

TECHNICAL SPECIFICATIONS AND OTHER ALLIED REQUIREMENTS

Sl No.	Description of items	Quantity
File No.	PUR/320/ISEG/RM/E/2023-24	
1	SUPPLY AND INSTALLATION OF UNMANNED AERIAL VEHICLE (UAV) MOUNTED GROUND PENETRATING RADAR (GPR) FOR DETECTION OF METALLIC AND NON-METALLIC OBJECT BURIED UP TO A DEPTH OF 3ft. (DETAILED SPECIFICATIONS AS PER ANNEXURE – I)	1 SET

1. DELIVERY AND INSTALLATION:

The delivery and installation are to be completed within 04 months from the date of issue of Purchase Order. The installation & commissioning shall be carried out by within 15 days your expert- engineers of supplier/Manufacture. During installation & commissioning necessary training on operation and maintenance of the goods/system shall be imparted to relevant Scientist/Engineer/Technicians.

2. PAYMENT TERMS:

100% payment shall be paid within 30 days after delivery installation of Unmanned Aerial Vehicle (UAV) Mounted Ground Penetrating Radar (GPR) and acceptance of the material upon submission of claim supported by the acceptance certificate issued by the purchaser and submission of Performance Security @3% of Invoice Value.

3. PERFORMANCE SECURITY:

Performance Security @3% of invoice value shall be provided by the supplier within 21 days from the date of issue of Purchase Order.

4. BID SECURING DECLARATION FORM:

Bid Securing Declaration is to be submitted by the Bidder as per the format prescribed in the tender document.

5. WARRANTY:

01 (one) year or more warranty will be provided by the supplier from the date of satisfactory installation of ordered goods.

6. MANUFACTURER AUTHORIZATION FORM:

Manufacturer Authorisation Form will be provided by the supplier.

7. MAKE IN INDIA CERTIFICATE FOR LOCAL CONTENT

Certificate for local content to be provided by the supplier in form 14 (Format attached along with Tender Document). Percentage of value addition & Name and address of the factory where the value addition was made should be mentioned clearly in the Form 14.

Annexure-I

1. Introduction:

CSIR-Central Mechanical Engineering Research Institute (CMERI) is a non-profitable research and development institute, located in Durgapur, West Bengal -713209. This institute is currently working in the domain of Unmanned Aerial Vehicle (UAV) based sub-surface object detection, especially detection of buried metallic and non-metallic objects. In this context, CSIR-CMERI is in requirement of a UAV mounted Ground Penetrating Radar (GPR) to meet the said purpose. The scope of work and the detailed specifications are covered in the subsequent sections.

2. Scope of the Work:

- (i) Supply of UAV mounted GPR along with the cart for GPR to perform aerial and terrestrial survey separately
- (ii) Integration and electro-mechanical interfacing of the GPR with the UAV and the cart alternatively
- (iii) Wireless Connectivity for simultaneous transmission of the GPR raw data and UAV telemetry data along with live First Person View (FPV) footage from UAV to the Ground Control Station (GCS)
- (iv) True terrain following of UAV mounted GPR system at 100 cm or lower height from the uneven ground surface for accurate data collection
- (v) Precision landing for UAV mounted GPR system within a circular area of maximum diameter 2 meter

