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The Deployment of UAVs Using Machine Learning for Security Surveillances on the Pipelines and Illegal Oil Refining Clusters: A Critical Review of the Nigerian Scenario

Stephen MALLO, JR
Department of Computer Science,
Faculty of Natural Science, University of Jos.

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Abstract

Oil pipelines are extremely safe modes of energy transportation, yet either by omission or commission they can occasionally fail. These failures in the developed economies are frequently related with impact damage resulting from earth moving equipment, corrosion, manufacturing defects from the pipeline materials. However, in developing economies such as Mexico, Ghana and Nigeria, pipeline theft, sabotage, and vandalism are severe problems and major issues resulting in pipeline failures and oil spillages. This article examines pipeline failures in Nigeria, with emphasis on pipelines that transport hydrocarbon liquids, establishing that pipeline sabotage through oil theft (oil bunkering), illegal refining of crude oil and oil leakages are the leading causes of pipeline failure with failure rates according to Ambituuni A et al, 2015, of about 0.35 per km-year which is far above those reported on other pipeline systems across the world. Pipeline failures have been established to result in about 0.04 to 0.38 deaths per km-yr in Nigeria, depending on the location with some estimated financial losses by Oil Companies for as much as 100 million dollars per year on the average. This figure excludes the costs of paying compensations, fines, environmental clean-ups and litigation, among others. The paper has proffered a solution for improving pipeline safety by engaging in proactive measures to reduce fatalities and financial losses in this all important sector of the Nigerian economy. The measure is through a strategic surveillance against sabotage, tracking of crude oil leakages, theft, tracking of illegal oil refining clusters and marketing routes of barges loaded with crude oil to awaiting offshore Ships and hinterland Trucks in the forested areas of the oil producing States. The Drones will allow for the acquisition of imagery data with high spatial and temporal resolution that can provide credible real time information and data on the activities of criminals within the numerous densely forested creeks of the Niger Delta region. The deployment of such modern surveillance strategy will certainly provide some economic leap to a country whose economic mainstay is Oil with as high as 90 percent dependency. The undertaking will curb oil pipeline sabotage, reduce oil theft and environmental degradation resulting from oil spillages and illegal refining of crude oil.

Keywords: UAVs, Pipelines, Drones, Security Surveillance, Oil and gas Sector.

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Introduction

Crude oil and Liquid petroleum products are mostly transported and distributed in Nigeria by pipeline and road truck tankers. Pipelines are often regarded as the most secure mode of transporting energy, particularly petroleum products (Hopkins. P, 2012). Pipeline operations provide a Risk of Loss of Containment (LOC) (Dziubiski. al et, 2006), with the potential for fatalities from fire and/or explosions, as well as environmental harm. As a result, pipeline risk must be assessed in order to establish appropriate mitigation strategies. According to data received from the National Oil Spill Detection and Response Agency (NOSDRA), a government-run satellite tracker, 12 states in Nigeria were involved in Illegal Oil bunkering resulting to about 881 incidences of oil spillages between January 2019 and April 2021. Out of these number the three top oil producing States of Bayelsa, Delta, and Rivers (Fig. 1), accounted for 77% of the spills within same period. Nigeria's second-highest oil-producing State, Akwa Ibom, saw only 26 oil spills. The entire spillage reported during this period amounted to a loss of around 43,000 barrels of oil, valued at nearly $3 million at $70 per barrel based on the international crude price on May 5. The civic organization Budget of 2018 Constituency Project Report, this amount can build three four-block classrooms (at N8 million each) and drill three solar-powered boreholes with 100,000-litre capacity tanks (at N25 million each) in each of the twelve aforementioned states. The above analysis presents a very hopeless situation associated with the enormous financial losses to the country occasioned by avoidable manmade disasters, requiring drastic modern technological approach using Drones to reduce the menace.

Drones, also known as Unmanned Aerial Systems (UAVs), are small aircrafts equipped with sensors and software that allow them to fly without the assistance of a human pilot. This is a breakthrough technology that has the ability to transform combat and open up new civilian applications. The air vehicle (Unmanned Aerial Vehicle), the control and communications systems, and the remote human operator are all examined when UAVs are being considered. Furthermore, the payload of the UAVs is a critical component of the aircraft's mission. Unmanned Aerial Vehicles (UAVs) are more suited to monotonous, filthy, or risky missions than human aircraft (Mangesh et al. 2013). UAVs are primarily used for intelligence, surveillance, and reconnaissance (ISR), border security, counterinsurgency, attack and strike, target identification and designation, communications relay, electronic attack, law enforcement and security applications, environmental monitoring and agriculture, remote sensing, aerial mapping, and meteorology, as well as the Oil pipes and sundry Infrastructures in this case. Whatever the UAVs are intended for, they must be protected from unwanted access. Unauthorized users can get access to the stored contents of UAVs, a system's processing capabilities (control), or information being transferred between systems. According to Mahalingam et al. 2004, each attack necessitates a unique collection of skills and targets - a unique set of vulnerabilities. Every system has vulnerabilities, and it appears hard to eliminate them altogether. Vulnerabilities are frequently discovered as a result of required capabilities. Unknown vulnerabilities that the owner or operator of a system is unaware of may be the result of poor engineering or unintentional effects of some of the system's required capabilities. Consequently, protecting oneself from assaults is a multi-step procedure that seeks to restrict and manage one's system's vulnerabilities (Ryan, R., & Julia, H. 2017)

