

EOI Ref: GTI/AIDOZER/EOI

Date: 28 June 2021

Expression of Interest for design, development, supply, integration/ commissioning and proving out of AI based system to BEML LTD to convert BD50HST Dozer into Autonomous Dozer for land slide/ Road / snow clearance application.

Response to Eoi : bemleoi@beml.co.in

Closing date & time: 14:00 hours of 20.07.2021

1. Brief about BEML:

BEML Limited, a Central Public Sector Enterprise under the Ministry of Defence was incorporated in 1964. Subsequently it became a listed company and is engaged in the design, development and manufacturing in the areas of Mining & Construction, Defence & Aerospace and Rail & Metro equipment. It is a leading multi-technology and multi-location Mini-Ratna category-I company offering high quality products for diverse sectors of economy such as Defence, coal, mining, steel, cement, power, irrigation, construction, road building, metro & railways and aviation. It has emerged as the forerunner of heavy engineering industry with a track record of growth and revenues for over four decades. We request you to please visit our website www.bemlindia.in for more details on BEML limited.

2.1 Mining & Construction:

Being India's leading mining and construction equipment manufacturer, BEML offers a comprehensive and diverse range of mining machineries for both open cast and underground coal, metal mines. BEML produces machines such as Hydraulic Excavators, Bulldozers, Wheel Loaders, Wheel Dozers, Dump Trucks, Motor Graders, Pipe Layers, Tyre Handlers, Water Sprinklers and Backhoe Loaders. BEML has ventured into Underground Mining with products such as Side Discharge Loader, Under Ground Mine Cruiser, Load Haul Dumper and Granby Car. The company is having one of its kind R&D centre at KGF complex to undertake design and development of new equipments needing to market with state-of-the-art new Technologies.

R&D centre is equipped with testing laboratories for comprehensive evaluation new power train aggregates of equipment. BEML has also developed Mining Dump trucks of 150 Ton and 205 Ton class and Excavators of both Hydraulic and Electrical of 180 Ton capacity.

2.2 Defence & Aerospace:

BEML Ltd is engaged in the business of High Mobility vehicle for all terrain operations, Heavy Recovery Vehicle, Pontoon Mainstream Bridge Systems, Crash Fire Tenders, Mobile Mast Vehicle, Engineering Mine Ploughs, Tank Transportation Trailers, Weapon Loading equipment, Armoured Recovery Vehicle, Rail Coaches and Wagons, Ground support vehicles and other products to the Indian and other Armed Forces.

2.3 Rail & Metro:

BEML Ltd is engaged in the business of Integral Rail Coaches, Overhead Inspection Cars, AC/DC Electrical Multiple Units, Stainless steel EMUs, Utility vehicles, Track Laying Equipment, Broad-gauge Rail bus, Treasury Vans, Spoil disposal Units to the Indian and other Railways.

BEML Ltd has also successfully diversified into manufacturing state-of-the-art technology stainless steel Metro Cars for various urban Metro Corporations and enjoys a dominant market share in this segment

3.0 Research & Development:

BEML Ltd has R&D establishment for Design & Development of high-tech engineering products for its three verticals. It employs over 300 professionals with high experience and skills spanning a wide range of technology areas.

The R&D establishment has CAD Centre, Fluid-power, Powerline, Structural Engineering & Material Science laboratories and is continuously engaged in New Product Development and upgradation of existing products to meet customer requirements. More than 68% of Company's Sales Turnover is through in-house developed R&D products. The R&D expenditure is around 2 ~ 3% of its turnover.

4.0 International Business Division (IBD):

BEML has a sizeable market share in export markets with exports to 68 countries across the globe. Over the years this division has exported over

1200 machines covering all the three verticals.

As envisioned and proposed by Ministry of Defence (MoD), Govt of India, BEML has charted out the AI Roadmap which covers induction of IoT/AI technology enabled products and solutions in the operations of the company for improving operational efficiency. Apropos, the main focus in the company is on developing and introducing IoT/AI enabled features on BEML products catering to Mining and Construction.

5. Objectives of the Eol:

To identify potential partners for design, development, supply, integration /commissioning and proving out of AI based Tele / Autonomous system for BD50HST Dozer.

6. Scope of Work:

A) BEML scope of Supply: BEML shall provide the BD50HST Dozer for installation & testing.

