IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 14, Issue 2 Ser. I (Mar. – Apr. 2019), PP 01-07
www.iosrjournals.org

Green Radars: Dual Use of Communication & Navigational Transmitters for Surveillance of Airports Against Stealth Aircrafts & Swarms / Mini / Micro UAVs

Anupam Tiwari[1], Lakshmi[2]
[1]*Senior Member, M209735, IETE-N Delhi,*
[2]*MS (ECE), JNTU-Hyderabad*

Abstract : ***"****Green Radar****"*** *is a passive system which does not emit Electromagnetic(EM) Wave and explores available EM scattered by target in region provided by transmitters. It reduces usage of EM spectrum and saving of scarce spectrum resources, so it is "electromagnetically Green. Airports are installed with communications and navigation transmitters; these can be integrated with "Green Radar" for airport protections and detections for against Stealth aircrafts and UAVs. Transmitters of Opportunity like TACAN, NDB, TV, FM radio, cellular towers, space-bone transmitters and mono-static ground Radars may be used. "Green Radar" offers distinct advantages over mono-static Radar in terms of silence or covertness. The need of "Green Radar" is need of an hour for surveillance of important assets, military base from stealth aircraft and airports. It can also be used to detect micro and mini UAVs. These Green Radar scan save EM spectrum but also protected from Anti Radiation Missiles (ARMs), jamming resistance with stealth detection capabilities [1]. Green Radars may form important and distinct component of Electronic Warfare (EW) setup which is very effective and coupled with existing transmitters as one reference signal is required from emitters. "Green Radar" could render stealth aircraft obsolete.*

Keywords: *Bi-static Radar, "Green Radar", NDB, 3GPP, Cooperative Passive Coherent Location (CPCL), 5G, FM, DAB, DVB-T.*

Date of Submission: 11-03-2019 Date of acceptance: 27-03-2019

I. Introduction

Airports surveillance is becoming challenging due to UAVs / drones usage & operations increasing exponentially in both civil and military domains. UAVs technology is growing and becoming affordable, civil usage including aero-modeling, photography, and commercial purpose (Amazon prime air) etc are increasing. Illegal usage of UAVs can't be denied by terrorist and espionage by enemy. Traffic congestion in air, regulatory enforcement for air laws imposed strict surveillance of air space by UAVs. In military aerodromes surveillance against stealth aircraft and micro / nano UAVs is also a big challenge.

""Green Radar" receives scattered EM waves transmitters deployed in a distributed area of airports and may also use ToI. Communications & radio transmitters are used in and around airports (Figure-1). 3GPP, Radio-navigation transmitter like NDB etc can be easily converted for dual usage with "Green Radar" (referred as PCL), exploiting scattering of EM energy from transmitters of microwaves in and around aerodrome in order to detect and track targets.

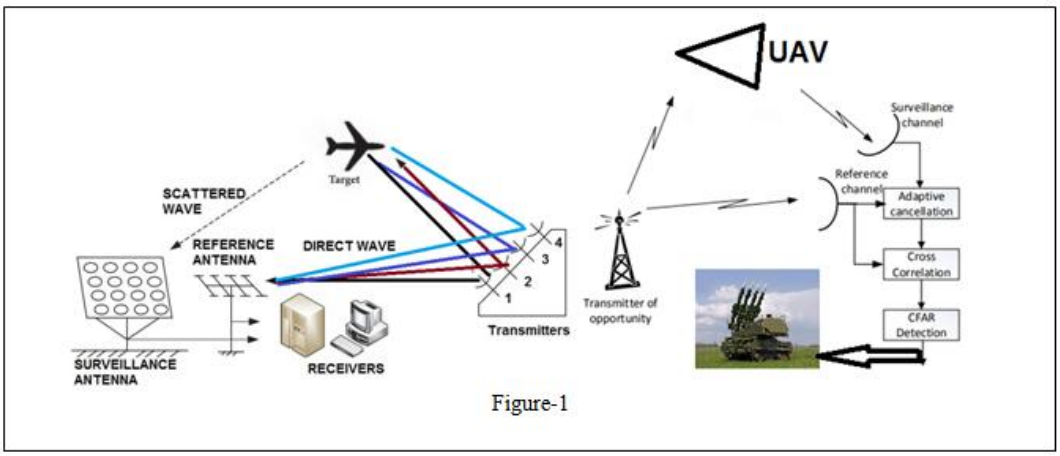


Figure-1

II. Types Of Radars

"Green Radar" is a sub-set of bi-static Radar which can also employ cooperative or non-cooperative transmitters. British Chain Home Radar and other Radar fences are examples of early bi-static Radars that employed cooperative transmitters as dedicated parts of the system. There are two broad classifications Green Radars (Figure-2) which depend on transmitter & type of transmitted signals. When communication transmitter is used it is called as PCL (Figure-3), when it uses Radar signals it is called as parasitic Radar (Figure-4). "Green Radar" is also known as

