DRONE WITH GROUND-PENETRATING RADAR

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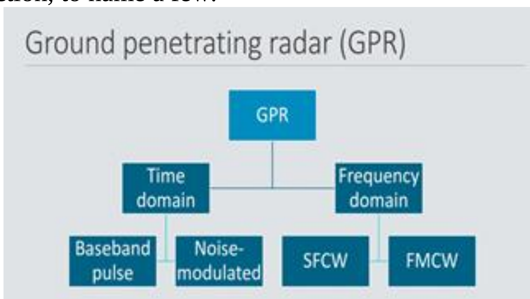
OBJECTIVE:
New technology is changing the surveying is done and the results it's able to deliver. Drones combined with ground-penetrating radar are making more things possible. While fieldwork on challenging terrain can be dangerous for surveyors, drone technology is helping to make the job safer and more efficient. Here, we outline the main advantages of this recent development for land developers, construction engineers, and more. When mounted on a lightweight drone, GPR is more accurate, efficient, versatile, and safer to perform.

AIM:
The main aim of the project is to increase the flexibility in the usage of GPR with the help of drone. Increasing the applications of Gpr drone like non-destructive testing, scanning the buried objects without any contact with the ground, using to find the landmines in military application. Decrease the effort like carrying the GPR systems accurately at a certain position and scanning the large-scale regions manually is too difficult.

INTRODUCTION:
Nowadays, we use the waves spectrums for many applications like communication, for transferring energy, for capturing energy, for scanning in x-rays, for creating the energy, for destroying the matter, for creating the future (test tube babies) ,etc. a lot of things are working with the principle of waves propagation and scattering. This wave propagation technology is started in 1888, The scientist Heinrich hertz gives the explanation about wave propagation in dielectrics. During 1900's the alexander graham bell created the first metal detector from that so many things are originated like GPR. The manual GPR working principle is to find the buried things or objects under the ground with the help of scattering of electromagnetic waves by operating a range of 10MHz – 3GHz.The GPR drone is working on the principle of the GPR system but it has extra application like flexibility in operation than the manual GPR systems. In this GPR is fixed to the drone and it is moves along with the drone and providing extra linear motion to the radar to decrease the effort of change the altitude of the drone with respect to operation. Only radar, receiving antenna, transmitter and the power source is fixed to drone, the simulator and controller is at the ground station.

GROUND PENETRATING RADAR:
Penetrating Radar (GPR) is the general term applied to techniques which employ radio waves, typically in the 1 to 1000 MHz frequency range, to map structures and features buried in the ground (or in man-made structures). Historically, GPR was primarily focused on mapping structures in the ground; more recently GPR has been used in non-destructive testing of non-metallic structures.
The concept of applying radio waves to probe the internal structure of the ground is not new. Without doubt the most successful early work in this area was the use of radio echo sounders to map the thickness of ice sheets in the Arctic and Antarctic and sound the thickness of glaciers. Work with GPR in non-ice environments started in the early 1970s. Early work focused on permafrost soil applications.
GPR applications are limited only by the imagination and availability of suitable instrumentation. These days, GPR is being used in many different areas including locating buried utilities, mine site evaluation, forensic investigations, archaeological digs, searching for buried landmines and unexploded ordnance, and measuring snow and ice thickness and quality for ski slope management and avalanche prediction, to name a few.



HISTORY:

1990-1995
The real explosion in the advancement of GPR occurred during this period. Many groups worldwide became interested in the technology. During this period, Mala Geosciences was spawned from the Swedish Geological Survey roots. ERA in the UK also became more active using its research into unexploded ordinance and landmine detection to create commercial products. Sensors & Software Inc. grew rapidly broadening its pulse EKKO product line.
Ground penetrating radar user meetings became more formalized and were held every 2 years at various locations around the world. This meeting provided a forum for the leading players in this field to meet, present results and discuss problems. These meetings led to series of proceeding publications which are listed as references. These proceedings provide a great deal of information for new users to the GPR field.
1995 – 2000

