# Utilization of the Internet in Pipeline Protection against Vandalism

Udeme E. Okon
Department of Electrical and Information Engineering
Covenant University, Ota, Ogun State
Nigeria.
udy4life2014@gmail.com

***Abstract*— The huge nightmare defying Africa's economy known as pipeline vandalism had obviously rendered all forms of protection innovations abortive because these innovations were strictly centered on a lone and narrow method of "sensor this; sensor that" type of protection design. Although prevalent in rural communities, it is clear that the perpetrators of this crime are no novice to plugging out the sensor based detection/protection systems' eye/ear before they carry out any operation; therefore, it becomes needful for the introduction of a thoughtful and appropriate method of protection that will ensure a global permanent solution to this atrocious nightmare. Consequently, this paper proposes the utilization of the internet in pipeline protection against vandalism; it also demonstrates the utilization of the Internet in the protection of pipelines taking into cognizance an accurate measure and comparison of the physical quantities around the conveyed fluid.**

***Keywords*— Pipeline; Protection; Vandalism; Internet.**

## I. Introduction

Pipeline transportation right from the 19th century, has proven to be the most effective method of transferring some kind of raw product from the point of extraction to the refinery or finished product from the refining point to the final consumers. Pipeline transportation is also a means for transporting toxic materials and waste to the points of neutralization or storage. In areas where there are minimal threat probabilities, it has proven to be the most cost effective and safest method. Pipeline management and flow control is very important to ensure that there is no service break to customers and consumers at the other end. Safety of pipeline is very important to the health of the people and the environment. Sometimes pipeline can be very lengthy travelling long distance away from the control station making it highly susceptible to vandalism. There must be proper system management to ensure pipeline security. This type of management usually involves highly sophisticated equipment that can capture especially the flow rate through the pipeline, operational status, pressure, and temperature which can be used to evaluate the healthiness of the pipeline at a particular point in time. Such equipment must be able to operate at real time and at the same time ensuring accuracy for effective monitoring. This work demonstrates the application of the Internet to pipeline monitoring and management to circumvent both planned and unplanned incidents. Planned incidents include security breaches while unplanned incidents are those resulting from natural conditions [2]. The importance of the damage incurred can be graded as first, damaged by third party second, corrosion and third, equipment malfunction [1]. It is therefore the major concern of the government to ensure security maintenance of the pipelines [2]. Overtime, numerous surveillance methods have been proposed and utilized in the servicing and management of pipeline to ensure safe operation. Modern methods of pipeline protection are operated either at ground level or may be airborne. Some of the mature technologies include; the use of sensor architectures both wired and wireless, physical patrolling around the site and pipeline Supervisory Control and Data Acquisition (SCADA) systems shown in figure 1. However, these technologies are not without practical drawbacks and limitations which serve as a spur for endless inquisition towards more reliable solution.

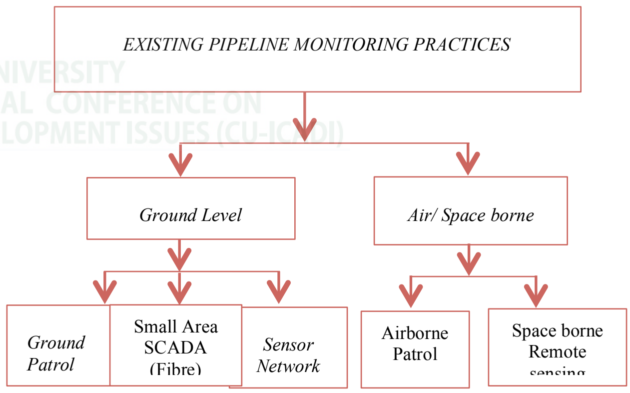


*Fig. 1. Grouping Established methods for monitoring*

### A. Ground Level Methods for Pipeline Monitoring and Controls

The ground methods employed for pipeline monitoring majorly cut across three commonly practiced techniques, namely; Ground Patrol, Wired Sensor Network and small area SCADA systems.

*1) Ground Patrol:* Pipeline monitoring by ground patrolling has been a legacy technique over the years [1]. This involves a physical patrolling and inspection of the pipeline area either by leg or by land transportation system in order to identify possible threat, intrusion or anomaly along or around the vicinity of the pipeline. Also to obtain an accurate measurement and assessment of defects so that human operators can take appropriate actions in the case of an incidence to prevent further damage. In Nigeria, a combined team of Pipelines and Products Marketing Company (PPMC) police and community vigilante groups are engaged to guard the pipelines. For efficiency purpose this method is always carried out in combination with other advanced method such as the aerial surveillance technique by the PPMC/Nigerian National Petroleum Corporation (NNPC) [2, 3].