B) Partner's Scope of supply:

- a) Jointly arrive the final specification of Hardware and System for development
- b) Software development along with necessary Hardware and engineering of the same on the equipment and proving of system in integrity
- c) Shall design, develop, supply the AI based Turnkey system as per final specification jointly arrived on BEML Dozer model BD50HST for Tele/ Autonomous operation which include supply of Hardware, software, sensors etc.,
- d) To integrate & commission the developed AI system as per final specification jointly arrived on BEML Dozer model BD50HST and demonstrate the tele/ autonomous operations at BEML Kolar Gold Fields as well as in the customer site.

- e) To demonstrate and ensure satisfactory and consistent Autonomous function in actual operating conditions at customer site with work profile of
 - i Dozing loose material.
 - ii Dozing rocks and boulders.
 - iii Dozing and stock piling.
 - iv Dozing and pushing the material over cliff.
 - v Levelling and grading jobs.
 - vi Snow Clearance

f) Application: For land slide/ Road / snow clearance

7. Specifications of Autonomous Dozer:

Dozer when integrated with autonomous solution (as briefed in Annexure-A to Drawing No. 115-EG-01018) shall carry out all functions of it autonomously through cognitive thinking/artificial intelligence

Autonomous solution from vendor shall consist of an intelligent control unit that will take inputs such as

1. Real time positioning & time synchronisation feedback of machine from GNSS/ IRNSS receiver.
2. Speed & acceleration feedback of machine from inertial measurement unit
3. Real time equipment data from machine control unit. Accordingly, Intelligent Control Unit should deliver the outputs such as
 - i. Autonomous driving & dozing
 - ii. Dynamic scheduling of tasks

Dozer shall also have remote mode and manual operation mode in addition to autonomous mode.

8.1 Operating Modes:

8.1.1. Fully autonomous navigation and intelligent implement control

In this mode machine should be fully operable automatically on its own after receiving initialization command from control system. Initially aerial survey/mapping of the mine to be carried out for path definition & during working dozer to follow the defined path and clear the pile accordingly by choosing required gears on its own by intelligence machine control unit. Gear selection to happen based on the load conditions perceived by the blade. Blade location to be evaluated using GNSS/ GPS antenna

and this to be passed on to Intelligent Machine Control Unit. Load on the machine to be calculated by using load sensing cylinders/by any other means as per prevailing technologies such as to provide precise load scenario to intelligent machine control unit. Intelligent machine control unit will command/communicate to machine control unit through multiple analogue/digital i/os

Under this mode system shall have following features:

- a. Cognitive thinking & machine learning capabilities
- b. Self driving capability
- c. Dynamic mission scheduling
- d. Real time terrain data based automatic blade control
- e. Track slip & blade overload intelligent adjustment
- f. Cloud based operating status/machine health parameters update
- g. Different dozing modes based on terrain nature
- h. Geo-fencing
- i. Digital twinning
- j. Remotely work scheduling & monitoring

8.1.2. Remote Control

Remote control is a portable, over-the-shoulder control unit. It shall allow operator to work safely and comfortably off the machine, while remaining on-site and in direct visual contact. It is required for short-term and emergency use.

Further it shall also be possible to operate the machine remotely, from a command centre setup from many miles away. It shall allow operators to work for long periods of time while seated in a safe, comfortable virtual cab. It requires video and audio support over a high-speed communications network

Intelligent machine control unit should be able to receive commands from remote pendant through a radio link/antenna/internet set up and intelligent control unit should further command/communicate to machine control unit for execution of commands sent by remote pendant

It should have following features:

- a. Line of sight control
- b. Provision for different dozing modes

- c. Driving & dozing capabilities through a remote pendant
- d. Remote starting & remote stopping
- e. Provision for visualising machine parameters, warnings and alerts.
- f. Provision for seeing dozer surrounding environment in real time to enable operator to control dozer movement and blade operation.

8.2 Vehicle Health Monitoring:

Intelligent control unit has to collect data information on location of equipment using internal/external GNSS receiver and equipment information from various on-board sensors and electronic controller. This data to be relayed to web server through satellite-based relaying/gprs or other means. The server has to store the information received from equipment in a database and this can be accessed by OEM's engineers. Limited data access can be extended to customers/dealers with due protection.