In this period, the evolution of the computers drove all of

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APPROPRIATE APPLICATION	PRIMARY ANTENNA CHOICE	SECONDARY ANTENNA CHOICE	APPROXIMATE DEPTH RANGE
Structural concrete, Roadways, Bridge Decks	2600MHz	1600MHz	0-0.3m
Structural concrete, Roadways, Bridge Decks	1600MHz	1000MHz	0-0.45m
Structural concrete, Roadways, Bridge Decks	1000MHz	900MHz	0-0.6m
Concrete, Shallow soils, Archaeology	900MHz	400MHz	0-1m
Shallow Geology, Utilities, USTs, Archaeology	400MHz	270MHz	0-4m
Geology, Environmental, Utility, Archaeology	270MHz	200MHz	0-5.5m
Geology, Environmental, Utility, Archaeology	200MHz	100MHz	0-9m

GPR advances. Numerical modelling of full 3D problems became possible albeit still with large computers (Holliger & Bergmann (2000), Lampe & Holliger (2000)). The ability to manage the large volumes of information in digital form and manipulate them quickly became routine. As a result, acquisition of data on grids to make maps and grids and 3D visualization became practical (Grasmueck (1996), Annan et al (1997)). The commercial market and demand resulted in a variety of different and simpler systems such as the Noggin from Sensors & Software Inc. Strong research groups appeared at a number of universities. ETH led by Alan Green, the University of Texas at Dallas led by George McMechan and the group at TU-Delft led by Jakob Fokema are some examples of groups pushing development of expertise and advancement of GPR frontiers.

COMPONENTS REQUIRED TO BUILT:
A GPR system is made up of three main components:
Control unit, Antenna, and Power Supply
GSSI GPR equipment can be run with a variety of power supplies ranging from small rechargeable batteries to vehicle batteries and normal 110/220-volt. Connectors and adapters are available for each power source type. The unit in the photo above can run from a small internal rechargeable battery or external power.

GPR CONTROLLING UNIT AND ANTENNA:
The control unit contains the electronics which trigger the pulse of radar energy that the antenna sends into the ground. It also has a built-in computer and hard disk/solid state memory to store data for examination after fieldwork. Some systems, such as the GSSI SIR 30, are controlled by an attached Windows laptop computer with pre-loaded control software. This system allows data processing and interpretation without having to download radar files into another computer.

The antenna receives the electrical pulse produced by the control unit, amplifies it and transmits it into the ground or other medium at a particular frequency. Antenna frequency is one major factor in depth penetration. The higher the frequency of the antenna, the shallower into the ground it will penetrate. A higher frequency antenna will also 'see' smaller targets. Antenna choice is one of the most important factors in survey design. The following table shows antenna frequency, approximate depth penetration and appropriate application. The following table shows antenna frequency, approximate depth penetration

Transmitting Antenna:
The transmitting antenna sits at or near the ground level on the site chosen for analysis. Researchers must choose antennas of frequencies depending on how far into the ground they want to go. Higher-frequency antennas do not go as deeply into the ground as lower-frequency options. However, higher-frequency choices detect comparatively smaller objects.

Receiving Antenna:
The receiving antenna captures the radio wave data sent up from the ground. The transmitting and receiving antennas must sit at the correct distance from each other. Having them too close together may distort the received data. That issue occurs because of the resonance of the copper plate associated with the transmitting antenna.

Power Supply:
Ground-penetrating equipment requires a power source. Batteries are popular due to their portability. Some models use rechargeable or automobile batteries. However, others work with external 110/220-volt energy sources.

WORKING PRINCIPLE:
Ground-penetrating radar (GPR) is a non-destructive technique used for investigating the characteristics of the subsurface. It is a real-time NDT instrument that employs high- frequency radio waves to study the underground surface. This technique provides high- resolution data within a short period.

