ANNEXURE – I

A. Introduction:
B. Tender:
C. Detailed Specifications of Motor & Driver along with other accessories:
D. Scope of the Work:
E. Eligibility Criteria of Vendors:
F. Terms & Conditions:
G. Acceptance & Test procedures:

A. Introduction:

This tender document is for fabrication, supply, testing and installation of In-wheel Hub Motors (BLDC) to be used in a robotic platform. The robotic platform will have 6x6 wheel configurations and can carry a payload of 100 kg with its net weight as 300kg. The robotic platform can move at a speed of 20km/hr (maximum speed may be upto 40km/hr) and the maximum inclination is 20^{o}.

The basic design and parameters for the hub motors are ready and presented in this documents. The vendor has to follow similar principles and prepare their own design and comply the requirements and specifications with that of CMERI, Durgapur. After, Confirmation from CMERI, the analysis and simulation should be prepared followed by development of a single prototype of designed hub motor. Upon realization of the first prototype, the same has to undergo several testing as per the acceptance and test procedures laid down in this document at their own laboratory setup (properly established installations and instruments) or any Govt. accredited laboratories.Upon acceptance, the clearance for development of remaining/ multiple hub motors will be provided. The final set of motors will be then fitted with the original vehicle and tested.

B. Tender:

Title: Design & Development of Customized In-wheel Motors along with Compatible Controllers

Responsible Organization: CSIR - CMERI, Durgapur

Time frame for the Tender: **1 Month**

Time frame for the Job after placement of PO: 210 Days (07 Months)

SL.	Activity	Individual Durations from Previous Stage
1.	A report on the design of the motor complying the tendered specifications	30 Days
2.	Assessment & clearance by CMERI	07 Days
3.	Detailed Analysis and Simulation report of the finalized model	21 Days
4.	Assessment and final confirmation for fabrication of single prototype motor by CMERI	07 Days
5.	Realization of the first prototype	45 Days
6.	Testing of the first prototype as per the laid-down ATP and submission of the report to CMERI	15 Days
7.	Acceptance of the test reports and clearance for development of remaining motors	07 Days
8.	Final manufacturing of the remaining Motors	30 Days
9.	Test Report of the remaining Motors	15 Days
10.	Installation of the Motors on the Vehicle for test run	30 Days

C. Detailed Specifications of In-wheel Hub Motor & Driver along with other accessories:

There are four major components of the motor and they are (a) Motor (b) Gearheads (c) Encoder (d) Brake and motor drivers are required for each of the motors for its operation. The detailed specifications of these components along with the motor driver are mentioned below.

(1) In-wheel Hub Motor System and its Components:

a) Rated Power: 2.8 KW
b) Rated Torque: 76.5 Nm @ 350 RPM
c) Supply Voltage: 24/ 48/ 72/ 96 VDC
d) Efficiency: 90% and above
e) Overall In-wheel Hub Motor System Weight: 20 kg or less (each)
f) Tyre size: 300 ~ 350 mm
g) Tyre Mounting: M12X1.4 (mm), 4 Nos.

I. Specification of the Motor:

a) Type of the Motor: BLDC/ PMSM
b) Peak Power: 5.6 KW or higher
c) Rated Continuous Current: Max. 230 A
d) Peak Current: 500 A or higher
e) Dimensions: Within Diameter 200 mm
f) Protection: IP67
g) Expected Radial Load: 750 N or less
h) Expected Shock Load: 3750N or less
i) Special features:
   - Overload protection capacity
   - Overheating/ Thermal Protection
   - Provision for Mounting of Wheels using Nut-Bolts

II. Specification of the Gear head:

a) Type: Planetary
b) Special Requirements: Heat treated

III. Specification of the Encoder:

a) Type: Hall Sensor/ IR Sensor
b) Resolution: Min. 256 ppr

IV. Specification of the EM & Mechanical Brakes:

a) EM Brakes
   - Supply Voltage: 24/ 48/ 72/ 96 VDC
   - Control Signal: 0 – 15 VDC
b) Mechanical Brake:
   - Type: Disc Brake
   - Braking Distance: Within 15 m

