

**REQUEST FOR PROPOSAL  
FOR  
VACUUM COMPATIBLE  
MID-WAVE INFRARED  
INTEGRATED DETECTOR COOLER ASSEMBLY  
(MWIR IDCA)**



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## Contents

<b>Introduction:</b> .....	<b>3</b>
<b>Section-1 General Background of the Requirement</b> .....	<b>4</b>
<b>Section-2 Electrical, Electro-optical, Mechanical and Optical Requirements</b> .....	<b>5</b>
2.1 Electrical and Electro-optical Requirements for MWIR IDCA: .....	5
2.2 IDCA Physical Dimensions and Mounting Provisions: .....	7
2.3 Optical Window and Bandpass Filter: .....	7
2.4 Temperature Sensors: .....	7
2.5 ROIC and Cooler Electrical Interface Requirements: .....	8
2.6 Absolute Maximum Ratings: .....	8
<b>Section-3 Environmental, Packaging and Screening Requirements</b> .....	<b>9</b>
3.1 Life: .....	9
3.1.1. Operating life: .....	9
3.1.2. Shelf life: .....	9
3.2 Environmental Conditions: .....	9
3.2.1. Storage and Non-operating Environment: .....	9
3.2.2. Operating Environment: .....	9
3.3 Vibration / Shock: .....	10
3.3.1. Random Vibration: .....	10
3.3.2. Sine Vibration: .....	10
3.3.3. Mechanical Shock: .....	10
3.4 Parts and Materials: .....	10
3.5 Marking and Identification: .....	11
3.6 Packaging, Storage & Transportation: .....	11
3.7 Screening and Electro optical (EO) Acceptance Test Plan: .....	12
3.7.1. Screening Tests: .....	12
3.7.2. Additional Screening Tests: .....	13
3.7.3. Electro-optical Acceptance Tests: .....	13
<b>Section-4 Documents Required</b> .....	<b>14</b>
4.1. Following information shall be provided as a minimum to SAC along with the proposal: .....	14
4.2. Following information shall be provided within 1 month of order placement: .....	14
4.3. Following information shall be provided along with the delivery of each IDCA: .....	14
<b>Section-5 Deliverables and Delivery Schedule</b> .....	<b>15</b>
<b>Section-6 General Terms and Conditions</b> .....	<b>15</b>

## **Introduction:**

Space Applications Centre (SAC), Indian Space Research Organisation (ISRO), Department of Space, Government of India, is involved in development of space borne cameras for meteorological applications and earth resource monitoring. SAC is planning to develop an imaging camera in Mid-Wave Infrared (MWIR) spectral band for space based remote sensing applications.

Proposals are invited from vendors having experience in manufacturing vacuum compatible focal plane array detectors integrated with active coolers (here in afterwards referred as IDCA, Integrated Detector Cooler Assembly).

**This is a two-part tender. Vendors are requested to submit their technical and commercial offers separately in sealed covers.**

It is very important for evaluation of the offer that the proposal includes sufficient technical data on form, fit and function. The proposal submitted in response shall be in conformity with requirements laid down in subsequent sections. It should also include the facilities available for fabrication and testing to meet the requirements. If this technical data is not available along with the offer, SAC reserves the right to reject the proposal.

Vendor shall provide the cost break-up including the aspects like NRE (if any), optional screening tests, command and control electronics, cooler drive electronics etc. as mentioned herein. Vendor shall submit all supporting documents in case the devices are proposed to be excluded from any testing mentioned herein. SAC reserves the right to include or exclude any test depending on the test history and cost.

Requirements given in this document may be modified by SAC before the finalization of the contract. After the award of the contract, any modification will be done as per terms of the contract. Vendor may propose alternate tests / conditions and provide detailed analysis, in case of any deviation from the requirements. SAC reserves the right to accept or dispose of such deviation depending on the test history and cost as mutually agreed.

