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Application of Radar Technology in Combating Insurgency in Nigeria

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***Abstract-* Nigeria as fondly called the 'giant' of Africa has experienced series of insurgency attacks in the recent past. These attacks have claimed many lives and properties worth billions of naira destroyed. The recent abduction of over 200 Chibok school girls by the dreaded Bokoharam groups has provoked the entire world to seek for an alternative means of combating this negative menace. The big question comes to our mind; "WHERE DO WE GO FROM HERE". The solution to this question is not too difficult to arrive at this point in time. Radar technology is the answer. Radar means Radio Detection and Ranging. It is a means of getting information about distant objects or target, by flinging electromagnetic waves at them and analyzing the echoes. The basic principle behind radar is simple - extremely short bursts of radio energy (traveling at the speed of light) are transmitted, reflected off a target and then returned as an echo. This paper aims at exploring the use of Radar systems in tacking insurgency in Nigeria**

***Keywords:* Radar, Insurgent, Detection, Target, Echo**

I. INTRODUCTION

The chains of killings and bombing of innocent citizens in Nigeria is alarming. Also, the recent abduction of over 200 female secondary students from Government Girls Secondary School (GGSS), Chibok, Borno State, Nigeria on April14, 2014 by the dreaded Islamic Sects (Bokoharam) has elicited consternation all over the world. Some groups in the country are already advocating for disintegration. United States of America (USA) in their magnanimous disposition gave a helping hand by sending her experts to help search and rescue the adducted Chibok School girls. Looking baffling and perplexing, the big question remains "WHO WILL BAIL THE CAT". Radar technology is a *sinequanon* to discover the location of these abducted girls and gives information about them and their abductors'. Radar is an acronym formed from the word Radio Detection and Ranging [1]. They are electronic devices used for the detection and location of targets. Radar makes use of a phenomenon we have all observed, that of the echo principle. A Radar system comprises of a transmitter which sends out large Ultra High Frequency (UHF) microwave power through a directional aerial and a receiver which collects energy from the echoes reflected in its direction by the target and then processes and display the information in a suitable manner. Radar is an active device. It utilizes its own radio energy to detect and track the target. It does not depend on energy radiated by the target itself.

The ability to detect a target at great distances and to locate its position with high accuracy is the chief attributes of radar. Radar has two functions namely: searching and tracking. Searched Radar gives information on all targets in a certain volume of sky, area of sea or land. Tacking Radar produces a narrow beam of radiation which is used to produce accurate information to the polar co-ordinate of the target. Radar systems can be seen in Civilian applications (Airport surveillance, Marine navigation, Weather Radar, Altimetry, Aircraft Landing, Security alarms, Speed measurement and Geographic mapping), Military applications (Air and marine navigation, Detection and tracking of aircraft, missiles, and super crafts, Fire control for missiles and artillery, and Reconnaissance), and Scientific application (Astronomy, Mapping and imaging, Precision distance measurement and Remote sensing of the environment) etc

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II. BACKGROUND REVIEW

Radar has long been used for military and non-military purposes in a wide variety of applications such as imaging, guidance, remote sensing and global positioning [2]. The history of radar can be traced back to the experiments by Heinrich Hertz in the late 19th century [3]. In the early 1800s, an English physicist, Michael Faraday, demonstrated that electric current produces a magnetic field and that the energy in this field returns to the circuit when the current is stopped [4]. In 1864 the Scottish physicist, James Maxwell, had formulated the general equations of the electromagnetic field, determining that both light and radio waves are actually electromagnetic waves governed by the same fundamental laws but having different frequencies. He proved mathematically that any electrical disturbance could produce an effect at a considerable distance from the point of origin and that this electromagnetic energy travels outward from the source in the form of waves moving at the speed of light.

At the time of Maxwell's conclusions there was no available means to propagate or detect electromagnetic waves. It was not until 1886 that Maxwell's theories were tested. The German physicist, Heinrich Hertz, set out to validate Maxwell's general equations. Hertz was able to show that electromagnetic waves travelled in straight lines and that they can be reflected from a metal object just as light waves are reflected by a mirror.

In 1904 the German engineer, Christian Hulsmeyer obtained a patent for a device capable of detecting ships[5]. This device was demonstrated to the German navy, but failed to arouse interest probably due in part to its very limited range. In 1922, Guglielmo Marconi drew attention to the work of Hertz and repeated Hertz's experiments and eventually proposed in principle what we know now as marine radar.

The first observation of the radar effect was made in 1922 by Dr. Albert Taylor of the Naval Research Laboratory (NRL) in Washington, D.C. Dr. Taylor observed that a ship passing between a radio transmitter and receiver reflected some of the waves back to the transmitter[6]. In 1930 further tests at the NRL observed that a plane flying through a beam from a transmitting antenna caused a fluctuation in the signal. The importance of radar for the purposes of tracking aircraft and ships finally became recognized when scientists and engineers learned how to use a single antenna for transmitting and receiving.