GPR employs electromagnetic waves to image the subsurface. GPR is a geophysical survey method that can survey concrete, masonry, asphalt, and ground. The GPR system consists of a transmitter, antenna, and radargram (control unit). The transmitter emits pulses of electromagnetic radiation into the surface to be surveyed. The difference in permittivity is an indication of the change in sub-surface features.

Some of the electromagnetic energy reflects when any change is encountered. The antenna receives these reflected waves, and the corresponding variations are recorded. The information is interpreted and displayed on the radargram. The time taken by the reflected signals to travel back is measured, which is an indication of the depth and location of interruption.

Buried Objects, Voids, and Singularities Detection:
GPR is typically used for detecting objects hidden in a homogeneous medium. According to scattering theory, EM waves transmitted by the GPR antenna are reflected by any

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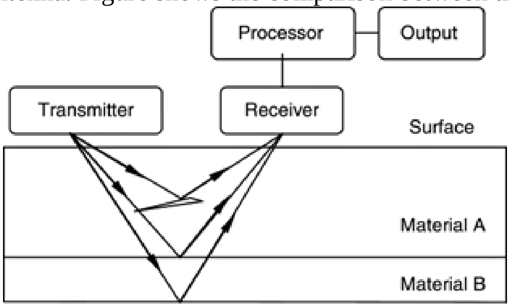
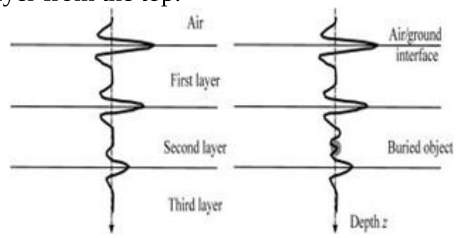
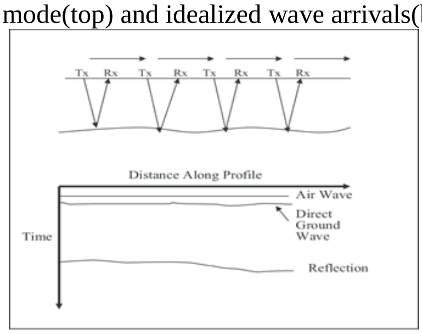
dielectric singularity whose dimension results are greater than the wavelength, according to the principles of geometrical optics. The reflections from this kind of target give additional peaks in the received signal at the GPR antenna. Figure shows the comparison between the



Received signal from a multilayer and the signal from the same multilayer when a cylindrical object is buried in the second layer from the top.



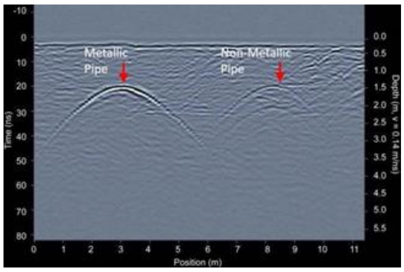
Collection mode(top) and idealized wave arrivals(bottom)



METHODOLOGY:
The data collection methodologies in concrete and ground are explained below:

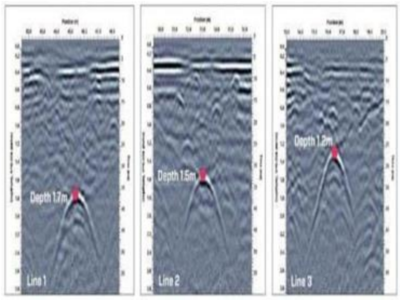
GPR data collection for Concrete
GPR is used in concrete to determine the location of reinforcement bars, conduits, or post- tensioned cables present in the concrete element. This is conducted by employing a high- frequency GPR system.
The GPR can be conducted in simple line scans, which determines the thickness of concrete. To determine a specific target within the concrete, the scan can be performed in grid formats. The results are obtained for different parts of the concrete in the form of images. These are combined to get a final 3D map of the picture.
GPR data collection for Ground
GPR can be used to analyze the location and depth of any object underground. Underground analysis can be conducted using various types of GPR equipment. The depth and the size of the target decide the kind of GPR instrument required. In this process, the GPR emits and receives a signal at a rate of thousand times per second. The field operator analyses this immediately and stores it in the system. It is later taken for further data analysis