Equipment data can be as below.

1. Vehicle data: available through CAN J1939 & RS485/Ethernet/sensors & switches
2. Engine data: can J1939/sensors & switches
3. Transmission data: RS232/RS485

9. DELEVERABLES:

Vendor shall supply the AI systems which consist of following modules-

9.1 For remote operation

1. Dozer drive module: Consisting of intelligent machine control unit, I/O module, amplifier module
2. Dozer communication module: GNSS/GPS/NAVIC communication for machine location w.r.t time & space, inertial measurement unit for speed/acceleration measurement
3. Dozer vision module: the vehicle shall be equipped with surrounding sense sensor package including LIDAR, cameras, RADAR, ultrasound with real-time sensor fusion for local navigation (decision making capability while in motion)

4. Portable base station- a transceiver for commanding dozer via a radio link for about 1 km distance apart & for receiving vehicle vital information on the same. It shall have a display to view received parameters/info and to view live video streaming of dozer when dozer is under operation.
5. Software: for line of sight operation & control
6. GPS tracking system
7. Power supply module

9.2 For Autonomous Operation

- 1) Aerial surveillance module- For 3D terrain mapping
- 2) Software- Including machine learning, data analytics & algorithms for controls.
- 3) Digital twinning module
- 4) High speed internet infrastructure and necessary hardware for remote monitoring & control
- 5) GNSS antenna cum receiver for identifying position of the blade

Specifications of components/wiring/connectors shall meet environmental and operating voltage conditions as has been brought out in the Annexure-A (Drawing No. 115-EG-01018)

10. Project Schedule:

- a. The design, development and supply of Hardware, Software: 12 Months
- b. Integration, commissioning, demonstration at BEML KGF: 3 Months
- c. Integration, commissioning, demonstration at customer site: 6 Months

11. SPECIFICATIONS OF BD50HST DOZER:

11.1 Engine: 100 HP BS-IV (CEV) Diesel engine

11.2 Transmission: Electronically controlled hydrostatic transmission with two travel speed control modes viz (1). Variable mode: travel speed is controlled from min to max proportionately. (2). Stepped mode: travel speed is controlled through gears i.e., F1, F2, F3 and R1, R2, R3

11.3 Electrical system: 24V operated system with 2 nos of 12V, 160AH batteries connected in series, engine driven alternator charging system of rating 45A

11.4 Electrical controls:

1. Key switch: it is used to make control panel on/off
2. Engine start push button: for cranking engine
3. Engine stop push button: for stopping engine
 - a. Engine ECU: it controls optimum fuel through fuel injection pump based on feedback from different engine sensors like engine speed, engine oil pressure, engine water temp and engine speed command
4. Engine speed control: electrical knob with 0 to 5V DC proportional output
 - a. Hydrostatic transmission ECU: it controls travel pumps & travel motors proportionately based on travel joystick commands
 - b. Travel joystick: it gives 0 to 5V DC proportionate commands to hydrostatic transmission ecu for dozer forward, reverse & steering control with digital switch input redundancy for its position validation
 - c. Blade control joystick: it gives 0 to 5V DC proportionate commands to hydraulic controller for PAT (Power Angle Tilt) blade operations
5. Head lamp rocker switch: for turning on/off head lamps
6. Rear lamp rocker switch: for turning on/off rear lamps
7. Fog lamp rocker switch: for turning on/off fog lamps
8. Mode selection rocker switch: for selection of variable or stepped mode
9. Emergency stop rocker switch: to stop engine upon emergency
10. Horn switch: it is a micro switch integral of blade control joystick for controlling horn through a relay
11. Battery positive isolation relay: it is key switch controlled, heavy duty cut off relay, for isolating battery positive terminal from the system.

11.5 Instrumentation System: 4.3-inch LCD display instrumentation system for displaying equipment gauge parameters, status indicators & warnings. It receives signals from Engine ECU & Hydrostatic Transmission ECU over CAN communication CAN J1939 2.0B network.