Due to the prevailing political and military conditions at the time, the United States, Great Britain, Soviet Union, France, Italy, Germany and Japan all began experimenting with radar, with varying degrees of success [7]. During the 1930s, efforts were made by several countries to use radio echo for aircraft detection. Most of these countries were able to produce some form of operational radar equipment for use by the military at the start of the war in 1939[8].

At the beginning of WWII, Germany had progressed further in radar development and employed radar units on the ground and in the air for defense against allied aircraft. The ability of radar to serve as an early warning device proved valuable as a defensive tool for the British and the Germans. Although radar was employed at the start of the war as a defensive weapon, as the war progressed, it came to be used for offensive purposes too.

By the middle of 1941 radar had been employed to track aircraft automatically in azimuth and elevation and later to track targets automatically in range [9].

All of the proven radar systems developed prior to the war was in the VHF band. These low frequency radar signals are subject to several limitations, but despite the drawbacks, VHF represented the frontier of radar technology. Late in 1939, British physicists created the cavity magnetron oscillator which operated at higher frequencies. It was the magnetron that made microwave radar a reality. It was this technological advance that marks the beginning of modern radar.

Following the war, progress in radar technology slowed as post war priorities were directed elsewhere. In the 1950s new and better radar systems began to emerge and the benefits became more important. Although radar technology has been advanced primarily by the military, the benefits have spilled over into many important civilian applications. The same fundamental principles discovered nearly a century ago and the basic data they provide, namely target range and bearing, still apply to today's modern tracking and detection.

III. COMPONENTS OF A RADAR SET

Figure1 shows the component of a simple Radar set. The modulator produces a series of short d.c pulses at the chosen recurrent frequency. These are converted into Radar frequency pulses in the transmitter. Because of the frequencies and power outputs required, the transmitter oscillator is a special type known as a MAGNETRON. The antenna system takes the R-f energy from the transmitter, radiate this energy in a highly directional beam, receive any echoes or reflections of

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transmitted pulses from targets, and pass these echoes to the receiver. The receiver amplifies the energy scattered back and produces a vertical deflection on the cathode ray tube. The trace of the CRO moves across the screen, from left to right once every circle, so that it appears to be stationary to the eye. The range of the aircraft is determined by noting the position of the aircraft echo along the time base, noting that the ground pulse is at zero range.

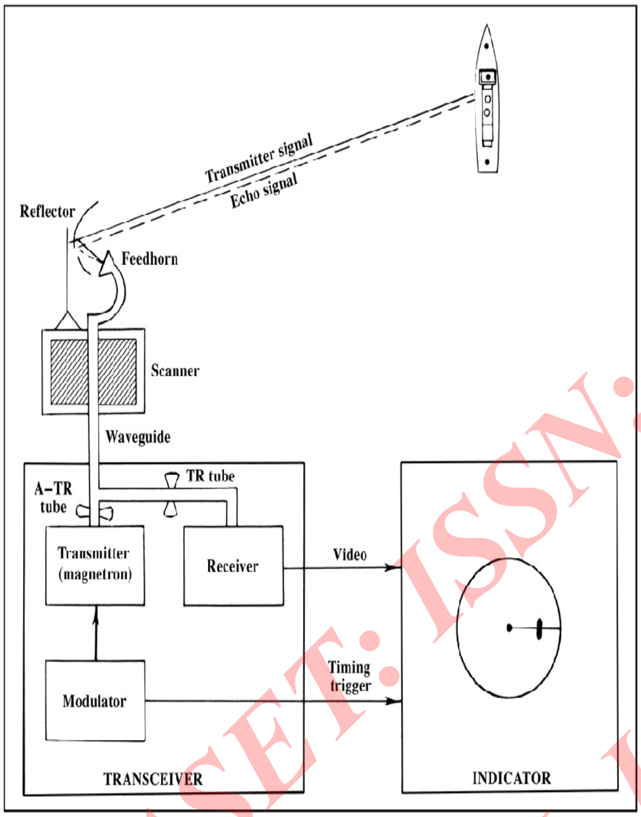

Figure1. Component of a simple Radar set

IV. The Radar Equation

The detection range of a radar system is primarily a function of three(3) parameters, namely: transmitted power(Pt), antenna gain(G), and receiver sensitivity(S).