UTILITY LOCATING:
1. LOCATING NON-METALS:



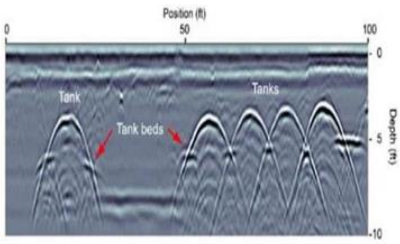
GPR can locate both metallic and non-metallic pipes and cables. This provides a complete picture of the underground and helps to ensure that nothing was missed using traditional locate methods.

2. DEPTH INFORMATION OF BURIED OBJECTS:
This example shows the location of a concrete storm sewer. GPR was able to find this “non- locatable” and determine the depth of the utility and that it was on a slope, aiding



With horizontal direction drilling planning.
3. UTILITIES CLOSE TO EACH OTHER:
GPR can map all utilities in a single survey. With the availability of in-field interpretations and viewing options, the multiple utility lines can be mapped easily on-site.

FINDING THE BURIED INFRASTRUCTURE:
GPR can also locate non-utility features, such as underground storage tanks. The example here shows 5 storage tanks



IN FIELD VISUALISATION:
1. MAPVIEW:
When using an external GPS, you can add flags and field dinterpretations on targets in the GPR data and quickly visualize them using Map View. This bird’s eye view helps to differentiate point targets from utilities and helps to

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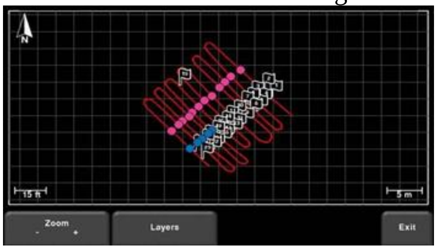
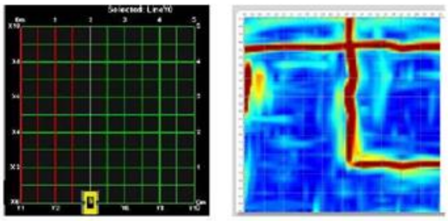
correlate the GPR results with site drawings.



1. GRID VIEW:

Using a grid scan of a complex area, you can visualize linear utilities at varying depths. This helps to provide an understanding of the subsurface while still on site.



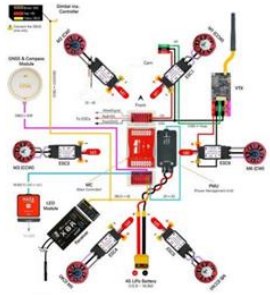
DRONE:

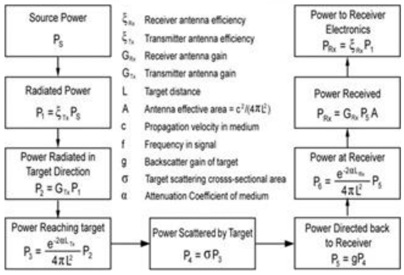
Using drone to maneuver the payload (i.e. radar , transmiting antenna, reciever antenna and power supply). So now we selected to do this project with hexacopter drone with 6 propellers. Although the octocopter has the ability as a hexacopter, it cost more price due to more number of the motors. Therefore, hexacopter is selected to be designed as heavy lift carrier as it discussed further in this paper.