3. Detailed Specifications of the UAV mounted GPR:

S	ITEMS	SUB-ITEMS	PARAMETERS	TECHNICAL SPECIFICATION
N				
1.	GPR	A)GPR Control System	<p>i. Compatible Platform and Survey Scenario:</p> <p>ii. Channel:</p> <p>iii. Centre Frequency:</p> <p>iv. Operating bandwidth:</p> <p>v. Sampling:</p> <p>vi. Data Format:</p> <p>vii. Samples per scan:</p> <p>viii. Sample rate:</p> <p>ix. Scan rate:</p> <p>x. Sample output:</p> <p>xi. Time range per sample:</p> <p>xii. Filters:</p> <p>xiii. Gain:</p> <p>xiv. RTK GNSS receiver:</p> <p>xv. Data Storage:</p>	<p>The lightweight GPR system along with accessories should be mountable with both medium-sized UAV (for aerial survey below 1 meter height) and cart (for terrestrial survey) for survey of buried metallic and non-metallic objects of diameter 30 cm- 50 cm buried up to a depth of 3 feet.</p> <p>Single Channel GPR with shielded antenna</p> <p>1 GHz</p> <p>50-1400 MHz</p> <p>Real Time Sampling (RTS) with high hardware stacking</p> <p>.sgy/ .dzt format</p> <p>512 or more</p> <p>10,00,000 – 15,00,000</p> <p>2000-5000 scans/s</p> <p>32-bit digital raw data or higher</p> <p>20 - 2500 Pico sec</p> <p>Digital vertical filters and Horizontal Filters with stacking and background removal operation</p> <p>0 to + 150 dB or more</p> <p>For accurate data collection in both terrestrial and aerial survey</p> <p>Integrated storage with minimum storage capacity of 500GB to store GPR raw data</p>

	xvi. Wireless Connectivity :	<ul style="list-style-type: none"> • In case of the UAV mounted GPR, the raw GPR data should be available wirelessly at the UAV-Ground Control Station (GCS) with minimum transmission range of 1 km through 2.4 GHz or other compatible open frequencies • In cart based display, the GPR data should be visible on a screen attached to the cart
	xvii. Display modes:	Line scan & O-scope(in line scan display, Full 3D is preferable)
	xviii. GPS type:	Integrated with internal data logger for GPS data storage.
	xix. Data collection modes:	Quick scan, Focus Mode, Scan 3D and Area Scan. <i>N.B.: -Data collection should be in stepped mode as well as continuous mode with ability to start & stop anytime.</i>
B) Antennas	i. Type & frequency:	<ul style="list-style-type: none"> • Centre frequency of 1 GHz for detection of metallic and non-metallic objects with diameter ranging from 30 to 50 cm buried up to a depth of 3 feet • Shielded antenna with no or minimum interference with the UAV frequency of operation or other communications • Antenna height from the ground surface when mounted on the UAV should be less than 100 cm • Data collection in direct 2-D, and 3-D modes in the field
C) Software	i. Software(s) for GPR:	Features: <ul style="list-style-type: none"> • Data acquisition of both UAV and cart mounted GPR field data • GPR data visualization at GCS with basic processing steps like background noise removal, surface clutter mitigation, amplification of signals, suitable filtering etc.
	ii. Software for UAV based GPR survey:	Features: <ul style="list-style-type: none"> • GPR integration and communication with the

		UAV including necessary firmware
		<ul style="list-style-type: none"> • Facility to import the raw data compatibility in standard post-processing software. • Very high precision true terrain following at altitude of 100 cm or lower • Mission planning and execution of UAV based GPR for survey at altitude of around 100 cm or lower
D) Hardware	i. Hardware for GPR and other sensor(s) data acquisition:	<ul style="list-style-type: none"> • On-board computational facility on UAV to log geotagged data from different sensor payloads like GPR, magnetometer, altimeter etc. with the following specifications: <ul style="list-style-type: none"> ○ Computational Core: 64-bit microprocessor with CPU frequency up to 1.5 GHz and up to 8 GB RAM ○ Interfaces: UART, RS-232, USB, Wi-Fi, Bluetooth, Ethernet ○ Power: Input – 12- 60 V Output- 9V/ 12V/ 15V/18V, up to 5 A ○ Weight: Maximum 200 gm ○ Compatible with standard UAV autopilot board.
	ii. Hardware for Integration with UAV:	<ul style="list-style-type: none"> • Mounting kit to fix the GPR system to the belly of the UAV maintaining C.G. • All necessary cables and attachments to connect the on-board computational facility with the UAV autopilot • Independent sensor for true terrain following at altitude of 100 cm or lower • Protective casing for the on-board computational facility and true terrain following kit
E) Mechanical Parameters	i. Dimensions:	<ul style="list-style-type: none"> • Airborne configuration (without protective casing)- L< 50 cm, W< 30 cm, H< 30cm and should be fully compatible to be mounted underneath the UAV to be provided