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Significance of the Study

The world is becoming very much technologically inclined and the use of unmanned aerial vehicles (UAVs) or Drones for security surveillances is becoming increasingly regulated by the national aviation authority of individual countries. Regulatory regimes can vary greatly depending on the size and use of drones. Since 2005, the International Civil Aviation Organization (ICAO) has been researching the usage of drone technology (Leslie, C., & James, C. 2012). Defence forces throughout the world are increasingly adopting UAVs for diverse applications such as surveillance, logistics, communication, attack, and combat, thanks to the significant cost reductions and breakthroughs in UAV technology (Sachin. M, 2020). The control technology has developed and costs have decreased, allowing them to be used in a variety of non-military applications. Aerial photography, product delivery, agriculture, policing and surveillance, infrastructure inspections, and smuggling are examples of these activities. As a result of this development, it is believed that advanced technology is required for surveillance on oil and gas infrastructures to aid in the reduction of crude oil theft from pipelines and in the identification of illegal oil Refining Clusters in the oil producing States of the Niger Delta. The deployment of UAVs from strategic locations in the oil producing States and especially in the densely forested creeks will in no small measure augment the existing security architecture which principally depends on the Nigerian military's access to intelligence information gathering which have not been absolutely reliable.

Aim of Study

The main aim of this study is to monitor oil pipeline vandalism and the entire security surveillance control for oil theft in the Niger Delta. Pipelines, including pipes, compressors, and pumps, are usually positioned in difficult-to-monitor and-secure situations (e.g. offshore, remote areas). Attacks or damage to such installations, as well as equipment failure or accidents, can have a huge environmental impact and result in losses of revenue while potentially disrupting international oil markets. Improving the security of oil and gas installations is a global priority, and the primary reason for monitoring oil and gas pipelines is for safety reasons. On a global scale, there is growing legislative and regulatory pressure to improve the safety and integrity of crude oil pipelines.

The Nigerian Oil Pipelines Networks and Oil Installations in the Niger Delta Oil Fields

The pipeline networks used in Nigeria to carry petroleum products (primarily Premium Motor Spirit (PMS), Automated Gas Oil (AGO), and Household Kerosene (HHK)) are presented in (Fig. 1). The pipeline system is divided into five operational areas for strategic purposes. Through its subsidiary, the Pipeline Petroleum Marketing Company (PPMC), the Nigerian National Petroleum Corporation (NNPC) owns and operates the 5001 km asset (PPMC). The PPMC pipeline network consists of multiproduct systems for product delivery, with subterranean pipelines connecting refineries and distribution depots. With a nameplate capacity of 438,750 million barrels per day, the country has four refineries: one each in Kaduna and Warri, as well as two in Port Harcourt. A crude oil pipeline connects the Kaduna refinery to the Escravos terminal through Warri with the pipelines divided into nine systems (Anifowose et al, 2012).

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This paper has focused on the creeks and forested regions of the Niger Delta (Fig. 2) where the Oil plants and numerous oil pipelines have been subjected to sabotage and theft. With this maps under consideration, the UAVs can be installed in specifically designated locations for monitoring all illegal activities in those areas.

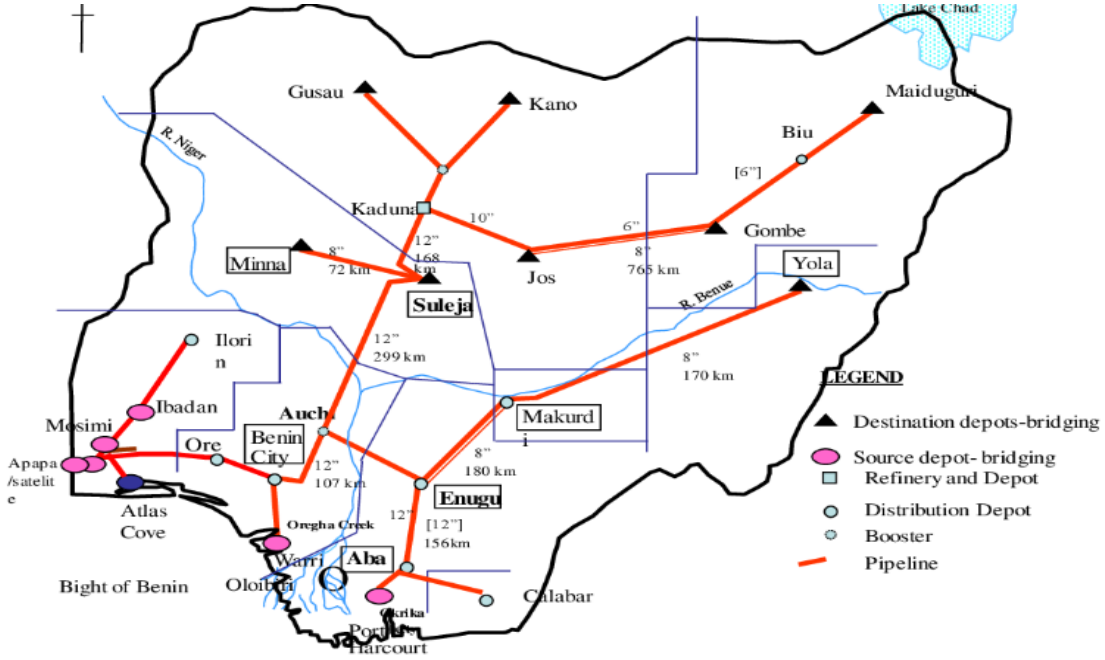

Figure 1: Map of Nigerian showing pipeline network and facilities (Source: After B. Anifowose, D.M. Lawler, D. van der Horst, L. Chapman, 2012).