(2) Motor Driver:

I. Specification of the Motor Driver:

a) Battery Voltage: 24/ 48/ 72/ 96 ± 15% VDC
b) Limb Home Mode: 50% Power below nominal voltage
c) Position Sensor: Hall/IR Sensor
d) Speed Sensor: Min. 256 ppr
e) Other essential sensor: Temperature sensor
f) Trip voltage: Within 90% of the Nominal Voltage

Nripen Chandra

g) Heat Sink: Cast Aluminium alloys
h) Connectivity: UART
i) Input:
    - Accelerator – Speed reference
    - Brakes – 2
    - IoT Interface
j) Maximum permissible shock: 2g or more
k) Maximum permissible vibration: 2g or more
l) Ambient Temperature range: -20° to +50° C
m) Efficiency: 80% or higher
n) Cooling: Natural
o) Special features:
    - Surge Protection
    - Overload protection capacity
    - Overheating/ Thermal Protection

D. Deliverables & Time frame:

The overall delivery and the time schedule of this present tender includes some document part (report based) and some system part and mentioned below.

1. ***Design documents:***
    a. Detailed Design and Compliance Report for the in-wheel Hub Motor with all the Physical Dimensions, Models, Drawings and Functional Parameters (Voltage, Current, Flux etc.)
    b. Detailed Analysis and Simulation Report (using Ansys Maxwell 3D, Ansys FEM Model) for the Assessed and Accepted Motor **- Within 58 Days from placement of PO**
2. ***Prototype motor (01 No.):***
    a. Realization of the First Prototype
    b. Test Report of the First Prototype of Hub Motor as per the laid down ATP mentioned in this tender document - **Within 125 Days from placement of PO**
3. ***Final motors (6 Nos.):***
    a. Development of the remaining Hub Motors - Within 162 Days from placement of PO
    b. Test Report for the remaining Hub Motors as per the laid down ATP mentioned in this tender document
    c. Installations of the Hub Motors on the Vehicle & Trial run - **Within 177 Days from placement of PO**

E. Functional Requirements:

The following protection functions should be enabled on the inverter:

i. **Torque Control and Speed control**
The inverter shall control the motor in torque control mode

ii. **I2t Protection**
Whenever the motor output torque goes above the rated torque of the motor, the controller shall allow a limited time of overloaded operation roughly as per the I2t function.

iii. **Protection against Short Circuit**
The inverter shall have protection against dc link short circuits

iv. **High temperature protection**
The inverter shall shut down if the IGBT/MOSFET junction or heat sink temperature goes above safe operating temperature.

v. **Transient over voltage protection**
The inverter shall be protected against transient over voltages up to 200 V.

vi. **DC Link discharge after power down**
The inverter shall have discharge resistors across the DC link so that the DC link voltage falls below 40 V DC within 3 minutes of shutdown.

vii. **Reporting of Motor/Inverter Status**
The inverter shall report the following parameters pertaining to the motor and inverter on UART:

- Motor shaft speed
- Inverter input DC current
- Inverter DC link voltage
- Inverter Heat sink temperature
- Inverter operating status
- Inverter On/OFF
- Inverter fault state
- Battery Current
- Brake Signal
- Overload/Current
- Voltage/Current/Temperature faults

F. Eligibility Criteria of Bidders:

- Bidder Firm should have experience in designing/analyzing Hub (BLDC/PMSM) motors of 1KW or higher for Indian Govt. R&D (CSIR, DRDO, ISRO etc.) organizations. Relevant PO copies are to be shared as documentary evidences.
- The Bidder should have own Manufacturing Unit for Hub Motors in India or collaboration with Indian Manufacturing Unit for Hub Motor. Documentary evidence of owning manufacturing unit or agreement copy of collaboration is to be provided.
- The Director(s) of the Bidder should be Indian national(s).