				<ul style="list-style-type: none"> • Terrestrial configuration (along with protective casing)- L< 70 cm, W< 50 cm, H<40 cm and should be fully compatible with the carrying cart to be provided
		ii.	Weight:	<ul style="list-style-type: none"> • Within 3kg (without protective case) for UAV borne aerial survey • Within 10 kg in protective transportation box for cart based terrestrial survey
	F) Environmental Parameters	i.	Operating temperature and humidity:	<ul style="list-style-type: none"> • -10 to 60 degree centigrade • Minimum 95% non-condensing humidity
		ii.	Protection rating:	<ul style="list-style-type: none"> • IP 52 or better for aerial surveys • IP 68 or better for terrestrial surveys with the protective casing <p><i>N.B: Single GPR unit will perform both the terrestrial and aerial survey</i></p>
	G)Power Supply	i.	Airborne Variant:	<ul style="list-style-type: none"> • The UAV power-pack should be used to power the GPR using power distribution board and necessary cables and attachments in case of continuous operation for minimum 30 minutes
		ii.	Terrestrial Variant:	<p>For ground surveys, GPR should have its own power source arrangement as follows:</p> <ul style="list-style-type: none"> • Battery Type: Li-Ion/ Li-Po/ Solid State • Operating Time: At least 6 hours • Compatible charger
2.	UAV	A) Purpose	i. Airborne GPR Survey:	<ul style="list-style-type: none"> • The UAV to be provided with GPR as payload will be used for aerial survey at altitude of 100 cm or lower with minimum endurance of 30 minutes at full payload
	B) Mechanical Parameters	i.	Category:	<ul style="list-style-type: none"> • Category: Small • All-up-weight (including GPR and other accessories as payload)- Within 25 kg
		ii.	Frame :	<ul style="list-style-type: none"> • Type: Quad/ Hex type Multi-copter UAV • Material: Standard Carbon Fiber frame • Standard landing gears with shock absorbing

		capabilities and with dimensions such that the view of the GPR sensor is not obstructed
		<ul style="list-style-type: none"> • Landing gear spacing should be enough to accommodate different sensors like GPR, Magnetometer, Camera with Gimbal, Precision Landing kit
C) Electronic Parameters	i. Autopilot features:	<ul style="list-style-type: none"> • 32-bit ARM Cortex M4 core with FPU or better • 168 MH z/256 KB RAM/2 MB Flash or more • 32-bit failsafe co-processor or better • Three redundant IMUs or more • Two redundant barometers or more • IMU should be temperature controlled and vibration-isolated mechanically • GPS cum compass module
	ii. Operating Frequency:	<ul style="list-style-type: none"> • Frequency: 2.4 GHz or other compatible open frequency <p><i>N.B.:- The UAV operating frequency should not interfere with the transmitting frequency of the GPR. There should be no interference in regard to the data collection using GPR</i></p>
	iii. Propulsion System:	<ul style="list-style-type: none"> • Type: Electric • Combination of battery, BLDC motors, ESCs and propeller dimension should be such that a hovering time of minimum 30 minutes can be achieved at full payload in ideal conditions • 2 sets of Spare Battery should be supplied
	iv. Power Source:	<ul style="list-style-type: none"> • Battery Type: Standard Li-ion/ Li-Po/ Solid State • Operating Voltage: 22 volts or higher
D) Flight Characteristics	i. Accuracy with Real Time Kinematics (RTK) Module:	<ul style="list-style-type: none"> • Positioning Accuracy: <ul style="list-style-type: none"> a) Horizontal <3 cm + 1 ppm or lower b) Vertical: <3.5 cm +1 ppm or lower • Frequency Range: Should not interfere with the GPR transmitting frequency
	ii. Endurance:	<ul style="list-style-type: none"> • Minimum endurance of 30 minutes at full payload (including GPR, on-board

computational kit with all cables and accessories, FPV transmitting antenna/s, other sensors like LASER, LIDAR etc.)