(i) Passive Radar
(ii) PCL
(iii) Passive Bistatic Radar (PBR)
(iv) Covert Radar
(v) Cell-Dar

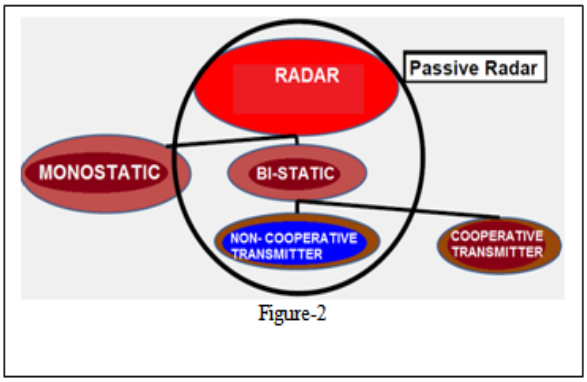


Figure-2

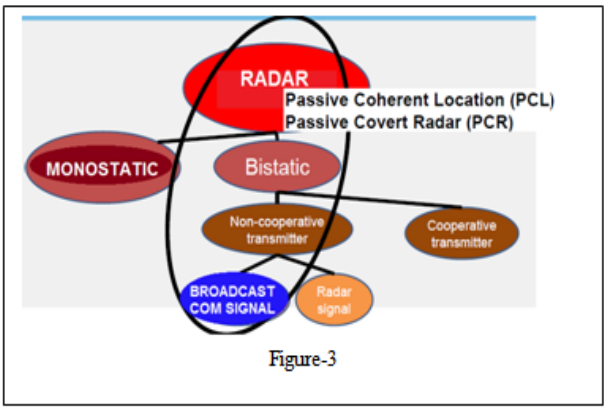


Figure-3

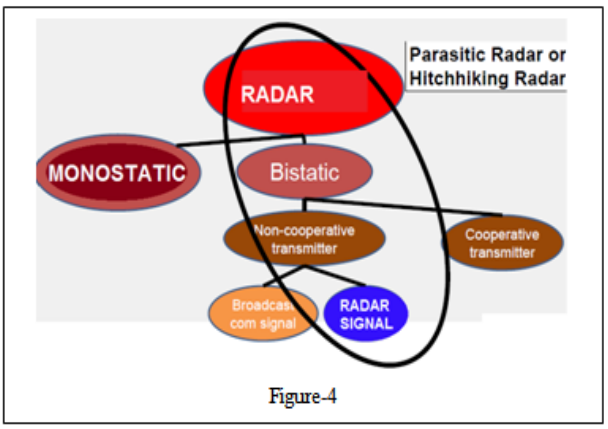


Figure-4

III. Advantages of "Green Radar"

Green Radar technology is emerging due to following benefits:

- RF spectrum for transmission is not used, covert surveillance and acts as silent observer. Electronic attack is difficult due to inherent resistance to jamming. No threat from ARMs.
- ToI frequencies used for scattering are optimised for target signature, it can detect stealth aircraft. Can be used to detect targets that are not transmitting, conventional EW sensors rely on emission of RF/EO of the target.
- 360^{o} continuous surveillance permits higher track update rates to be achieved as there is no scanning for targets as conventional Radars and electronically steered beams.
- Advanced signal processing with Artificial Intelligence (AI) can be configured for slower track update rate, large integration time to increase the probability of detection of targets with small signatures.
- Relatively low cost, no rotating elements, no transmitter, dual usage of transmitters and low power requirements.

EW, radio silence in is called as electronic emission policy which is important to maintain covertness. It eliminated background noise or clutter Low Probability of Intercept (LPI) Radars. It uses inverse-square law, so it is highly sensitive receiver electronics and detects very low level emitter's signals Radar Cross Section (RCS).