1. Gauge & numerical parameters available on display:

- a. Engine oil pressure
 - b. Engine water temperature
 - c. Engine speed/rpm
 - d. Volt meter
 - e. Equipment speed/gear selection
2. Bar Graph Parameters
- a. Left steering & right steering
 - b. Fuel level
 - c. Hydraulic oil temperature
3. Warning indicators:
- a. Engine oil pressure
 - b. Engine water temperature
 - c. Fuel level
 - d. Hydraulic oil temperature
 - e. Volt meter
4. Status indicators:
- a. Mode selection switch: stepped/variable
 - b. Equipment current gear

11.6 Communication among controllers:

SAE CAN J1939 2.0B is the communication STD. to be followed across but RS232 serial/USB communication provision should be available.

12. Eligibility Criteria:

The following are the mandatory conditions to be fulfilled by the firm for responding to the EoI.

- Firm should be registered Company either in India or in other countries.
- Should have demonstrable experience of developing/customizing AI based autonomous solutions for Mining, Construction & Defence Equipment.

- The firm shall be an OEM having track record in Artificial Intelligence based products/Technology. Only the OEM needs to respond to this EOI. Dealers/distributors/agents/representatives may respond along with OEM authorisation.
- Firm shall present minimum one PO from DRDO/Defence agencies/construction companies/mining machinery OEM's or mine operators to whom they have supplied the technology and converted equipment into Autonomous version. Firm shall also produce customer certificates indicating that they have successfully delivered the project.
- The firm should have certified ISO 9001:2015 & CMMI Level 3 Company.
- In addition to the above points Annexure – B i.e qualification criteria of Annexure - B mandatorily to be uploaded.

13. Terms and Conditions

- The firm shall customize the AI solution on BEML BD50HST Dozer as per customer's need.
- Bidder to share the specification details of all bought out items.
- Bidder to indicate the price per Dozer for conversion kit for autonomous scope
- The OEM should be able to get the applicable export clearance, if any.
- The firm shall accept branding of the product (AI Solution) in BEML name.
- The product (AI Solution) specifications shall meet the regulatory requirement of Govt. of India.
- The firm shall provide credentials with document evidence for having developed and demonstrated the AI Solution on any of the Mining, Construction & Defence Equipment.
- The firm shall be ready to share complete technical details including software, hardware and engineering details to BEML Ltd for ensuring seamless support to customers. Further firm also shall provide continuous support to BEML LTD and its customers for the period of minimum 10 years
- Capability to furnish Bank guarantees

14. Pre-bid meeting (Eoi clarification meeting)

Pre-bid meeting for technical clarifications is tentatively scheduled on 09.07.2021. The interested firms may participate. Technical clarifications may be sent before the meeting date to email: gse@beml.co.in

15. Presentations on proposed Solution/ Methodology

The firms shortlisted based on the eligibility criteria may be invited to make a presentation at a date, time and location notified by BEML. The purpose of the presentation would be to allow the participants to present their solution/ methodology, experience, capabilities, infrastructure, and other key points, if any.

12. Submission of the EOI

The EOI shall be submitted on or before 14:00 hours of 20.07.2021 with all the formats duly filled. EOI in sealed covers stating compliance to all the points (Annexure-B, C, D & E) should be sent by e mail to bemleoi@beml.co.in

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For Technical clarification, please contact

Contact Person: Sri C.M.Dudhe, DGM(R&D)

Contact number: 089719 95950,

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**QUALIFICATION CRITERIA: (mandatory)**

The firm should have the followings:

| Sl. No. | Parameter                                                                                                                                                                                                                                  | Unit    | Details                                                     |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------------------------------------|
| 1       | Prior experience with heavy equipment                                                                                                                                                                                                      | Yes/No. | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 2       | Minimum experience of 5 years                                                                                                                                                                                                              | Yes/No. | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 3       | Has minimum 20 employees                                                                                                                                                                                                                   | Yes/No. | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 4       | Has an active Indian operation and service support team in India.                                                                                                                                                                          | Yes/No  | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 5       | Willingness to modify the equipment to the customer's need.                                                                                                                                                                                | Yes/No. | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 6       | The firm shall accept co-branding of the product.                                                                                                                                                                                          | Yes/No. | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 7       | Willingness for BEML to have the sole right to market the customised product.                                                                                                                                                              | Yes/No. | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 8       | Willingness to transfer the technology to indigenise at least 50% of the value of equipment in India to meet "Make in India" criteria as per 'Buy & Make (Indian)' category.                                                               | Yes/No  | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 9       | Willingness to share with BEML any up-gradations / improvements made during the period under which the joint working arrangement is effective.                                                                                             | Yes/No  | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 10      | Willingness to train a core technology team of Engineers from BEML Ltd.                                                                                                                                                                    | Yes/No  | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |
| 11      | The firm shall be an OEM or a Information Technology (IT) company having track record in Artificial Intelligence based products/Technology. <i>Only the OEM needs to respond to this EOI.</i> Dealers/distributors/agents need not respond | Yes/No  | Yes <input type="checkbox"/><br>No <input type="checkbox"/> |