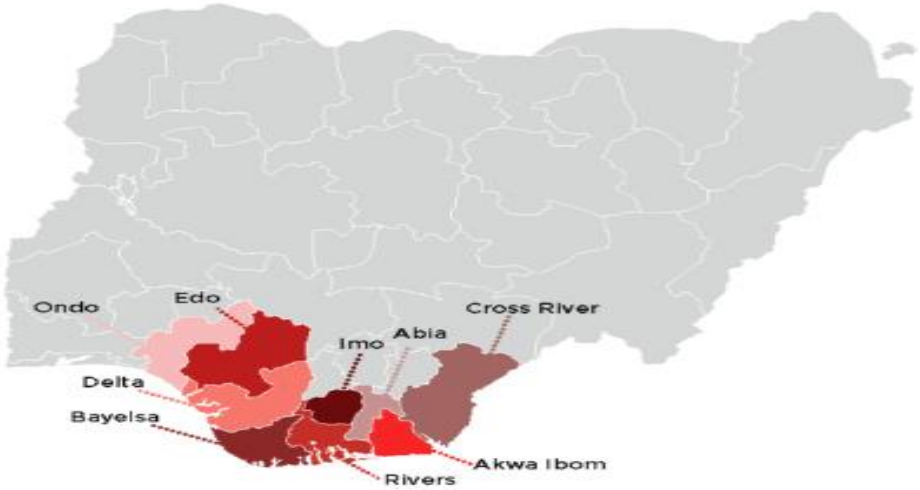

Figure 2: Map of states in the Niger Delta (Source: After Christina Katsouris & AaronSayne, 2013).

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The Statistics of Oil Spillage in Nigeria

An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and is a form of pollution. The term is usually given to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Oil spills penetrate into the structure of the plumage of birds and the fur of mammals, reducing its insulating ability, and making them more vulnerable to temperature fluctuations and much less buoyant in the water. Clean-up and recovery from an oil spill is difficult and depends upon many factors, including the type of oil spilled, the temperature of the water (affecting evaporation and biodegradation), and the types of shorelines and beaches involved. Spills may take weeks, months or even years to clean up. Oil spills can have disastrous consequences for society; economically, environmentally, and socially. As a result, oil spill accidents have initiated intense media attention and political uproar, bringing many together in a political struggle concerning government response to oil spills and what actions can best prevent them from happening (Broekema, W. 2015).

The statistics of oil spillage in the Niger Delta has shown that Rivers, Delta and Bayelsa State has the highest cases of oil spillage. While Rivers State had 352 spills, Delta State had 233 cases and Bayelsa was third with 89 within the period of review is in 2021. The three states together, thus, recorded more oil spills (674) than all other states put together (207); or about 77 per cent. As observed, each of Rivers and Delta recorded more oil spills than the nine other states (apart from Delta and Bayelsa) put together (207). Abia State had 41 incidents; Imo State - 31; AkwaIbom State - 26; Edo State -19; Lagos State -11; while Kaduna and Ondo States each had only 2 cases. The statistics of oil spillage in term of numbers and volume of is shown in Fig 3.

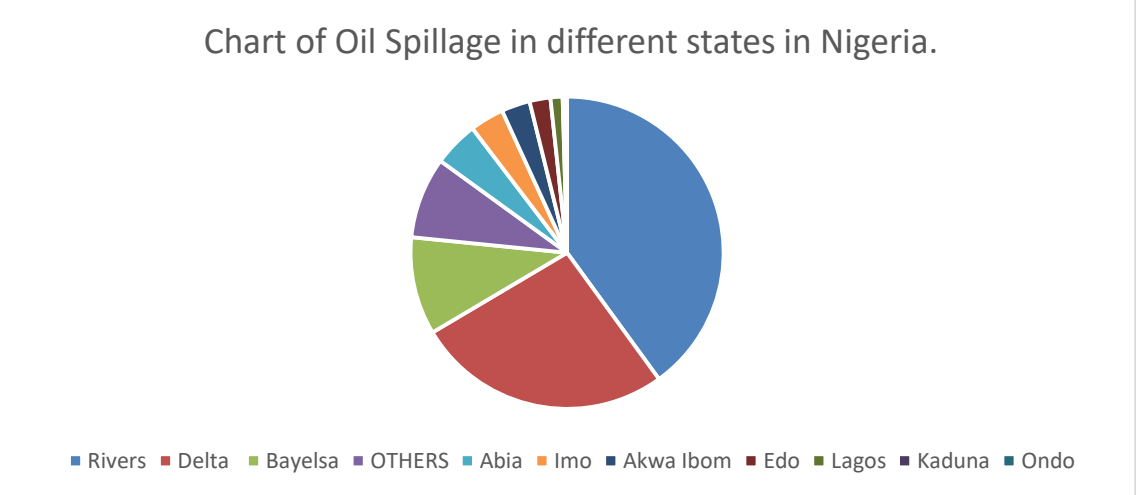

Figure 3: States in Nigeria with the highest number of Oil Spillage and Bunkery. (Source: After Yusuf Akinpelu, 2021.