*2) Pipeline SCADA Systems:* Supervisory Control and Data Acquisition (SCADA) systems used for pipeline monitoring centers on integrated data collection and control. The overall aim is to provide real-time security status of the entire pipeline to ensure applicable steps are taken by the monitoring team supervising the central information to either avoid or mitigate the threat. This technology utilizes several Remote Terminal Units (RTUs) that receive information from field instrument on the level of pressure, temperature, and rate of flow of the fluid flowing through the pipes in conjunction with the conditions of valves and pumps along the pipeline as seen in figure 2 [2].

In a typical SCADA network the RTUs are in turn linked to a central master station via communication channels such as satellite, cable, cellular, or fiber optic transmission media which determines whether the SCADA architecture is wired or wireless [2, 4].

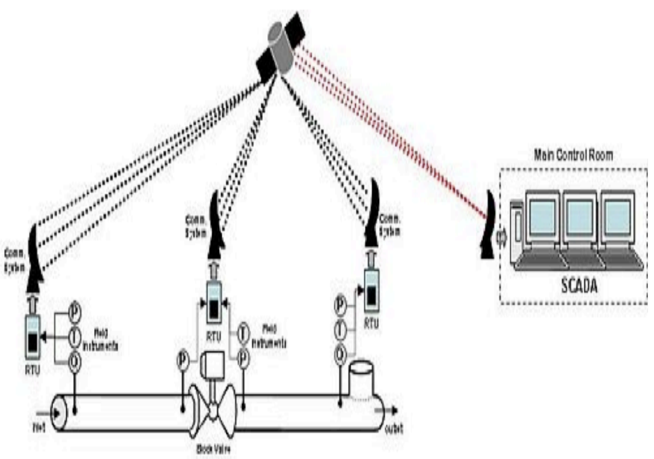


*Fig.2. Sowing RTUs linking Main Control Center*
Source: http://3.bp.blogspot.com

*3) Sensor Network:* Sensor network has been in as one of the modern techniques available for pipeline monitoring and control. A sensor network can be either wired or wireless. The type of infrastructures available can determine the type of network architecture suitable for a particular application. A number of linear topology sensor networks have been designed to detect, locate and report anomalies such as leakages, corrosion, fracture and any other damages on the pipeline infrastructures [2]. In wired sensor networks, copper cables or fiber optic cables are used to effect both communication and electrical power supply to the different parts of the pipeline system. This network is feed with signals from regular sensor devices that measure specific qualities in and around the pipeline as seen in figure 3, such quantities include flow rate, pressure, temperature, vibration and probably humidity [2]. A Wireless Sensor Network (WSN) as the name implies comprised of several interconnected sensor nodes linked by a wireless communication channels. These sensor nodes are minute devices that can collect data externally, perform simple evaluations and communicate with other nodes in the network or the central station [2]. This type of network can either be categorized as infrastructure or infrastructureless network. An example of infrastructure network is the cellular wireless network and such network consists of wireless node with a network backbone. On the other hand ad-hoc and Wireless Sensor Network (WSN) can be said to belong to the infrastructureless network category since they are widely distributed, independent, dynamic topology, low-power, task–oriented wireless nodes [2].

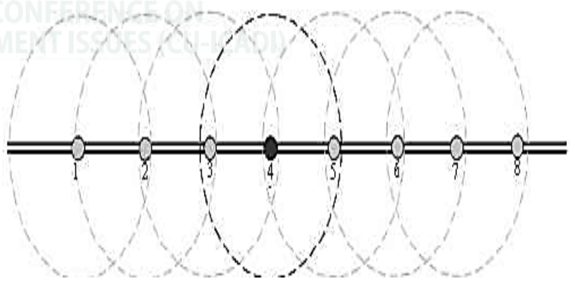


*Fig.3. Showing Linear Sensor Network for Pipeline Monitoring*
*Source: https://www.researchgate.net/*

*B. Air Space borne Methods for Pipeline Monitoring and Control*

There are certain constraints that must be eluded with extra effort if the economic and environmental damage caused by pipeline injury is to be mitigated or absolutely avoided. To this end, air/space borne method for pipeline monitoring and control has been introduced as additional measure in combating threat intrusion and possible vandalism.

