths, are the most important areas.

When a cable operator assesses potential data sources, a key requirement should be to understand how many individual aerials cover the target area, thus confirming whether the required availability and redundancy can be achieved. Some data feeds allow this level of analysis whilst for others it may be harder to discern.

Most mainstream free-to-access websites and commercial services take feeds from typically several hundred individual aerials around the world in order to provide an aggregated data stream. This global presence, and typically dense coverage in small geographic areas, can appear to provide good redundancy to the subsea owner. However, what often can appear as wide ranging coverage does not necessarily mean that all vessels carrying AIS are being seen.

In addition, careful analysis of data feeds is required in order to determine how reliable they are, in a given location. Some websites cache recent vessel positions in the event that no vessel updates are received for a given period. As such, what may appear to be an indication of steady coverage far from land, may just be irregular and infrequent updates with a non real-time view. Analysis of the vessel height should also be taken into account (along with prevailing weather and atmospheric conditions) as a tall vessel will, all other factors being equal, be seen further away that a low-lying vessel.

An owner operated aerial network has the advantage of being designed specifically for high availability, but unless the owner can access suitable (high) locations to site their aerials, within range of the cable route, coverage is likely to be limited. As an approximation, an aerial 100m above sea level will have coverage to around 50-60km from the aerial. At only 50m above sea level, this drops to around 30-40km. This may be all that is required if the target areas are close to land, but in many locations (for instance around the United Kingdom), depths that could theoretically be anchored in can extend well beyond reasonable radio-horizon from the shore, thus making the height of the land based aerial important.

Reliability of individual data feeds is another crucial aspect; either for building your own network or in analysing a commercial offering. Whilst a standard implementation of an AIS receiver is suitable at a hobbyist level, it is not enterprise grade for high availability. This can only be assured by re-engineering standard kits to allow for remote monitoring and hardware resets.

Free web sources of AIS data such as marinetraffic.com (Figure 1) may well provide coverage of your area of concern but ship tracks are only available for 24hrs and the integrity of the data is not guaranteed, so this approach - although free - is not recommended as a complete solution. However as a starting point, combined with the ability to obtain screenshots and playback video from a third party for specific locations, it can provide a basic approach to using AIS for asset protection.

Figure 1 - marinetraffic.com coverage off the south coast of the UK

One point which should be borne in mind is the accuracy of the data that is received.

Whilst physical information such as position and speed are supplied from on-board GPS systems, details such as the ship name and IMO number are normally entered by either the crew or system supplier. Reports [3] have shown that these fields can be left blank or contain the system default value, leading to the inability to identify vessels. In addition, there is widespread abuse of the ships navigational status with a large number of vessels either stating they are "at anchor" at all times, or being somewhat slow to update after weighing anchor. It has also been observed by the author that ships knowing they have fouled a cable turn off their AIS transmitter. With the ability to play back the ships movement up to that point, this action can actually help identify the vessel responsible for a fault rather than hide it.

3. REACTIVE ASSET PROTECTION

With data available there are two basic approaches to using it to protect subsea assets:

The first and simplest is to be reactive; that is to wait until an incident occurs before taking action. Once this happens, AIS data can be used to determine the likely source of the damage, advise vessels of their likely engagement with a seabed installation and the best method of damage avoidance, and if the worst happens, provide an indication of the fault position. The information obtained will allow potential claims for damages against the perpetrator which not only allows repair costs to be reclaimed but also provides a deterrent to future incidents. It will also allow the complexity of the repair to be understood in advance of a repair ship being dispatched, allowing extra plant to be loaded if multiple hits are suspected.

Using AIS in this reactive manner does not in itself prevent faults but can provide a long-term deterrent and can be a low cost, low manpower option for low risk assets.

In order to react to an incident using AIS to help determine the fault location and recover repair costs from a third party, the following will be required:

- Complete AIS coverage of the cable system or ideally until the 2000m water depth contour. Bottom fishing activity is currently limited to water depths less than 2000m and ships' anchors can only reach to less than 200m with anchoring commonly taking place in water depths between 20 and 50m. The risk of external aggression in waters depths greater than 2000m is limited to oil and mineral exploration activities that should be covered by notification to cable owners in advance, and relatively few locations globally will be afforded reliable land based coverage of the sea at these water depths.

- Ability to record, store and playback data for at least 3 months. Notification of failure is not always immediate, and the exact fault position not always apparent from initial fault finding, as time of fault may not be precisely known. In this case the ability to playback data is essential in order to identify possible locations and responsible vessels.

- Ability to obtain screenshots or video. This will be required as evidence in any damage claim, in which case documentation from an independent third party may be required. There are several commercial companies that provided such a service. The ships position, the date and time in UTC should be clearly visible in relation to

the damaged asset, as should the recent track of any vessel.