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Triggers of Oil Spills: Aside from bunkering and oil theft which are potentially lucrative businesses for criminals, oil spills have thrived due to the inaccessibility of some oil spill sites. The presence of armed criminals participating in illegal refining surrounding these facilities further compounds the matters. Even though oil spills are supposed to be reported within 24 hours, some go unreported since the party responsible for the spill has a vested interest in cleaning it up and paying compensation or bribery to locals and authorities that are supposed to report the spillage to National Oil Spill Detection and Response Agency (NOSDRA).

Similarly, there have been reports of spill clean-up teams or regulators being denied entry to spill sites by affected local people. Suspicion and reciprocal hostility between oil firms, regulatory authorities, and local communities (some of which may be concealing illicit refining operations) further exacerbate the vulnerable situation. The spills of Oil companies and performance are shown in table 1.

Table 1: Oil spills by company compliance and performance 2021/2022 (Source: After EklavyaGupte, 2021)

Company	Reported Spills	Reported Volumes	Number of Joint Investigation Unit (JIV)	Number in Quantity
SPDC	131	4110 Barrels	34% (45)	0% (0)
NAOC	107	1047 Barrels	37% (40)	0% (0)
MPN	30	12404 Barrels	3% (1)	100% (30)
Heritage	19	344 Barrels	11% (2)	0% (0)
NPDC	11	1142 Barrels	0% (0)	0% (0)
Eroton E&P	11	4315 Barrels	9% (1)	0% (0)
SEPLAT	10	44 Barrels	20% (2)	0% (0)
CHEVRON	8	7 Barrels	25% (2)	0% (0)
ERL	7	75 Barrels	0% (0)	0% (0)
TOTAL	6	47 Barrels	17% (1)	0% (0)
FIRST	4	2 Barrels	0% (0)	0% (0)
Platform	4	1 Barrels	50% (2)	0% (0)
Midwestern	3	19 Barrels	33% (1)	0% (0)
Neconde	3	23 Barrels	0% (0)	0% (0)

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Aiteo E&P	3	244 Barrels	0% (0)	0% (0)
NDWEST	2	71 Barrels	0% (0)	0% (0)
TUPNI	1	0 Barrels	0% (0)	100% (1)
NNPC-NPSC	1	0 Barrels	0% (0)	100% (1)
ESSO	1	27 Barrels	0% (0)	100% (1)
HEIRS OIL AND GAS	1	0 Barrels	100% (1)	0% (0
	1	0 Barrels	100% (1)	

The Operational Mechanisms of Oil Theft and Artisanal Crude Oil Refineries

Operational mechanism of oil theft: Hot-tapping and cold-tapping are highly sophisticated oil theft techniques that are mostly used in large-scale operations at the crude oil stage. Theft of crude and refined oil products from storage facilities throughout the export transit process is known as terminal and vehicle transportation theft.

The Hot-tapping which is an illegal secondary pipeline belonging to oil theft criminals is connected to a high-pressure primary pipeline belonging to a multinational firm during the hot-tapping procedure (Agren. D, 2019). Oil is diverted from the original pipeline onto mobile oil bunkering facilities connected to the secondary pipeline when the breach is successful. The major pipeline can work at nearly normal pressure and remain undetected by oil company officials by progressively withdrawing modest volumes of oil. Although a steady withdrawal is required, the pressure within a pipeline is sufficient to fill a transport barge with thousands of metric tons of oil in a matter of hours. Hot-tapping is said to be exceedingly dangerous and difficult to master.

In the Cold-tapping is a section of a pipeline is blown up and a secondary pipeline is connected to the shut-down primary pipeline during the cold-tapping process (Ian, R., & Ojekunle, J. 2019). Cold-tapping is thought to be less hazardous. Cold-tapping is a term used to describe a method of tapping into a live tubing, well or pipeline casing without any need to do any welding or hot work. Cold taps are used to safely check for or release unknown pressure of fluid in piping.

Terminal and vehicle transportation theft: Although oil theft is common during the initial stages of the oil production process, theft is rampant at the port terminals where crude and refined oil products await shipment to international locations and during the transportation of oil product from corporate facilities. Administrative collaboration and security force corruption aid the siphoning of oil shipment reserves into illicit gasoline trucks at export terminals. These fuel

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trucks are then used to transport illegal oil products for sale in neighbouring African countries, where oil prices are far higher than Nigeria's subsidized rates (Silas. F, 2015). There is a lack of monitoring into controlling the original value of oil generated by multinational oil firms because oil meters are not present at the site of production and are only present at export facilities.