G. Terms & Conditions:

- Minor change in the specifications after the Qualification Tests of the first prototype motor, if any, needs to be accommodated, with mutual discussion.
- Payment will be made in stage-wise manner as per the time line given below in Sl. I and upon acceptance.
- Pre-despatch inspection at site will be carried out by CSIR – CMERI, Durgapur and team with the help of the bidder as per the procedures mentioned in Sl. H below. 7 Days prior intimation should be made by the bidder to CSIR – CMERI, Durgapur.
- Qualification tests are to be carried out as per the procedure mentioned in Sl. H below from any DRDO Labs or any other NABL accredited Govt. Labs. The cost for performing such tests only will be borne by CSIR – CMERI, Durgapur at actual basis on production of Original Invoice/ Bill/ Receipt and therefore will not be the part of Tender.
- The transportation and other costs related to delivery and carrying the specimen(s) to the Testing Laboratory(s) will be borne by the bidder.

- After Qualification tests, the items/ materials are to be delivered to CSIR – CMERI, Durgapur.

H. ATP: Acceptance test procedures for the Overall System:

(I) Tests for the first prototype motor and remaining final motors:

1) **Pre-despatch Inspection at site:** *Physical and visual check*: Items will be inspected for physical dimensions like overall diameter, weight etc. using conventional and duly calibrated scale, weighing scale etc.
2) **Pre-despatch Inspection at site:** *Functionality check at rated load*: Hub motor and controller (Drive) will be checked for its functionality in lab test set up. Vender has to make necessary arrangements for testing. Parameters like rated torque, speed, voltage, current and power will be measured during this test using conventional and duly calibrated measuring instruments, Tachometer, Voltmeter, and Ammeter.
3) *Qualification (Environmental) Test Specifications to be carried out at DRDO Labs or any other NABL accredited Govt. Labs.:*

3a. High Temperature Test:-

i. +55 ºC ± 3ºC : for 6 Hrs
ii. +65 ºC ± 3ºC : for 4 Hrs
iii. +55 ºC ± 3ºC : for 6 Hrs

a. Pre testing at ambient temp
b. Testing inside chamber for last 30 minutes of soaking period
c. Post testing at ambient temp

3b. Low temperature test:-

i. -10 ºC ± 3ºC : for 6 Hrs
ii. -20 ºC ± 3ºC : for 4 Hrs
iii. -10 ºC ± 3ºC : for 6 Hrs

a. Pre testing at ambient temp
b. Testing inside chamber for last 30 minutes of soaking period
c. Post testing at ambient temp

3c. Vibration Test:-

i. Sinusoidal vibration:
   a. 5 - 8 Hz : ± 6mm constant displacement peak to peak
   b. 8 - 500 Hz : ± 1.5g peak

(OR)

ii. Random Vibration:
   a. 5 - 20 Hz: (6dB per octave) desirable.
   b. 20 - 50 Hz : $0.02g^2$ / Hz, then rolling up to $0.001g^2$ / Hz at 500 Hz

Duration: 30 min cumulative

(II) Tests for the final motors at CSIR – CMERI, Durgapur:

1) *Integrated test*: Motors and drives will be integrated on the test set up/ vehicle (which ever is available) and integrated test will be carried out. Parameters like maximum speed of the motor

and vehicle, current, voltage will be monitored using conventional measuring instruments, Tachometer, Voltmeter, Ammeter.

I. Payment Schedule:

Payment Sl.	Description	Deliverables/ Milestones	% of PO Value
1.	**Design & Analysis completion**	**Upon receiving and acceptance of the following:** • Detailed Design and Compliance Report for the in-wheel Hub Motor with all the Physical Dimensions, Models, Drawings and Functional Parameters (Voltage, Current, Flux etc.) • Detailed Analysis and Simulation Report (using Ansys Maxwell 3D, Ansys FEM Model) for the Assessed and Accepted Motor	**30%**
2.	**Prototype motor & Testing**	**Upon receiving and acceptance of the following:** • Delivery of the first prototype motor • Test Report of the First Prototype of Hub Motor as per the laid down ATP mentioned in this tender document	**40%**
3.	**Final delivery & Trial run**	**Upon receiving and acceptance of the following:** • Final motors - 6 Nos. • Test Report for the remaining motors as per the laid down ATP mentioned in this tender document • Installations of the motors on the Vehicle & Trial run	**30%**

****