4. PROCTIVE ASSET PROTECTION

A proactive approach to asset protection aims to prevent incidents occurring by monitoring an area around the asset for particular patterns of shipping activity, using suitable computer software and a reliable AIS data supply. The alert produced can enable staff to take appropriate action to prevent faults occurring.

There are several providers of suitable software. Some have been specifically written for the purpose and others are adoption of systems written for monitoring ship movements in ports. They can also differ in how they are accessed: Web-based systems allows access from any web connected PC or even smart phone, providing global access to your solution, in addition, the service provider is responsible for maintenance and storage of data. Alternatively, software on a standalone dedicated PC at a given location could be used. This may reduce third party dependencies, and allow more powerful features / datasets to be utilised but also has maintenance, storage and backup requirements. Issues such as getting data paths through company firewalls also need be taken into consideration. Some suppliers are also able to supply suitable AIS data coverage for specific areas offering an "all in one" package. The optimum solution will vary depend upon the exact needs of the system or company concerned and a careful technical review of what is available should be made to ensure those needs are met.

The software chosen needs to allow for the graphical display of AIS data relative to the assets concerned. It may also allow the display of admiralty charts or, at a minimum, coastline details. Asset data is normally entered by the user or supplier from existing RPL's and the ability to update this information when routes change is required. Assets are protected by the setting up of buffer zones of various sizes around them and then defining rules based upon the AIS data feed such as speed, heading, and status or derived from the feed such as changes in speed or course. Ships within these zones that break the rule or rules generate alerts which then allow the cable owner to take appropriate action. The alerts may be in the form of an e-mail, SMS text or audible alarm depending on the software used and the requirements. Different rules can be set up to produce different levels of alerts on some software allowing large degrees of customisation. Once alerted, staff can review the information and decide if further action is required. This could be contacting the vessel direct via the local coastguard or port authority. It should be noted that it is only possible to advise of the presence of the asset and the danger and possible consequences of contact with it - asset owners have no authority to direct a vessel at sea.

The setting up of the protection zones around each asset requires careful consideration in order to fully protect the asset, prevent false alarms and provide enough reaction time to reasonably allow a vessel to be contacted prior to reaching the asset / causing damage. The total length of the asset may not need to be monitored, dependent on prevailing risks. Vessels normally anchor close to land for shelter and carry limited anchor warp (160m is typical). By monitoring only where damage is likely to be preventable and ships can be contacted by VHF, costs and

false alarms are kept to a minimum. The need to actively monitor further offshore to protect against fishing activity should be considered only if it is thought that contact can be made with the vessel and that avoiding action will be taken otherwise resources are wasted and the chance of false alarms being generated increased. However owners may wish to monitor fishing activity around assets to assist in targeting fishing liaison activities. Specific rules and low level alerts can be set up for this purpose.

The width of any monitored zone will determine how much reaction time is available if an alarm is triggered at its extremity and the type of manoeuvre that is being monitored for. The setting up of double zones around assets with a narrow inner zone within a wider outer zone with appropriate different rules to react to varying threats should be considered in appropriate areas, such as those close to anchorages (see Figure 2).
In general a monitored zone would extend an equal distance either side of the cable. The ability to vary the width of the zone at points such as anchorages or harbour entrances is also required to help prevent the generation of false alarms.

Figure 2 - Double protection zone on asset using AssetMonitor™

It should be noted that it has not yet been possible to determine a universal rule which will spot all vessels about to cause cable damage without also generating false alarms. It is also particularly difficult to detect anchors deployed whilst a vessel is underway, due to many larger vessels not being unduly affected by dragging their anchor. Rules need to be tailored to the area and type of threat that is applicable. They will need to be fined tuned as part of any installation process. Also once in operation, the system and associated processes and procedures should be periodically reviewed to ensure it is working correctly, not generating excessive false alarms and any improvements implemented.

Figure 3 - low-lying AIS receiving Aerial

5. OWN NETWORK

To build a wholly owned network a combination of high availability equipment

and elevated aerials help minimise costs and maximise coverage. Aerials can easily be placed on the side of low lying buildings such as in Figure 3.

However, placement on tall structures (Figure 4) will increase maximum range and area covered coverage.

Figure 4 - High aerials give useful coverage

A typical AIS kit is shown in Figure 5.

Figure 5 - AIS Receiver, data converter and modem

It comprises of several parts: an AIS receiver, which receives and decodes the AIS signal from the aerial. A serial to Ethernet converter which converts the output of the receiver, and a broadband router which is used to transmit the data to a remote location. This is simple set up but has several drawbacks.

Custom designed kits can overcome these. The installation shown in Figure 6 allows secure remote control, remote power control, automatic rebooting and reconfiguring of equipment to maintain uptime. In an unpublished study of AIS kit availability, only 98.0% uptime (12 hours outage per active aerial per month) could be achieved with a standard kit. This was mainly due to the delay in getting staff to site. In seeking to utilise the minimal number of optimum sites, this level of availability could become an issue. Relatively inexpensive improvements to the standard kit easily allow most common equipment issues to become self-healing, thus improving the availability.