IV. 3G / 4G / 5G Transmitters Integration with "Green Radar"

Green Radars may also integrate communication transmitters like FM, GSM, LTE (4G) & 5G transmitters. Signal transmitted from 3G base-station (e-Node B) has excellent properties to be use signal for "Green Radar" systems. Studies of 3G signal ambiguity function signal based on the WCDMA library & its simulations has proved that the signal has excellent properties for range and Doppler resolution. 4G with modulation Orthogonal Frequency Division Multiple Access (OFDMA) has very low side lobes & ambiguity function. 4G based "Green Radar" has capability to detect ground targets like vehicles, motorbikes and humans on ground make is useful for fence monitoring (Figure-5& Figure-6) [2].

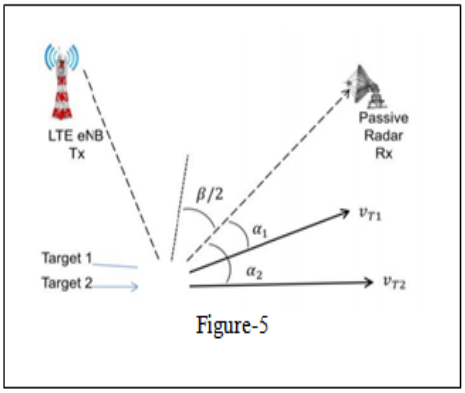


Figure-5

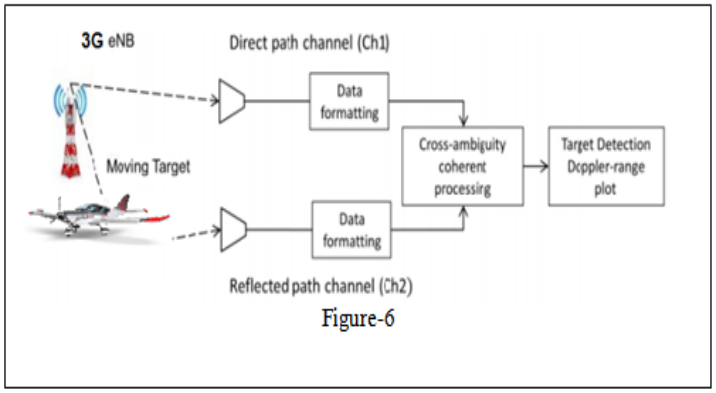


Figure-6

5G uses Multi Input and Multi Output (MIMO) with enhanced data transfer rate. The mobile radio technology is best suited for CPCL is distributed MIMO as "Green Radar" additionally. It combines and extends the feature of "Green Radar" by cooperative principle ranging from synchronous radio signaling, multiply and Accumulate (MAC) and Radar data fusion. Software Defined Radio (SDR), network technologies with real-time mobile computing facilities. CPCL & SDR feature combination to become an Omni-present Radar system which is fully adaptive, re-configurable and cognitive. CPCL makes dual use of radio resources in both frequency and hardware.Networked receivers, integrated with "Green Radar" can detect, track targets and provide cue for weapons systems for missile Air Defence systems. "Green Radar" can be camouflaged and deployed in city areas. Passive system produces no indications on Radar Warning Receiver (RWR) and is difficult to locate and target.

V. Survey of "Green Radars"

Worldwide leading military manufacturer had developed and proven technology. First modern "Green Radar", HA 100 Radar was tested successfully by France in 2007, which is used by European countries. HA100 Radar **(**Figure-7) has 100 Km range; it is designed for air surveillance for low and medium altitudes for surveillance of airspace, fly-past, UAVs and maintains its security at forward airbases. Chinese YLC-8B, YLC-29 has stealth aircraft detector uses TV signals (Figure-8). FM Passive Radar by Cassidian is shown in Figure-9. Lockheed Martin "Silent Sentry" Radar has proven effective to ranges of 220 km. Other Passive Bi-static Radars are:-

(i) Cell-Dar – Cell Phone Radar (BAE Systems – Roke, UK)
(ii) AULOS Passive Covert Location Radar (Selex Sist. Int., Italy)
(iii) Hellenic Multi-target Passive System – HEMPAS or CCIAS ("Thessaloniki Team", Greece), multi-static PCL – ESM system
(iv) Silent Guard – FM Radio (ERA, Czech)
(vi) Kolchuga-M, Passive Radar from Ukraine (Figure-10)