The fabrication of artisanal refineries in the Niger Delta is crude but maybe substantially in conformation to the principle of J.S. Hogan's first build refinery in 1976 consisting of one-skid portable crude topping machine (12 feet wide, 45 feet long, and 11 feet high) for the production of straight run gasoline, diesel oil, and heavy fuel residue. The locally fabricated crude oil refinery is made up of a large drum which is used for boiling up the crude oil. These drums have pipes protruding from them, leading to collection troughs of the products which are kerosene and petrol for the local markets and diesel which is transported away in barges or inland in trucks by traders. The fourth product from the illegal refinery is bitumen which is sold to road construction companies while the firth product which is gas is flared. The main activities which are carried out by criminals mostly during the night is to avoid detection of locations from the oozing smoke by the Security, has very devastating environmental impact on the soil and water. See footages of illegal refineries which are found in Nigeria (Niger Delta) regions as shown in Fig. 4.

Figure 4: Locally made illegal Crude oil refinery footage (Source: After Will Ross, Geoffrey Uzono, 2022)

The socio-economic and environmental impacts of oil theft

The Nigeria's crude oil production is losing an average of 200,000 barrels per day to theft, according to the state-owned Nigerian National Petroleum Corporation. The loss, attributed to pipeline sabotage and illegal pilfering by thieves, is a massive increase over the industry average

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of 70,000 b/d of oil output lost to theft as of August 2020, according to NNPC (Gupte. E, 2021). It's still going on in terms of crude losses. "We're losing 200,000 barrels per day on average," NNPC Managing Director Mele Kyarisaid in Abuja, according to an NNPC release (Ugbodaga. M, 2021). Kyari revealed this during a meeting with Nigeria's military chief, Major General Lucky Irabor, to discuss ways to reduce pipeline attacks and large-scale crude siphoning. While security agency cooperation has reduced attacks on the NNPC's major oil products pipeline network System 2B, which is largely used to transport imported gasoline, crude oil theft has increased. Irabor promised to enhance military collaboration to provide maximum security for Nigeria's oil and gas assets, according to the NNPC announcement. Irabor stated, "It is my desire to work with you to the greatest extent feasible and to provide required directions to all commanders in the Armed Forces." (Ogunyemi. D, 2022).

However, Nigeria as Africa's biggest producer has recently suffered a financial setback due to a decline in crude and condensate production and lower pricing on the international market. Nigeria's oil industry auditor, the Nigeria Extractive Industries Transparency Initiative (NEITI), released a report in 2019 revealing that the OPEC member had lost around 138,000 barrels per day of crude oil worth $40.06 billion to theft over the previous ten years. Costs are continued to increase in Nigeria as a result of attacks on infrastructure in the country's key producing region, the Niger Delta, according to producers. Shell, ExxonMobil, Chevron, and Total, among others, have associated the continuous oil theft to their divestment in several onshore properties. Nigeria's oil facilities have been targeted for sabotage numerous times over the years, while others have aged, resulting in recurrent failures that create operational disruptions, significant maintenance costs, and income losses. The NNPC is now examining funding proposals from local and foreign partners for the construction and maintenance of its crude oil and petroleum products pipelines. Pipeline disruptions, which reduced crude supply, were also blamed for the erratic operation of its four refineries, which have a combined nameplate capacity of 445,000 b/d. The NNPC has a 5,000-kilometer pipeline network that transports crude from overseas partners as well as imported refined oil products across the country. In the second half of last year, Africa's largest oil producer saw its output steadily decrease as it was forced to make major cuts as part of its OPEC+ commitments. Nigeria has the ability to produce 2.2 million barrels of crude and condensate per day, but S&P Global Platt's estimates that it will only pump 1.72 million barrels per day in 2020. This is the lowest output since 2016, when terrorists in the Niger Delta attacked major oil installations on a daily basis, cutting output to 1.4 million-1.5 million barrels per day. The Niger Delta has seen a decline in militancy in recent years, but the security situation in the region remains dangerous, given the region's history of warfare. According to the country's budget, President Muhammadu Buhari has dealt with militancy in the restive Niger Delta by continuing to give amnesty payments until 2020.

Nigeria is the world's 13th largest producer oil and it is being stolen on an "industrial scale" in Nigeria, and the country's politicians and security officials are among those profiting, according to a report from a prominent British research group *Petroleum* Technology *Research Group* (PTRG) which is in the University of Salford. Reuter's photographer recently gained rare

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access to an illegal oil refinery near the river Nun in Nigeria's oil state of Bayelsa. There, he was able to document the secret and dangerous practice of oil bunkering, where locals hack into oil pipelines, steal the crude oil, and refine or sell it abroad (Akinleye, A., & Nossiter, A. 2013). Large firms have been extracting crude oil and natural gas from the Niger Delta for nearly 50 years, and they have had their share of environmental disasters. Much of this oil winds up being exported globally, said the report, which was released by the London-based organization Chatham House (Katsouris, C., & Sayne, A. 2013). The problem has grown to the point where major oil firms working in Nigeria have recently complained that theft is reducing production significantly. According to the Nigerian report, "stealing from tank farms, refinery storage tanks, jetties, and ports" is a problem. "Officials and private actors disguise theft through manipulation of meters and shipping documents." Small-scale pipeline tapping operations can easily be detected in short daytime trips into the swamps from the Niger Delta's population centers. Telltale plumes of smoke from illegal refining operations rise above the water. But more significant "bunkering," as oil theft is known here, involves siphoning oil from pipes on land or underwater, loading it onto small barges, then transferring it to bigger barges offshore in the Gulf of Guinea. Sometimes thieves use pipes up to 12 inches in diameter to tap the lines, according to Chatham House.