Figure 6 - High availability receiver

6. PRACTICAL EXAMPLES

Three practical examples are described below to show the range of systems available:
Figure 7 shows a fictional cable route plotted on a free web based GIS system

overlaid with fictional traffic data again from a free web based source. This allows a reactive approach at no initial cost and will even allow monitoring from a smart phone with good data connectivity. The figure shows a suspect fault position with ships at anchor and the track of a fishing vessel crossing the cable line.

Figure 7 – Screenshot from Google Earth™ with fictional cable system overlaid

Figure 8 is a screenshot from a standalone software monitoring package. The vessel in Figure 8 is shown anchored just west of the cable. The system here should have raised the alarm before the ship anchored allowing appropriate action to be taken. If this initial opportunity was missed, the system could still be used to identify the culprit either when the fault occurred when the anchor was retrieved, or subsequent to that as the system has a playback function.

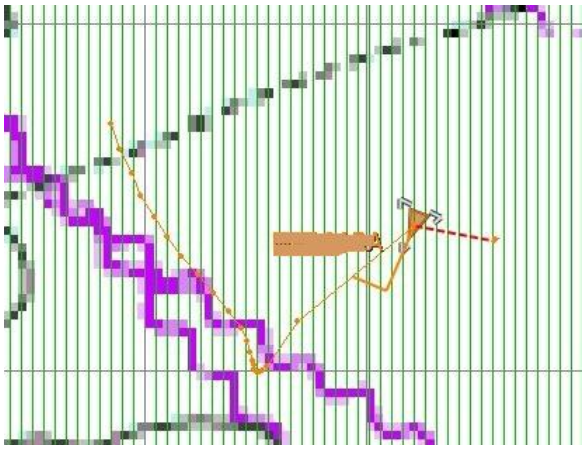

Figure 8 - Screenshot from a Horizon™ based standalone system

In Figure 2, a warship conducting manoeuvres over a cable close inshore has triggered firstly a low speed alarm in an outer protection zone and then another alarm due to a rapid change of course in an inner zone. Having received an SMS alert to the vessels slow approach to the cable, the system owner was able to confirm that there was no threat to the cable concerned from their home PC via a commercial web-based system out of office hours. The AIS data was provided direct to the web based hosting service so the system owner has no system maintenance overheads or extra hardware requirements and access to the system can be given to any interested party.

7. AIS SUCCESS

Whilst many operators will be able to recount examples of one off AIS based damage claims, some more tacit success is interesting to review.

One result of the use of AIS was analysis that resulted in a markedly different assessment of cable faults [4]. Whereas fishing had been attributed to most faults prior to the adoption of AIS within the Subsea community, its introduction has revealed that anchor damage to be more prevalent than previously expected. This in turn allows a change in focus on both preventing faults but also route planning.

In an unpublished study by one of the author, data for 2012 showed intervention against anchored vessels close to cables on 15 occasions. Whilst the distance from the cable at the time of intervention varied from 80m to a few hundred meters, a number of these incidents could have gone on to cause cable faults. Whilst there is no conclusive way of knowing if a fault has been avoided, faults have been generated

from similar anchoring behaviour in the past.

Even where a vessel doesn't move following intervention by the Maritime and Coastguard Agency, such contact is considered a success both from the immediate awareness and the follow up dialogue with the vessels' owners.

8. FUTURE/OTHER DEVELOPMENTS

A major limitation of current real-time AIS services is that most aerials are located on land, thus as already mentioned limiting the effective range from shore. Some satellites have been equipped with AIS receivers to allow this coverage to be extended. However there are limitations to this, in that the time a satellite is overhead in a high ship density area may not allow all vessels to be identified and at the present time there is not global 24 hour coverage. Some suppliers are able to offer set frequency monitoring of high value assets at an appropriately high cost, but the lack of 24 hour cover limits it value in this application. As this coverage expands, the offshore gaps are filled and the service becomes cheaper, the possibilities to analyse long term patterns in vessel movement will enable enhanced route development with the ability to identify traffic patterns, actual anchorage areas with the type of vessel which uses them and current fishing zones.

It is possible using a suitable transmitter and software to use an AIS monitoring system to automatically alert ships to the presence of nearby cables. However given that the number of alerts that this could generate on board a vessel would seriously reduce the effect, and that there is no way to confirm that the signal has been received by the vessel, this practice could not be recommended.

9. REFERENCES

[1] Regulation 19 of SOLAS Chapter V
[2] EU Commission Directive 2011/15/EU
[3] Abbas Harati-Mokhtari, Alan Wall, Philip Brooks and Jin Wang
"Automatic Identification System (AIS): A Human Factors Approach"
[4] CIL-ICPC Workshop on Submarine Cables, April 2011