The power density from an omnidirectional antenna is given by

$$P_d = \frac{Pt}{4\pi R^2} \ldots\ldots\ldots\ldots\ldots\ldots 1$$

If the gain of the antenna is Gt, then the power density at the target from the antenna becomes

$$P_d = \frac{Pt\,Gt}{4\pi R^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where R is the range

The amount of energy reflected is related to the targets Radar cross section,ş. Therefore, the energy reflected power from the target is given by

$$P = \frac{Pt\,Gt\,\text{ş}}{4\pi R^2} \ldots\ldots\ldots\ldots\ldots\ldots 3$$

Hence, the power density of the echo signal at the radar becomes

$$P_d = \frac{Pt\,Gt\,\text{ş}}{(4\pi R^2)^2} \ldots\ldots\ldots\ldots\ldots\ldots 4$$

If the effective capture area of the receiving antenna is Ar, then, the echo power received becomes

$$P_r = \frac{Pt\,Gt\,\text{ş}\,Ar}{(4\pi R^2)^2} \ldots\ldots\ldots\ldots\ldots\ldots 5$$

The gain of an antenna is related to the capture area by the expression

$$Gr = \frac{4\pi Ar}{\lambda^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Substituting equation (6) into equation (5), we have

$$P_r = \frac{Pt\,GtGr\text{ş}\,\lambda^2}{(4\pi)^3 R^4} \ldots\ldots\ldots\ldots\ldots\ldots 7$$

In most Radars, the same antenna is used for transmission and reception. Thus,

Gt =Gr=G

Therfore,

$$P_r = \frac{Pt\,G^2\text{ş}\,\lambda^2}{(4\pi)^3 R^4} \ldots\ldots\ldots\ldots\ldots\ldots 8$$

The maximum range, R_{max} is the maximum distance at which the target can be detected. It occurs when the received echo signal Pr just equals the minimum detectable signal (S_{min}). Thus maximum range is giving by

$$R_{max} = \left[\frac{Pt\,G^2\text{ş}\,\lambda^2}{(4\pi)^3 S_{min}}\right]^{1/4} \ldots\ldots\ldots\ldots 9 \quad \text{Or}$$

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$$R_{max}=\left[\frac{P_t A_e^2 \sigma}{4\pi\lambda^2 S_{min}}\right]^{1/4} \quad \ldots\ldots\ldots\ldots 10$$

V. RESULT.

Table1 below shows different Radar frequencies bands and application.

Table1. Radar frequency bands

Radar frequency bands			
Band name	Frequency range	Wavelength range	Notes
HF	3-30MHz	10-100m	Coastal radar systems, over-the-horizon, Coastal radar systems
VHF	30-300MHz	1–10 m	Very long range, ground penetrating; 'very high frequency'
P	< 300 MHz	1 m+	'P' for 'previous', applied retrospectively to early radar systems; essentially HF + VHF
UHF	300–1000 MHz	0.3–1 m	Very long range (e.g. ballistic missile early warning), ground penetrating, foliage penetrating; 'ultra high frequency'
L	1–2GHz	15–30cm	Long range air traffic control and surveillance; 'L' for 'long'
S	2–4 GHz	7.5–15 cm	Moderate range surveillance, Terminal air traffic control, long-range weather, marine radar; 'S' for 'short'
C	4–8 GHz	3.75–7.5 cm	Satellite transponders; a compromise (hence 'C') between X and S bands; weather; long range tracking
X	8–12 GHz	2.5–3.75 cm	Missile guidance, marine radar, weather, medium-resolution mapping and ground surveillance; in the USA the narrow range 10.525 GHz ±25 MHz is used for airport radar; short range tracking. Named X band because the frequency was a secret during WW2.
Ku	12–18 GHz	1.67–2.5 cm	High-resolution, also used for satellite transponders, frequency under K band (hence 'u')
K	18–24 GHz	1.11–1.67 cm	K-band is used for detecting clouds by meteorologists, and by police for detecting speeding motorists. K-band radar guns operate at 24.150 ± 0.100 GHz
Ka	24–40 GHz	0.75–1.11 cm	Mapping, short range, airport surveillance; frequency just above K band (hence 'a') Photo radar, used to trigger cameras which take pictures of license plates of

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			cars running red lights, operates at 34.300 ± 0.100 GHz
V	40–75 GHz	4.0–7.5 mm	Very strongly absorbed by atmospheric oxygen, which resonates at 60 GHz.
W	75–110 GHz	2.7–4.0 mm	Used as a visual sensor for experimental autonomous vehicles, high-resolution meteorological observation, and imaging.

VI. CONCLUSION

In this paper, the ability of a RADAR system to detect a target at great distances and to locate its position with high accuracy has been well elaborated by the authors. RADAR technology is a means of getting information about distant objects or target, by flinging electromagnetic waves at them and analyzing the echoes. Therefore, since Nigeria a once 'peaceful' nation has drastically becoming a dwelling place for insurgents, the need to apply Radar technology to detect the location of these insurgents cannot be over-emphasized.

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