*1) Airborne Patrol:* Airborne patrol employs special patrol team which used airborne transportation to move along the area where pipeline intrusion and vandalism are rampant. Helicopters or other forms of aircraft can be used to achieve this aim. This method has the advantage of covering areas of restricted accessibility such as mountainous or swampy areas where ground patrolling is impossible. Special equipment and airborne scanners are used to capture the status and circumstances around the pipeline. Data and images are captured and sent through very complex processes which include automated classification, noise removal, layer extraction, automated filtering, georeferenced, calibration of geocoordinate system, data reprocessing and quality control. The final data is used as a warning signal for decision making [1].

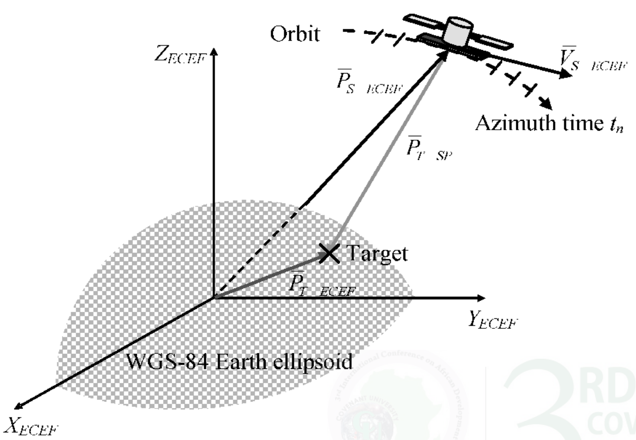


*Fig. 4 Remote Sensing from Space Platform*

*2) Space borne Remote Sensing :* Space borne sensors design depends on the type of orbit or platform they are mounted as shown in figure 4. There are no airborne scanner due to low temporal, long interval, inadequate number of data and limitation in flight over the pipeline corridor. The geostationary orbit, the polar orbit, and the sun-synchronous orbit are the three orbits where satellites are placed around the earth. However, the sun-synchronous orbit makes a good choice for space borne laser profile [1].

## II. DRAWBACKS IN CURRENT PIPELINE INFRASTRUCTURE MONITORING

Pipeline infrastructure monitoring and control techniques discussed in section (1) have numerous benefits derived from their proper implementation. However, these methods are not without some drawbacks. Some of these drawbacks either make implementation of these techniques ambiguous or totally impracticable. Examples of these drawbacks are discussed below:

### *A. Coverage Limitation*

Limitation in coverage may arise as a result numerous factors depending on the technique used in the monitoring process. In the physical patrol technique, limitation in coverage area can be as a result of inaccessibility of some areas where pipeline is running. In mountainous areas for example, the problem of accessibility may be as a result of unfavorable terrain [1]. Lack of adequately skilled personnel for airborne patrol operation also results in limitation of coverage and makes it necessary to have a backup plan. Coverage limitation can be experienced in the SCADA systems due to the inflexible architecture and rigid design of RTUs which limits their operational compatibility with other systems posing serious difficulty in extending the SCADA to other applications thereby limiting the coverage [2, 4].

### *B. Sensor Blackoutn*

In pipeline monitoring and control the linear topology network is preferably employed for sensors' interconnectivity. This type of networking is very effective for communication since all sensor nodes are distributed on straight lines. But then, a lot of attention is also needed to justify the numerous demands essential for a linear network. Power supply to all the sensor nodes is very important. Connectivity is ensured as long as all nodes are up and functioning. This is a major requirement in pipeline monitoring because of the continuity of operation. However, reliability issues set in when there is malfunctioning of one or more of the sensor nodes with a consequential and unavoidable blackout of the entire network [2, 5].

### *C. System Complexity*

For a timely response by human agents overseeing security status updates supplied by pipeline monitoring systems, real-time information covering the entire length of the pipeline is needed. For SCADA systems, network complexity may result from installation of several hundred RTUs communicating over dedicated links to a central master station. In systems where different sensor network or combined network architectures are used for reliable communication in pipeline monitoring systems, system may become bulgy and costly on the attempt to account for the combination of wired and wireless network architectures. Also, remote sensing platforms that used space may involve tedious technical manipulation which is common to very few expert personnel. Network maintainability and fault recovery mechanism should be taken seriously, as faults in the network or in the nodes can occur at any time for different reasons and can lead to very damaging consequences [2, 4].