## Artificial Intelligence based Autonomous Dozer

|    |                                                                                                                                                                                                                                                                                                                                  |        |                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12 | Submission of Undertaking as per <b>Annexure-C</b> regarding that the company has not been debarred / blacklisted by PSU/Government of India / any State Government in India / Central or State Government undertaking for corrupt or fraudulent practices or non-delivery, non performance <b>(Annexure-C to be uploaded)</b> . | Yes/No | Yes <input style="width: 30px; height: 15px;" type="checkbox"/><br>No <input style="width: 30px; height: 15px;" type="checkbox"/>                                                                                                                                                                                                                                                                                                    |
| 13 | Submission of undertaking as per <b>Annexure-D</b> regarding number of arbitration cases pending and details regarding the same.<br><b>(Annexure-D to be uploaded)</b>                                                                                                                                                           | Yes/No | Yes <input style="width: 30px; height: 15px;" type="checkbox"/><br>No <input style="width: 30px; height: 15px;" type="checkbox"/>                                                                                                                                                                                                                                                                                                    |
| 14 | Submission of Quality Certificates to be uploaded such as ISO 9001, ISO 14000 or any other relevant certificate.<br><b>(Certificates are to be uploaded)</b>                                                                                                                                                                     | Yes/No | Yes <input style="width: 30px; height: 15px;" type="checkbox"/><br>No <input style="width: 30px; height: 15px;" type="checkbox"/><br>List of certificates:<br>(i) <input style="width: 30px; height: 15px;" type="checkbox"/> (ii) <input style="width: 30px; height: 15px;" type="checkbox"/><br>(iii) <input style="width: 30px; height: 15px;" type="checkbox"/> (iv) <input style="width: 30px; height: 15px;" type="checkbox"/> |

Note: Please tick the relevant boxes and provide the information. Documents required to authenticate the above information/details may be enclosed/ uploaded.

**UNDERTAKING**

This is to certify that \_\_\_\_\_ (Name of the Firm) has not been banned / black listed / debarred from Trade by any PSU/Government of India / Autonomous Institution/any State Government in India / Central or State Government undertaking for corrupt or fraudulent practices or non-delivery, non-performance

I / we hereby certify that all the information given above is factual.

Signature with date of Authorized signatory

Name: \_\_\_\_\_

Designation: \_\_\_\_\_

Firm's Seal: \_\_\_\_\_

**UNDERTAKING**

This is to certify that \_\_\_\_\_ (Name of the Firm) has \_\_\_\_\_ number of arbitration cases pending and details regarding the same is furnished below.

- 1.
- 2.
- 3.

I / we hereby certify that all the information given above is factual.

Signature with date of Authorized signatory

Name: \_\_\_\_\_

Designation: \_\_\_\_\_

Firm's Seal: \_\_\_\_\_

**Annexure-E**

**Compliance check sheet for Remote controlled cum Autonomous system for BD50HST Dozer ( To be uploaded).**

Please tick the relevant.