SPECIFICATIONS OF DRONE:

NAME OF THE MODEL	F
NUMBER OF ARMS	5
NUMBER OF BASEPLATES	5
ARM MATERIAL	0
BASE PLATE MATERIAL	
PRINTED CIRCUIT ONPLATE	6
DIMENSIONS	
ULTIMATE LOAD OFFRAME	2
LANDING GEAR FITTING	FIBER REINFORCED PLASTIC
WEIGHT OF THE FRAME	POLY-AMIDE FIBER
	YES, ON THE BOTTOM PLATE220 X
	50 MM
	˜12000 PSI
	YES, ITS AVAILABLE FOR 4 NOS
	620 grams

CIRCUIT DIAGRAM OF DRONE AND GPR RADAR:





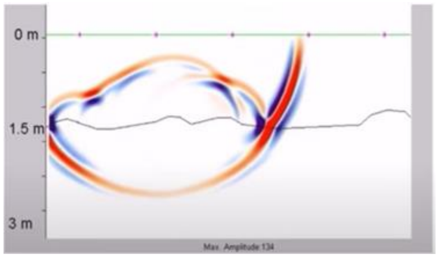
SIMULATION OF GPR RADAR:

The simulation Is the main process which provides the data by displaying it to us, for this project this simulation is major part because the output data from the radar is the purpose of the project.

The 2D FDTD SIMULATOR – GPRMAX2D, this simulator receives the input from the radar in the form of binary language, this has data about the strength of signal and location of the radar then simulator plots the 2d graph about the data, this provides the information.

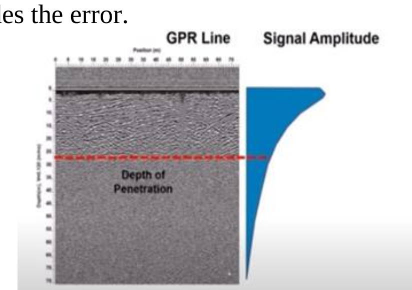
SOME EXAMPLES OF FDTD SIMULATION:

1. SEPERATION OF THE BOUNDARIES USING GPR:



2. THE DEPTH VS THE NOISE WAVES:

There is one more difficulty is when the depth is increasing then the strength of the wave is going to decrease as shown in the figure. The waves transmits the waves at a frequency, when the frequency is less than the external noise waves or disturbances frequency the simulator can't determine the data and provides the error.



3. WHEN IT FOUND A LAND MINE HOW THE SIMULATOR SHOWS THE DISPLAY:

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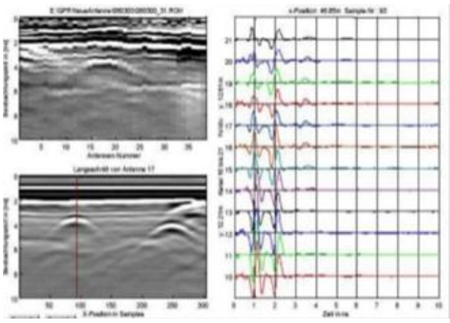
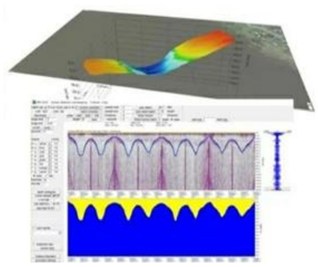
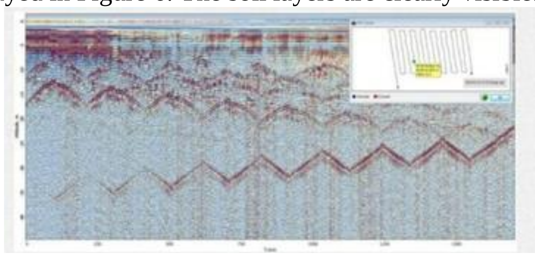


Those fluctuations of wave that showing in the display refers that an object is there, the fluctuation shape refers the material which made of that object. The metals have the sharp shapes when compared to water, air or any other materials because these have low permittivity when they are compared to any other materials. So, the shape of the simulation is depending on the permittivity of the material.