Figure- 7, HA 100 Radar

Figure- 8. JY-50 Radar

Figure 9- Left (Stationary Cassidian FM Passive Radar) Right (Vera –NG)

Figure-10, Kolchuga-M, Passive Radar from Ukraine

Figure-11 YLC-20, Passive Radar

figure-12TwInvis" passive Radar system

Figure-13, CORA, Antenna

Figure-14, FM based PCL & 3 TV Antenna

Summary of various Green Radar are tabulated below as Table-1:-

Sl No	"Green Radar"	Feature
1	HA 100 Radar (Thales), France Figure-7	FM radio broadcasts, extension with DAB (Digital Audio Broadcast), AVB (Analog Video Broadcast) and DVB-T (Digital Video Broadcast –Terrestrial), 100 km
2	Silent Sentry, Lockheed Martin, USA	PCL system uses FM radio
3	Celldar, British	PCL GSM signals, 900 MHz / 1800 MHz bands, Celldar is a low level/surface surveillance system, 60km
4	Vera –E, Vera-NG, Czech	TDOA, 88 MHz - 18 GHz, tracks 200 targets, 3 –D (210 / 130 W) 400 km, target library of 10,000 targets. Antenna dimensions – (500mmX1720mm), weight of antenna is 85 kg & 15 kg for communication equipment. Vera-NG (mobile, long-range passive surveillance system)
6	DWL-002, China	Three station, PCL
6	JY-50, China, Figure-8	VHF band
7	Cassidian FM Passive Radar, Germany	PCL, DAB and DVB-T waveform, Figure-9
8	Kolchuga, Ukrainian	130MHz to 18GHz, and 36 channel , sensitivity of (-145 dBW), Figure-10
9	PaRaDe , Poland	PCL, real time FM, Offline DAB-T, GSM, WI-FI signal , 3m diameter antenna on eight meter height mast
10	YLC 20, YLC 29, China	FM , 85MHz-110MHz, figure-11
11	"TwInvis" passive Radar system, Germen figure-12	200 aircraft in 3D, radius of 250km, AD & ATC applications. Up to 16 FM transmitters (analogue) with 5 frequencies from DAB and DAB transmitters (digital), DVB-T and DVB-T2 (digital, terrestrial television), can be simultaneously analysed.
12	CORA (Covert Radar) , German, Fraunhofer-FHR	PCL sensor, DVB-T & DAB, Figure-13

Table-1

VI. Development of Obsolete Radio Navigation Transmitter as "Green Radar"

India is in region -3 ITU frequency for fixed aeronautical Radio navigation 160.0 - 190.0 KHz (up to 200 KHz). These transmitters are now getting phasing out, for dual use these can be easily integrated with "Green Radar". India has two EL/M 2080 (L-band & 500 km), Israeli Green-Pines Radar is not passive Radar. Distance Measuring Equipment (DME) is a two way (request & reply) ranging system. Traditionally it utilizes pulse pairs in L-Band approximately between 960 to 1200 MHz [3]. VOR transmitters, DME can also be integrated with "Green Radar". Fifth generation stealth aircraft are designed against S-band Radars, so lower band of navigation aids frequency will detect these aircrafts.

An EW receiver scans entire EW spectrum to tune to enemy emitters and interpretation of signal or waveform or transmitter parameters. Green Radars uses reflections from own transmitters & enemy transmitters used for communication or navigation or active Radars. It takes one direct feed called reference channel and other is scattered energy accumulation by target. In "Green Radar", parameters of waveform is known and compared with reflected wave the target can be displayed on scope. In case of IFF failure, ADS-B signal can be received by "Green Radar" and surveillance of air traffic with situation awareness will be enhanced as shown in Figure-15.