The Civil Society Legislative Advocacy Centre (CISLAC), has revealed that Nigeria lost at least $3.5billion revenue to crude oil theft in the year 2021. There is several information about loses, they must be aggrouped and organized in one only point of the paper CISLAC executive director, Auwal Ibrahim Musa Rafsanjani, made the revelation in Port Harcourt on Thursday while speaking during a one-day design workshop on the roadmap towards fostering civil-security relationship in Nigeria (Onukwugha. A, 2022). Rafsanjani, who was represented by a member, Board of Trustees of the organization, Mr.AdesinaOke, stated that the figure represents 10 per cent of Nigeria’s foreign reserves. He said: “Recent findings suggest that the issue does need to be investigated further and more data gathered to inform firmer conclusions and better targeted policy recommendations. In 2021, Nigeria lost at least $3.5 billion revenue to crude oil theft, a figure that represents 10 per cent of Nigeria’s foreign reserves. “Oil theft and pipeline vandalism threaten oil exploration and accruable revenue. In 2019, the Nigerian National Petroleum Corporation (NNPC) announced that it lost ₦159 billion to oil theft and pipeline damages”. The CISLAC executive director raised concern over military and other security personnel' involvement in oil theft, calling it a "issue." "Military and other security services' involvement in oil theft is a concern," he continued, "with armed forces either turning a blind eye or benefitting from the illegal oil trade throughout the process." Soldiers have been reported protecting "tapping points," where crude oil is retrieved from illegally installed taps on oil pipelines, turning a blind eye to, or even protecting, illegal bush refineries, and soldiers soliciting bribes in exchange for undisturbed passage for illegal oil transportations."

Nigerian former Finance Minister Ngozi Okonjo-Iwealatold the London Financial Times that the trade in stolen crude had led to a 17% drop in official oil sales in April - equivalent to around 400,000 barrels a day. The Nigeria Extractive Industries Transparency Initiative (NEITI)

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reported in its most recent audit report, released in July 2021, that in 2019, Nigeria lost 42.25 million barrels of crude oil worth $2.77 billion to oil theft. The Nigeria Extractive Industries Transparency Initiative (NEITI) stated in its most recent audit report released in July 2021 that Nigeria lost 42.25 million barrels of crude oil worth $2.77 billion in 2019 due to oil theft, up from 53.28 million barrels taken in 2018. Despite the fact that the Nigerian National Petroleum Corporation (NNPC) operates four conventional refineries (Kaduna, Warri, Old Port Harcourt, and New Port Harcourt), none of them work at more than 60% of their design capacity. Despite the fact that these refineries are expected to generate 445,000 barrels per day, the country is now experiencing a refinery capacity shortfall, resulting in a refinery scarcity. However, there have been many theories as to why this unfortunate situation exists, the most obvious ones are: insufficient funding and autonomy, poor maintenance culture, political instability, poor management, irregular feedstock supplies, non-implementation of the Petroleum Industry Bill (PIB), ineffective technical services department, pipeline vandalism, obsolete technologies, and delayed turn around maintenance. (Ogedegbe. A, 2009). Some private investors acquired licenses in 2002 and 2004 in which about 26 private business where established. This refineries and petrochemical industries made open bidding for private investors abroad to invest in the petroleum downstream industry in Nigeria. (Angela. M et al, 2019). Although some companies attempted to launch, they were forced to stop due to challenges encountered at various stages of the project. Inadequate funding for capital projects, political issues, government price regularization on items, an adverse environment, power and security challenges, and the Federal Government's inability to attract local investors are just a few of the stated reasons. (Okere. R, 2015). Current Challenges; The country is left with the following possibilities in an attempt to find answers to the preceding negative scenario: More conventional refineries are being built, illicit refineries are being legalized, crude oil is being swapped for refined products from other nations, and modular refineries are being built all across the country. Pollution, air pollution, land soil pollution, and water pollution are all difficulties linked with illegal refineries. (Odunlami, O.A. et al, 2018). The manufacture of yield cuts with poor specifications, fires and explosions, the loss of capital infrastructures and revenues for the government, the country's terrible reputation, community conflict, and the death of plants and animals are among scenarios that could occur. Although the government should not legitimize the illegal refinery, operational changes can be made to create a win-win situation. The Modular Refinery Era; The concept modular refinery is not a practice that is relatively new. Although they were earlier used in the early forties, this concept later re-surfaced in the seventies when there were needs to solve problems associated with the conventional refinery (Hogan. J.S, 1974). A modular refinery is a conventional refinery constructed in a fragmented way or simply a big refinery in miniature form (Igwe. G.J, 2015). When crude oil and a ready market are accessible around the world, but refining capacity is low, this notion works well. According to additional research, it can also be utilized to lower the transportation costs associated with moving crude oil from the field to refineries in remote locations. It also involves building a refinery that can be quickly hidden or dismantled if the necessity arises (Duncan J.W. & Knox. L., 2004). J.S. Hogan was the first to build a one-skid portable crude topping machine (12 feet wide, 45 feet long, and 11 feet high) for the production of straight run gasoline, diesel oil, and heavy fuel residue.