This document gives details of the requirements of the MWIR IDCA in the following five sections:

Section-1: General Background of the Requirement

Section-2: Electrical, Mechanical and Interface Requirements

Section-3: Environmental, Packaging and Screening Requirements

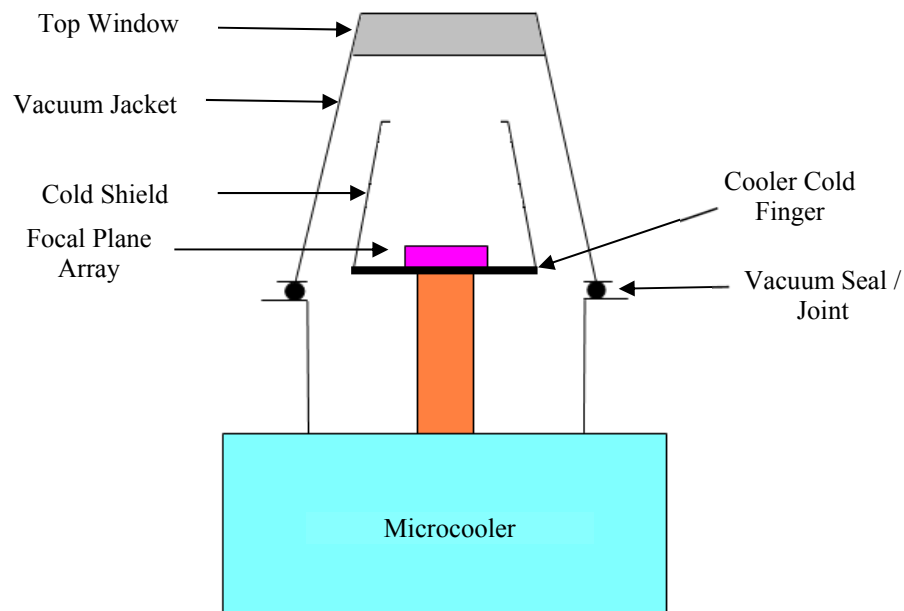
Section-4: Documentation Requirements

Section-5: Deliverables and Delivery Schedules

## Section-1 General Background of the Requirement

### General Description of MWIR IDCA:

The MWIR IDCA shall consist of Mercury Cadmium Telluride (MCT) based photovoltaic detector array having 640 x 512 pixels with a pixel pitch of 15 $\mu$ m, sensitive in mid-wave infrared spectral band of 3.7 $\mu$ m to 4.8 $\mu$ m. The detector array is hybridized with a Read-out Integrated Circuit (ROIC) for individual detector element signal conditioning and multiplexing. The hybridized detector ROIC assembly, known as Focal Plane Array (FPA), shall be mounted on the cold finger of space qualified integral rotary cooler and hermetically sealed with a vacuum jacket with an optical window at the top. A cold shield having specific F-number shall be placed over the FPA inside vacuum jacket to restrict the detector field of view. The IDCA shall meet the electrical, mechanical, environmental and screening specifications given in sections 2 and 3 of this document. Typical schematic overview of MWIR IDCA is shown in Fig.1.



**Fig.1 Typical Overview of MWIR IDCA**

## Section-2 Electrical, Electro-optical, Mechanical and Optical Requirements

This section gives details of electrical, electro-optical, mechanical, thermal and optical requirements of the MWIR IDCA.

### 2.1 Electrical and Electro-optical Requirements for MWIR IDCA:

Typical electrical and electro-optical requirements of the MWIR IDCA are given in Table-2.2 below. Unless otherwise mentioned, all electrical and electro-optical parameters mentioned in Table-2.2 shall be demonstrated at integrated IDCA level under test conditions specified in Table-2.1. Deviations if any from either test conditions or performance parameters shall be brought out for each deliverable IDCA in its individual Acceptance Test Report (ATR). SAC reserves the right to accept or dispose of such deviation depending on the test history and cost as mutually agreed.