N.B.: -Endurance vs All-up-weight chart should be provided

iii. Operating range:

- The UAV operating range should be at least 500 m LOS when near the ground and 1km at 50m from ground
- The UAV telemetry data along with the raw GPR data and live FPV camera view should be available in the Ground control Station at-least from a range of 1 km

iv. True Terrain Following:

- The UAV should be accompanied by independent sensors like laser altimeter, LIDAR for true terrain following such that the GPR antenna is at less than 100 cm height above ground surface with speed of 0.5-2 m/sec.

v. Precision landing:

- The UAV integrated GPR system should be able to land within a circular area of 2-meter diameter

N.B.: -Sensor selection should be such that the landing performance should not be affected due to harsh weather and low light environmental conditions

vi. Speed:

- Ascent Speed: 2-6 m/sec
- Descent Speed: 1- 4 m/sec
- Horizontal Speed: 0.5 - 8 m/sec

vii. Wind Resistance and Back Thrust:

- Minimum 8 m/sec

N.B.: -The UAV should be capable to handle the back thrust coming from the ground while flying at such low altitude of 100 cm

viii. Flight Modes:

- Altitude Hold
- Hover at a defined waypoint
- Autonomous Waypoint Navigation (pre-defined as well as dynamically adjustable) waypoints during flight

		<ul style="list-style-type: none"> Fully autonomous from Take-off to Landing without using any R/C controller Semi-Autonomous or Guided Mode (guided to specific location) Remotely Piloted mode for video-based navigation (RPV Mode) or Manual Mode
	ix. Failsafe Modes:	<ul style="list-style-type: none"> Return Home on communication failure in manual or auto mode Return Home/Land on low battery, Dual GPS on-board for GPS failure redundancy
	x. Safety:	<ul style="list-style-type: none"> IP 55 rated or better (dust and drizzle resistant) <p><i>N.B.:- Carrying case should be provided</i></p>
	xi. Technical Life:	Minimum 500 landings
	xii. Deployment time:	Ideally less than 10 minutes
E) Vision System	i. First Person View (FPV) camera:	<p>To get the live video feed from the UAV mounted GPR system to the GCS:</p> <ul style="list-style-type: none"> a) Analog or digital type b) Resolution: 720P@120fps or better <p><i>N.B.:- To be mounted with UAV</i></p>
F) Ground Control Station(GCS)	i. Preloaded software:	<p>The GCS should be preloaded with the following software:</p> <ul style="list-style-type: none"> a) Mission planning and payload actuation software to operate the UAV and GPR b) GPR software to get raw GPR data
	ii. Transmission Range:	<p>Minimum (i) 1 km LOS @50 m and above and (ii) 500m LOS @100 cm from ground surface</p> <p><i>N.B.:- Provision for telescopic mast antenna connected to the GCS to increase the transmission range</i></p>
	iii. Operating Frequency:	The receiving frequency of the GCS GPR should be such that there is no interference between the telemetry reception, video/ photo reception and GPR raw data reception
	iv. Video/ Image Resolution:	Live HD display (minimum 720 HD) of the FPV and GPR raw data feedback on screen
	v. Display:	Type: Dual (one for UAV telemetry and FPV;

second for GPR data)

Size: Minimum 10 inches each

N.B:- Screen should be usable in outdoor condition also

vi. Joystick:

Built in Joystick for manual control of the various type of movements of UAV like roll, yaw, pitch etc. along with sufficient two position and three position switches for payload actuation and flight mode selection

vii. Power Source:

Minimum 5000 mAh in-built battery and directly from AC supply

viii. Safety Rating:

IP- 67 grade in terms of waterproof, dust proof

ix. Storage:

Minimum 500 GB TF storage for flight time of 30 minutes

3. Training and Support*

A) For UAV

i. Basics of GCS operation and Mission Planning:

Minimum 4 hours in On-Line/ Off-line Mode for at least a batch of 4 persons in India or abroad

ii. True terrain Following and Area Scan using GCS:

Minimum 6 hours through On-Line/ Off-line Mode for at least a batch of 4 persons in India or abroad

B) GPR

i. GPR fundamentals:

Minimum 6 hours through On-Line/ Off-line Mode for at least a batch of 4 persons in India or abroad

ii. GPR data acquisition:

Minimum 8 hours through On-Line/ Off-line Mode for at least a batch of 4 persons in India or abroad

iii. GPR data processing and interpretation:

Minimum 6 hours through On-Line/ Off-line Mode for at least a batch of 4 persons in India or abroad

C) GPR on UAV

i. GPR integration with UAV and operations:

Minimum 6 hours through On-Line/ Off-line Mode for at least a batch of 4 persons in India or abroad

ii. Field testing of the integrated system:

Minimum 4 hours through On-Line/ Off-line Mode for at least a batch of 4 persons in India or abroad

** As no such expertise/ capability is available at CSIR-CMERI*

4. Scope of Delivery:

1. Unmanned Aerial Vehicle (UAV):

- (i) UAV with FPV Camera: 1 set
- (ii) GCS: 1 set
- (iii) Li-ion / Li-Po/ Solid State battery – 3 sets
- (iv) Compatible Charger – 1set
- (v) Carrying case for UAV – 1 set

2. Ground Penetrating Radar (GPR):

- (i) GPR hardware with integrated antenna – 1 set
- (ii) Cables, connectors and all accessories to establish connection between the GPR on-board computer including console and the UAV autopilot module – 1 set
- (iii) 2 sets of GPR batteries along with 1 set of compatible charger
- (iv) GPR cart: 1 set
- (v) Carrying case for GPR – 1 set

5. Acceptance Test Procedure (ATP)

1. Physical verification:

Items supplied will be inspected at CSIR-CMERI for physical verifications before installations

2. Sub-system Testing:

GPR and UAV will be tested individually as per the checklist and operation manual at CSIR-CMERI before integration as follows:

- (i) Cart Based GPR survey will be conducted on a test bed (to be prepared by CSIR-CMERI) at CSIR- CMERI, Durgapur to observe the responses with minimum 5 number ferrous and non-ferrous objects each buried up to a depth of 3 feet.
- (ii) GPR data acquisition and basic processing.
- (iii) UAV flight testing inside CSIR-CMERI in different modes like auto (waypoint navigation), manual (RC Control), altitude-hold, GPS hold, return to launch etc.
- (iv) Performance testing of the stability, endurance and payload lifting capacity
- (v) Performance testing of the true terrain following nature of the UAV for different terrain heights and specially at 100 cm or lower height above the ground surface
- (vi) Performance testing of the precision landing feature of the UAV within a circular area of maximum diameter 2 meter
- (vii) Performance testing of RTK GPS module in terms of flight performance accuracy

3. Integrated test:

After successful sub-system testing only, the GPR will be integrated with The UAV and the following test procedures will be conducted:

- (i) Pitch, Roll, Yaw and Rudder movement of the integrated system at a maximum speed of 5 m/sec at different altitudes, especially at 100 cm or lower height above ground surface at 1 m/sec.
- (ii) Endurance testing at full payload for 30 minutes followed by battery failsafe activation and landing
- (iii) Data acquisition using the integrated system over a test bed at 100 cm or lower height
- (iv) Telemetry data and GPR raw data quality checking at the ground control station over a range of 1km
- (v) Landing Performance of the integrated system within a circular area of maximum diameter 2 meter