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The Deployment of Small Drones (UAVs) in the Rainforest and Creeks Areas of the Niger Delta.

The benefits and drawbacks of using tiny UAVs to monitor pipelines like any other technology, have advantages and disadvantages when it comes to monitoring energy infrastructure. Small UAVs provide a number of advantages over traditional surveillance methods, including lower costs, increased operational safety, and greater mission flexibility. Ground and manned aerial surveys are both more expensive than unmanned aerial surveys, with manned aerial surveys being less secure and flexible. Furthermore, whereas traditional aerial platforms are limited by wind, clouds, and other climatological factors, small UAVs often fly at less than 150 meters, benefiting from low cloud flying altitude and hence good spatial resolution. The use of unmanned aerial vehicles (UAVs) to install security surveillance base stations throughout the board will provide depots with an aerial view.

In order to have absolute security surveillance in the Oil producing region of the Niger Delta, there will have to be a combination of multiple Drones with different take offs time intervals which will be deployed from designated workstation bases. This is in order to enable all locations of Illegal oil refining Clusters, oil bunkering activities, oil spillages and sundry criminal activities to be captured by the UAV's technologies through aerial views from workstation bases. The following are some of the UAVs which are being suggested to be used:

Single-Rotor Drones. U.S. Army Northrop Grumman's RQ 8 Fire Scout UAV: As already mentioned, there are drawbacks to that design. First, the single blade design which is gas powered in nature can mean that single-rotor drones can sometimes cost more than their counterparts. What's more, larger rotor blades mean a higher chance of fire accidents. In addition, the drones are often not as stable, and while they can still hover over areas, they can also be more difficult to fly than drones that have multiple rotors to keep them balanced and airborne. They can cost anywhere from $25,000 to a whopping $300,000. Nevertheless, there are different specification for military defence war purposes.

Tactical Drone: These drones are large enough to not be pocket-sized, while still being far smaller than the type used for general combat and larger tasks. The preferred tactical drone of the US military is the Raven, which measures 4.5 feet and weighs 4.2 pounds. These types of drones are often used for surveillance work. The Ravens, like the Black Hornets, can be mounted with unique infrared cameras that allow them provide soldiers with an accurate image of the area even at night. On-board GPS technology is included in the units. While they are simple and lack a lot of bells and whistles, this also makes them very accessible and straightforward to use for soldiers who do not have specialized training.

Micro Drone: Micro drones are all business for military who operate drones. While smaller drones may appeal to consumers, they are all business for armies who deploy drones. The Black Hornet, designed for the British military, is the most well-known example of this type of drone in use today. The British military has been using these tiny 1" x 4" drones to scan behind walls and

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other installations in Afghanistan since their introduction in 2013. While cameras may be too much for recreational tiny drones, the small drones' particular micro cameras can provide vital information and intelligence. Black Hornets can be placed in a specific belt while not in use. They have a range of up to a mile and can fly for up to 25 minutes on a single battery charge. In addition, infrared cameras have been installed on certain Black Hornets.

The aerial photography is obtained using a Remotely Piloted Aircraft System (RPAS), also known as a drone. With digital photogrammetry, additionally generated two main products: Capturing changes in vegetation and a digital surface model. That is basically a mosaic of aerial images that will be stitched together and adjusted to correct for things like topographic relief, lens distortion, and camera tilt. Therefore, these reproduce the real dimensions of the objects, with horizontal spatial resolution varying between 3-7 cm. Due to the high resolution, these allows to visualize the canopy. They also provide a range of rich physical and ecological information. For instance, we can observe leaf changes, the dynamic growth of lianas, the death of canopy and sub-canopy trees, and even branch fall. Through synchronized ground surveys, the drone can sometimes lose the signal with the radio control. Trying to avoid this requires accurate flight planning. In addition, the reduced open space often requires that the take-off and landing can be performed both automatically and manually, without the aid of obstacle detection sensors but in delicate situation it will be installed on drone. Recent UAVs can fly to a range of (18 hectares) without losing the radio control signal. Monitoring the canopy dynamics of dense tropical forests is pretty challenging. Tools such as drones allow for the acquisition of imagery data with high spatial and temporal resolution and therefore lots of important details. (Simonetti. A., & Marra. D.M, 2021). According to Paneque Gálvez. J, et al, 2014, there are more advantages associated to using UAVs in tropical forest regions namely; extremely high spatial resolution, potential for high temporal resolution, Insensitivity to cloud cover, potential for three-dimensional drone image generation, Potential to ease Niger Delta regions and make it more attractive to communities, shallow learning curve of drone users, relatively low price of drone imagery, High cost-effectiveness within the context Niger Delta, Data acquisition decentralization. There is also Enhanced monitoring of illegal activities, Access to otherwise inaccessible areas, Potential environmental benefits, potential social and institutional strengthening of communities, control of data acquisition and ownership by community members.