## III. PROPOSED SYSTEM

The proposed system used optical fiber technology intrinsically, in pipeline monitoring and control with the Internet used as the medium for communication. Optical fiber applications have been used as sensors to measure physical quantities such as temperature, pressure and strain by varying the intensity of the optical fiber properties. Intrinsic or active fiber sensing is when the optical fiber itself is used as sensing element [6].

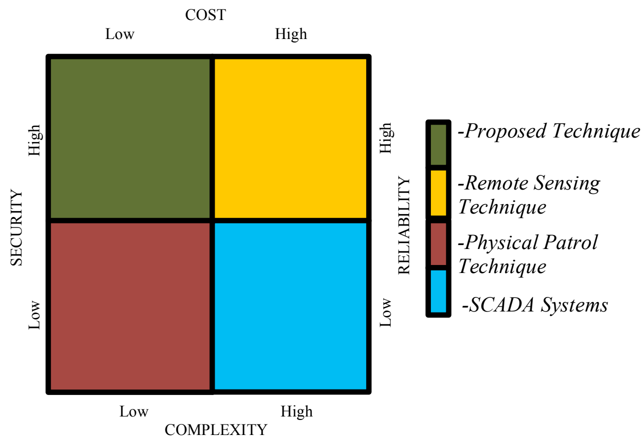


*Fig. 5. Tile Chart Comparing Different techniques*

In this form, optical fiber can be utilized in sonar application as optical acoustic sensor in pipeline monitoring. With Distributed Acoustic Sensing (DAS), acoustic events can be detected, discriminated and located on an optical fiber over a long distance based on optical fiber sensing [7]. This method has an advantage over other techniques in terms of security, reliability, and noncomplex system design. This can be seen in figure 5 above.

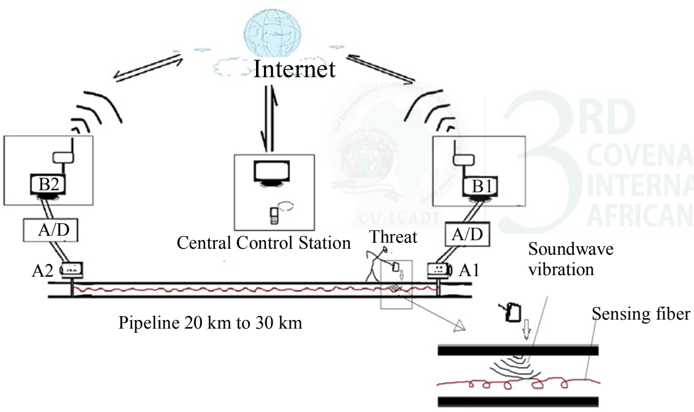


*Fig.6. Utilization of the Internet in Pipeline Protection*

## A. *System Description*

The diagram in Figure 6 is used to demonstration how the internet is used to achieve solution to pipeline vandalism. In the diagram, A1 represents control station equipment consisting of Distributed Acoustic Sensing (DAS) interrogator that separates out the optical fibers that is run through the pipeline into a collection of separate microphones.

This is spanned several kilometers from control station A1 to another control station at (A2). A/D is an advance signal processor and converter. B1and B2 comprised of some bi-directional computing and routing devices that aid in signal conversion, recovery and real-time transmission of processed signal via the internet.

## B. *Principle of Operation/ Implementation*

On the occasion of intrusion where there is a bang or a noise which is unmatched with the steady background hums around the vicinity of the pipeline, the distributed acoustic sensor in the optical fiber running inside the pipeline will detect and transfer the sound through real-time backscattering of light to control station at A1 or A2 where the detected signal is processed and passed to system B1 or B2 for transmission over the internet to the nearest protection station, depending on the point of the threat. The protection station personnel can then interpret and use such information for appropriate decision making to rescue the situation.

# CONCLUSION/RECOMMENDATION

The design and installation of a pipeline transmission system, if to be totally saved from wasteful assaults, requires an excellent and applied protection mechanism of this form, pipeline vandalism which is virtually prevalent in this part of the world seems to be an African problem and it is likely that, the solution also will come from this part of the world. It has been shown in this work, how optical fiber technology can be intrinsically used with the Internet as the medium for communication to deliver an effective method for pipeline monitoring and control. As shown in figure 5 this technique has comparative advantages of low cost of implementation, low system complexity, high reliability and high security above existing methods. Is a well thought out solution as a contributive effort to the global battle against this lingering cynicism and is therefore, recommended for the Oil and Gas Sector to unify with existing expertise in the field during the design and installation of fluid transmission systems.

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