**Table-2.1 Test Conditions for MWIR IDCA**

S.No.	Parameter	Test Condition / Value
1	FPA Operating Temperature	Shall be adjusted in the range 90-120K, typically 95K (actual value shall be specified in ATR)
2	Frame Rate, $F_{fr}$	50 Hz
3	Master Clock, $F_{mclk}$	$\geq 5$ MHz
4	Readout Mode	Integrate then Read
5	Integration Time	Shall be adjusted for half well fill condition (actual value shall be specified in ATR)
6	Test Environment	Standard lab ambient conditions: Temperature: 22 +/- 3°C Relative Humidity: 50 +/- 5%

**Table-2.2 Electrical and Electro-optical Requirements of MWIR IDCA**

S. No.	Parameter	Unit	Specification / Requirement
1	Spectral Response	$\mu\text{m}$	$\lambda_{\text{cut-on(50\% point): } 3.60 - 3.70}$ $\lambda_{\text{cut-off(50\% point): } 4.80 - 4.90}$
2	Sensor Material	-	HgCdTe
3	Number of Columns	-	640
4	Number of Rows	-	512

5	Pixel pitch along Row and Column Direction	$\mu\text{m}$	15
6	Cold Shield*	-	Cold shield shall be compatible with f/1.9 (TBD) non-telecentric optics.
7	FPA Operating Temperature**	K	Shall be adjusted in the range 90-120K, typically 95K
8	Average NETD (for 293K scene at 50% well fill with f/2 optics)	mK	$\leq 30$
9	Array operability (operability criteria as defined in note-1 below)	%	$\geq 99$
10	ROIC Characteristics	-	<ul style="list-style-type: none"> <li>➤ Snapshot operation</li> <li>➤ Windowing capability</li> <li>➤ Integration then read mode</li> <li>➤ Programmable exposure time</li> </ul>
11	Number of Analog Video Output Ports	-	1 or 4 (selectable)
12	Maximum Pixel Readout Rate per Port	Mpixels/s	$\geq 5$ (Minimum and maximum readout rates supported by ROIC shall be specified)
13	Full Well Capacity	electrons	$\geq 14$ million
14	Video Signal Dynamic Range	-	$\geq 2.7$ V
15	Cooler type	-	Integrated Rotary Stirling Cooler
16	Cooler Power Consumption (under lab ambient conditions) (i) During Cool Down Phase (ii) During Regulated Phase	W W	$\leq 20$ $\leq 10$
17	Cooler MTTF	hours	$\geq 10,000$
18	Maximum allowable cooler electrical ON-OFFs	-	$\geq 2000$ $\geq 8000$ (goal)
19	IDCA Total Weight	kg	$\leq 0.6$

\*Cold shield aperture and its distance from focal plane array will be finalized at the time of order placement. Typical requirements are:

Cold shield aperture: 10.8 +/- 0.05mm.

Cold shield aperture distance from focal plane array: 19.889 +/- 0.15mm.

\*\*Vendor shall optimise FPA operating temperature for best trade-off between EO performances and cooler power consumption.

**Note-1:** A pixel is termed as operable if it fulfils following criteria under the specified operating conditions:

(i) NETD  $\leq 50\text{mK}$

- (ii) After Field of View (FOV) correction, peak responsivity dispersion is less than  $\pm 35\%$  of average measured value.
- (iii) After FOV correction, at 293K scene, output signal dispersion is less than  $\pm 35\%$  of average measured value.

A cluster is defined as two or more non operable pixels which are adjacent by a side or by a corner. For entire array no cluster shall have more than 15 pixels.

## **2.2 IDCA Physical Dimensions and Mounting Provisions:**

Dimensional details of the IDCA shall be provided by the supplier in the form of engineering drawings with SI units. IDCA shall have proper provisions to enable adequate mechanical mounting, in the form of flanges/holes (to be detailed in the drawings).

Supplier shall provide IDCA thermal model, if available, and details of thermal interfaces along with provisions / recommendations for cooler heat removal.

## **2.3 Optical Window and Bandpass Filter:**

A suitable optical window shall be fixed at the top of the Dewar housing to protect the detector array and maintain the vacuum/inert gas atmosphere inside. The window shall allow radiations of the desirable Mid-Wave (MW) band to penetrate into the Dewar. It shall be anti-reflective (AR) coated in order to maximize the incident radiation on the FPA. An optional optical bandpass filter may be fixed over the sensor array inside the vacuum jacket and cooled to FPA operating temperature to minimize parasitic radiations. It shall be a bandpass filter which precisely defines the spectral bandwidth of the IDCA.