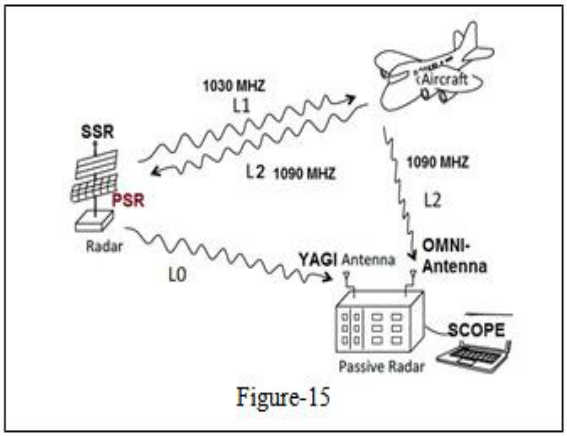
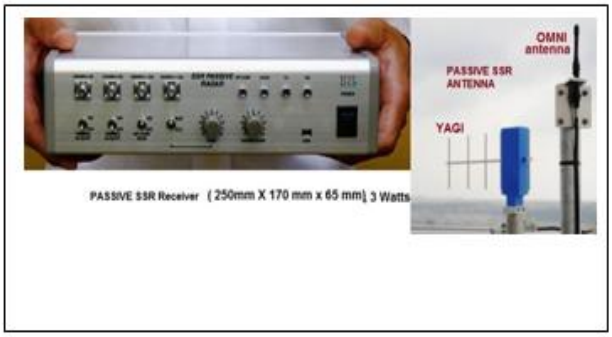


Figure-15



VIII. EXPERMINTAL SET UP

PCL require two directional antennas (Yagi-Uda) with minimum of two coherent receivers. One antenna directed at the transmitting 'reference' tower and the other at the 'surveillance' area to monitor for scattered reflections. It's important to try and keep as much of the reference signal out of the surveillance antenna as possible, so directional antennas with high directivity are used. Every airdrome should be installed with the experimental set up of "Green Radar" as shown in Figure-16 below. It's Software defined processor will integrate various transmitters and reflected signals with direct signal [4]. MATLAB simulation tool may be used to analyze for simulation of "Green Radar" with digitally modulated communication signals. The signal on the surveillance channel is delayed with doppler shifted due to target scattering. An ambiguity function detector is implemented to identify the time delays & doppler shifts.