APPLICATIONS OF GPR DRONE:
Currently the GPR-drone integrated system can be used in areas where deep ground penetration is required but a good resolution is not very important.
Examples of applications include:
1. BATHYMETRY:
The GPR-drone integrated system enables to measure the depth of water or profiling the bottom of freshwater rivers, lakes, ponds up to 15 meters in depth.
Benefits –
Possibility to do work even when the water is frozen, or the surface of the water is partially covered with ice. Compared to bathymetry using a boat (equipped with echo sounders) the drone with a GPR provides better accuracy in following survey lines thanks to the inbuilt GPS and automated flight. Also, in most area.
The results displayed in Figure 5 were gathered with the drone flying at an altitude of 20 meters above the water surface level to profile 8 meters deep frozen lake.
Cases, a drone makes it a lot easier to deliver the necessary equipment to the desired.



2. GEOLOGICAL AND ARCHEOLOGICAL SURVEYS:
Soil layer profiling is a standard task that needs to be done before any serious area development or construction works. The standard technique is drilling dozens of holes or conducting a GPR survey on carts.
GPR-drone integrated system delivers higher work productivity and enables safer work conditions for the personnel in cases of rough terrain.
GPR allows finding any potentially dangerous underground water streams or lakes.
Data gathered by GPR-drone integrated system flying at an altitude of 5 meters over an asphalt-covered car parking lot is displayed in Figure 6. The soil layers are clearly visible.



3. TUNNELING AND UNDERGROUND MINES:
Several geologic challenges can be addressed with GPR. Whether attempting to examine rock mass stability or locate mineralized zones, GPR provides a powerful method of looking into the subsurface. Salt and potash present highly favorable settings for using GPR.
4. QUARRY ROCK QUALITY:
Extraction of rock for building stone requires the selection of sound and workable rock. GPR's ability to detect structure integrity and undesired jointing and cracking prior to extraction deliver major economic benefit. Marble, granite, and limestone quarrying operations worldwide use GPR for critical development decisions.
5. INTRUSION MONITORING:
Security uses of GPR are wide ranging. A common application is the location of embedded wires and cables in structures. Location of buried bunkers, tunnels and buried caches are areas of growing interest. The ability to sense human motion through walls and underground sees GPR being used for intrusion detection.
6. SECURITY INSPECTION LIKE SEARCHING LAND MINES:
Military uses of GPR focus primarily on the location and detection of buried explosive devices. For area clearing, GPR is used on ranges and old sites to identify unexploded ordnance (UXO). More recent live campaign applications involve the real-time location and identification of buried improvised explosive devices (IEDs) and buried fusing mechanisms.
MAJOR DISADVANTAGES:
1: don't provide the accurate data about depth or material.
2: provides the pseudo images in simulation, it's hard to analyze.
3. Easily affected with the interference with the outside electromagnetic radiation.
4. Need to create high frequency wave to explore deep objects.
5. Simulation changes with respect to permittivity of different mediums like soil, water, air, etc.

CONCLUSION:
In this project, I have presented the development of a custom designed lightweight GPR by approaching the interplay between hardware and software radio. Additionally, our project introduces the integration of the SDR-based GPR into an autonomous aerial drone (UAV). The performance of the GPR from the results obtained validates the possibility to

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integrate a lightweight radar system into a UAV.
In terms of GPR performance, the directional antennas radiated and received more power in a specific direction, which consequently increased the detection by means of reducing the interference caused by other sources.
In overall, our proposed system was able to detect buried artifacts with smaller transversal areas that do not necessarily need to be made full of metal. The outdoor experiments have enabled us to establish the following conditions and limit for an accurate detection: relative humidity > 70% (semi-wet or dry terrain), artifact depth 20cm, and diameter (> 15 cm) with a transversal area > 16 cm^2 and 30% of the material made of metal.

LITERATURE SURVEY:

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GROUND-PENETRATING RADAR DRONE

This is a final year project in Bachelor of Technology in aerospace engineering by Suhail Khaja. D, under the guidance of Dr S. Charulatha, professor in IIAEM Jain University, Bangalore.

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