| Compliance to Technical Parameters |                                                                                                                                                                                                                                                                                                                                                                                                                                                         |            |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Sl No                              | Parameter                                                                                                                                                                                                                                                                                                                                                                                                                                               | Compliance |
| 1                                  | The system is to be cost-effective, easy to retrofit on equipment and shall be an add-on module to existing BEML offered Dozer (BD50HST). BD50HST Dozer has Electronically (ECU) controlled engine & Electronically (ECU) controlled Transmission. Vendor offered system should connect seamlessly to BD50HST Dozer electrical system and should have mutual communication & commanding to achieve remote controlled & autonomous functions completely. | Yes/No     |
| 2                                  | The proposed system has to work on 24VDC battery160Ah rated, Alternator (45Amps) system of equipment.                                                                                                                                                                                                                                                                                                                                                   | Yes/No     |
| 3                                  | The proposed system shall be rugged, vibration proof and suitable to work in mining harsh environment and to meet latest EMI/EMC compliance. The offered system should have minimum IP67 protection (or) better and vibration sustaining capability up to 9g & shock vibration up to ±50g                                                                                                                                                               | Yes/No     |
| 4                                  | The offered system shall make the equipment capable to function in remote mode (line of sight control) through radio link, up to one kilometre distance with redundancy of manual operation mode in addition to autonomous mode.                                                                                                                                                                                                                        | Yes/No     |
| 5                                  | The system should be able to respond as fast as possible to dynamic allocation of tasks & commands from remote station. Operational latency/delays of systems on machine, if any persists during development, vendor should take necessary hardware/software correction to the extent that machine becomes functionally acceptable                                                                                                                      | Yes/No     |
| 6                                  | Speed & acceleration feedback of machine from inertial measurement unit or any suitable mechanism should be available                                                                                                                                                                                                                                                                                                                                   | Yes/No     |
| 7                                  | Real time positioning & time synchronisation feedback of machine should be available. The offered system should comply to IRNSS/Navic functional requirements apart from GNSS and areas where positioning of eqpt is not possible, then vendor should have alternate mechanism for positioning/navigation/functioning of equipment                                                                                                                      | Yes/No     |
| 8                                  | Usage of high resolution cameras to detect equipment surrounding environmental conditions & to provide visual feedback                                                                                                                                                                                                                                                                                                                                  | Yes/No     |
| 9                                  | Modular design with various sensors interfacing on a CAN J1939 standard & extended bit protocol. Dashboard of equipment to be mimicked to identify warning & alarms remotely to know real time                                                                                                                                                                                                                                                          | Yes/No     |

## Artificial Intelligence based Autonomous Dozer

|    |                                                                                                                                                                                                                                                                                                                                                                                                 |                    |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
|    | status                                                                                                                                                                                                                                                                                                                                                                                          |                    |
| 10 | Aerial survey/mapping of the path shall be possible by the system                                                                                                                                                                                                                                                                                                                               | Yes/No             |
| 11 | Gear selection to happen based on the load conditions encountered by the blade through load sensing cylinders during working and Blade location to be evaluated using stroke sensing cylinders or any suitable technology such as Radar or Lidar                                                                                                                                                | Yes/No             |
| 12 | Load on the machine to be calculated by using load sensing cylinders/by any other means & precise load data to be shared among controllers to take necessary decision automatically                                                                                                                                                                                                             | Yes/No             |
| 13 | Algorithm to control Dozer functions in mentioned working modes shall make use of control software that include machine learning module, Aerial surveillance module for 3D terrain mapping/geo fencing, data analytics. The control modules shall be capable to communicate on High speed internet for transferring data seamlessly to remote control station, capabilities should be available | Yes/No             |
| 14 | System shall be equipped with a gamut of sensors such as LIDAR, high resolution cameras for surround sense detection, object detection, RADAR, ultrasound with real-time sensor fusion etc.. for navigation & surveillance                                                                                                                                                                      | Yes/No             |
| 15 | cloud based operating status/machine health parameters update, line of sight control, different dozing modes, remote starting & remote stopping, visualising machine parameters, warnings and alerts, live video streaming of dozer when dozer is under operation, remotely work scheduling & monitoring features should be available                                                           | Yes/No             |
| 16 | Machine shall be capable to operate for continuous work from a command centre setup far away from equipment.                                                                                                                                                                                                                                                                                    | Yes/No             |
| 17 | Demonstrate and ensure satisfactory and consistent Autonomous & remote function in actual operating conditions at BEML premises & at customer site with various working profiles                                                                                                                                                                                                                | Yes/No             |
| 18 | Vendor shall be willing to share ToT( Transfer of Technology), bill of materials, technical details of components used, O&M manuals, Service Manuals                                                                                                                                                                                                                                            | Yes/No             |
| 19 | Vendor to provide exhaustive training at BEML ltd & site location                                                                                                                                                                                                                                                                                                                               | Yes/No             |
| 20 | The comply statement as above shall be read in conjunction with BEML drawing to P/N: 115EG01018 (Annexure-A) where ever it is necessary.                                                                                                                                                                                                                                                        | For Reference only |