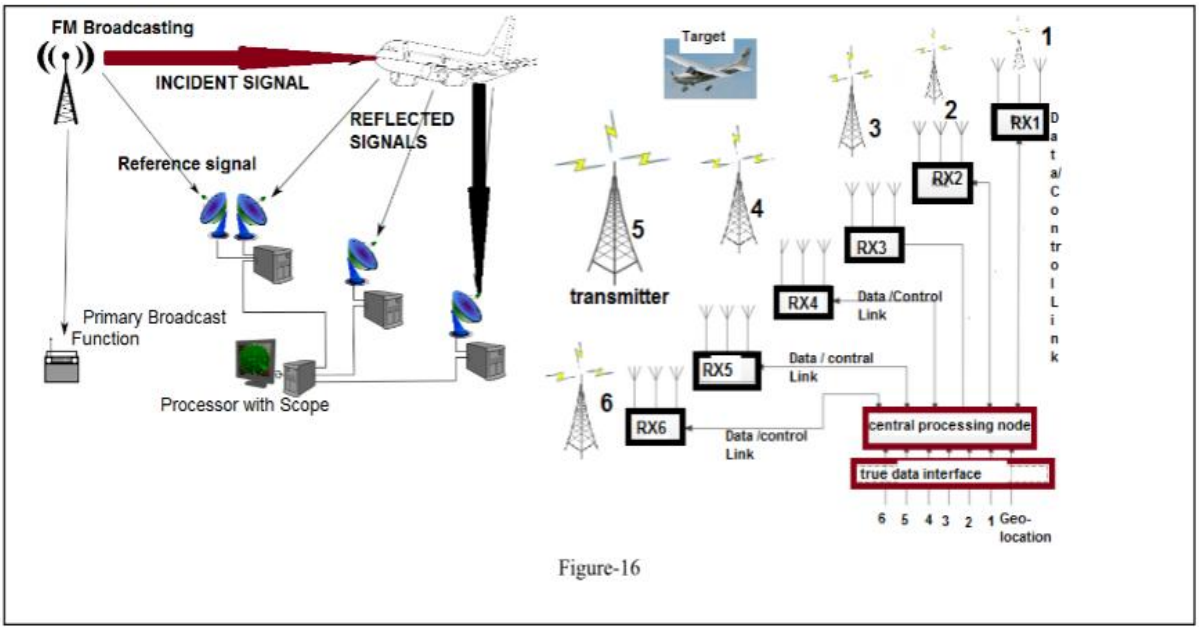


Figure-16

VII. Conclusion

"Green Radar" is a very promising & emerging technology which is still in nascent stage in India. New field for "Green Radar" systems to be used in many applications which includes stealth fighter detection, homeland security, border scanning, fence scan by microwave and monitor of UAVs without EM wave spectrum usage[5]. Various types of Green Radars are proved and manufactured by leading defence industries. Military including India's neighbour are already using "Green Radars". The main advantage is that system is Passive (silent) and does not transmit signals. The system can be used as EW also with existing transmitters. Green SAR for ground surveillance is a new field of research area, with first successful prototype testing in year 2012 by utilizing public utilities broadcast services stations as target illuminator in frequencies of FM, DAB and DVB-T. They are very difficult to detect, so resistance to jamming for their inherent passive nature. With "Green Radar", it is now end of stealth aircraft.

Anupam Tiwari (09 Jul 1972), IETE member, N-Delhi, M.Tech (Modeling & Simulation in Applied Mathematics from DIAT – DU Pune, 2009), B.E (Electrical Engg (Hons), 1996). He has also received M Sc (Disaster Mitigation from Sikkim Manipal University), IETE (E&TC) and He has **30 papers** in Journals, National & International conferences. His main interest of research includes Mathematical Modeling & simulation, Radar, Fractals, Communication, Antenna and Human Resource Management.

Lakshmi (24 Sep 1970) is perusing her M S(ECE)from JNTU-H. She had received B.Tech (ECE), NERIST-NEHU. She is Life member of IETE Hyderabad. She is working in DRDO as scientist. She has rich experience of 21 years in D&D of Electronics systems. She many research papers in various Journals, National & International conferences. Her area of interest is satellite communication and error detection codes.

References

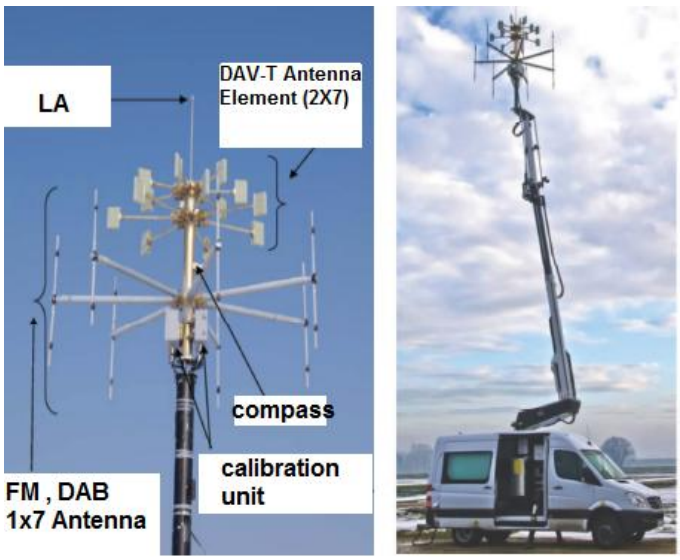
[1]. Griffiths, H.D. and Baker, C.J, "An Introduction to Passive Radar", Artech House

[2]. Raja S. A. Raja Abdullah, Asem A. Salah, and Nur E. Abdul Rashid, "Moving Target Detection by Using New LTE-Based Passive Radar*",* Progress In Electromagnetic Research B, Vol. 63, 145–160, 2015

[3]. International Civil Aviation Organization, "Annex 10 to the Convention on International Civil Aviation: Aeronautical Telecommunications", Volume 1: Radio Navigation Aids, 6th Edition, July 2006.

[4]. Piotr Samczyński, Mateusz Malanowski, Grzegorz Krawczyk, Janusz Kulpa, Marcin Żywek Warsaw University of Technology Institute of Electronic Systems Warsaw, Poland "Passive Radar as a Part of Critical Infrastructure Protection System".

[5]. A r e n d G W e s t r a, "Radar versus Stealth"



Anupam Tiwari. "Green Radars: Dual Use of Communication & Navigational Transmitters for Surveillance of Airports against Stealth Aircrafts & Swarms / Mini / Micro UAVs." IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 14.2 (2019): 01-07.