The Network Ground Control Station (Workstation for Drones (UAVs))

Although the 3GPP (3rd Generation Partnership Project) is still focusing its efforts on cellular-connected (UAVs) standardization, multiple potential wireless architectures that involve flying systems carrying an intelligent router. The control and non-payload communications (CNPC) connection and the data link are the two primary types of communication links that characterize ABS design. The base station (BS) deployed on unmanned aerial vehicles (UAVs) is a flying antenna system that serves as a hub between the backhaul and access networks (Bin et al. 2019). The so-called fly ad-hoc network (FANET) is formed when more than one ABS is participating in such a relaying mechanism. FANETs are a type of wireless ad hoc network (WANET) or

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mobile ad hoc network (MANET) that is used in the air. One of the revolutionary characteristics of the 5G/6G network is the ability to give "connectivity from the sky." ABSs have the capacity to create on-demand networks at specific places, thanks to their in-built qualities of mobility, flexibility in three-dimensional space, adaptive altitude, and symmetric rotation, which set them apart from static conventional network architecture. These characteristics enable premium services to be provided to ground users, including high-quality wireless networks, low degradation, high capacity, and low interference. Different use cases for ABS network deployment have been developed from an industrial perspective in order to provide connectivity during temporary events and emergency situations, as well as in zones or rural locations where there is no pre-existing robust network infrastructure. The Drone and (UAVs) network ground control workstation is presented in Fig.5.

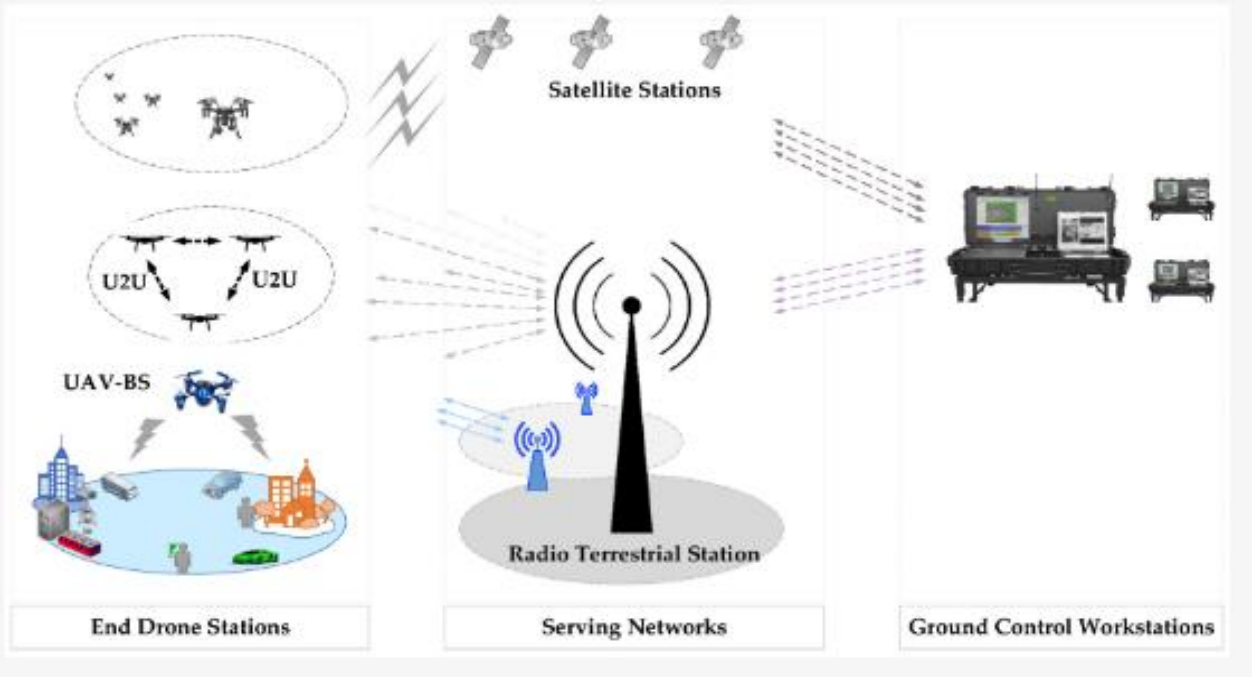

Figure 5: Drone and (UAVs) network ground control workstation (Source: After *Saad,Walid; Bennis, Mehdi; Mozaffari, Mohammad; Lin, Xingqin, 2020).*

Conclusion

The menace of operational activities of oil theft and illegal refining and their socio-economic and environmental impact on the pillar of Nigerian's source of income have been discussed. Drones or unmanned aerial vehicles (UAVs) have various benefits in aerial and security surveillance and contribute enormously in tackling insecurity in the Oil and Gas industry. Due to the further research it has come to my knowledge that machine learning will play a great role to facilitate this achievement since it has to do with multiple datasets. Tools which are used to explore are just a handful of our favourite Big Data tools are Apache Spark, Apache Hadoop, Kaggle and many others. It is recommended that the government in collaboration with various Oil and Gas

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companies should be licensed to use drones for monitoring of forests, creeks, and other hideouts of crude oil and petroleum thieves and illegal refinery criminals in their domains. This can be accomplished through the deployment of drones from designated strategic locations that guarantees the coverage of all creeks and forests to monitor illegal activities on oil infrastructures. This undertaking, will augment in very high measure the efforts of security officers, and vigilantes in securing Oil plants infrastructures. The paper is proposing that if the drones or UAVs with the aid of machine learning are deployed for aerial and security surveillance, the increasing level of insecurity associated with oil theft and illegal refining of oil and its attendant environmental menace in Nigeria would definitely be drastically reduced or even eliminated.

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