Typical specifications of the window and filter like material, spectral transmission, thickness, flatness, parallelism, surface quality and distances from focal plane shall be provided along with offer by the vendor.

## **2.4 Temperature Sensors:**

Two temperature sensor diodes, 2N2222 diode type or equivalent, shall be integrated in the IDCA at FPA level.

- One sensor will be used as a temperature feedback to cooler drive electronics for FPA temperature control.
- Second sensor will be used for monitoring FPA temperature to derive the cool down time.

Supplier shall provide electrical interface and transfer function (sensor analog output to temperature) details of temperature sensors over the range 60K to 320K at optimised input bias.

## **2.5 ROIC and Cooler Electrical Interface Requirements:**

SAC intends to develop its own space qualified command and control electronics (C&CE) for the ROIC and cooler drive electronics (CDE) for the microcooler. Vendor shall provide all the necessary electrical interface details to SAC required for this development. Vendor shall also provide all other necessary details and guidance required for SAC to develop its own space qualified C&CE and CDE.

## **2.6 Absolute Maximum Ratings:**

Supplier shall provide absolute maximum ratings (above which the useful life of the IDCA may be impaired) for following FPA, ROIC and cooler parameters.

- Photodiode threshold damage flux
- ROIC analog and digital supply voltages (Vbias, VDD etc.)
- ROIC clock high and low levels
- Cooler voltage, current, frequency etc.

Supplier shall identify the operating conditions for maximizing the life of the IDCA. Dos and Don'ts for IDCA operation shall also be brought out.



## **Section-3 Environmental, Packaging and Screening Requirements**

### **3.1 Life:**

#### **3.1.1. Operating life:**

IDCA shall meet all the design requirements for operation in excess of 10,000 hours under the specified ambient and vacuum conditions with at least 2000 ON/OFF cycles.

#### **3.1.2. Shelf life:**

The IDCA shall be capable of meeting all the functional requirements after various stages of storage and assembly as follows:

- 4 years in controlled environmental conditions.
- 3 years storage at various levels of assembly and operation (subsequently).

Vendor shall specify the exact method of storage for the IDCA; as well as the recommended criteria for their retest, in case of long duration storage. Vendor shall also specify the nature and extent of degradation and its impact on reliable performance of the detector when storage time exceeds 4 years.

### **3.2 Environmental Conditions:**

IDCA shall be capable of withstanding the following environmental conditions:

#### **3.2.1. Storage and Non-operating Environment:**

- |  |                                 |
|--|---------------------------------|
| a) Temperature                               | -40°C to +70°C                  |
| b) Vacuum                                    | Ambient to 10E-6 torr or better |
| c) Relative Humidity (during ground storage) | 50 ±5 % RH @ 22±3°C             |

#### **3.2.2. Operating Environment:**

- |                                       |                                  |
|---------------------------------------|----------------------------------|
| a) Temperature                        | -40 °C to +70°C                  |
| b) Vacuum                             | Ambient to 10E-10 torr or better |
| c) Relative Humidity (during Lab use) | 50 ±5 % RH @ 22±3°C              |

Vendor shall specify typical IDCA/cooler skin temperature required to be maintained during operation to achieve electro-optical performance specified in Table-2.2.

### 3.3 Vibration / Shock:

IDCA design and fabrication shall be such that it should be capable of withstanding following vibration and shock levels.

Acceptance test levels (100% IDCA screening) are -3dB below qualification test level and given in Table. 3-1A/B.

Notching requirement, if any shall be brought out by vendor and shall be applicable as per mutual agreement.

#### 3.3.1. Random Vibration:

Random vibration in three mutually perpendicular axes during 2 minutes per axis, with the following random profile equivalent to 12.2 g RMS:

- Between 20Hz and 100Hz: linear from 0.014 g<sup>2</sup>/Hz to 0.095 g<sup>2</sup>/Hz
- Between 100Hz and 350Hz: constant 0.095 g<sup>2</sup>/Hz
- Between 350Hz and 380Hz: linear from 0.095 g<sup>2</sup>/Hz to 0.12 g<sup>2</sup>/Hz
- Between 380Hz and 1000Hz: constant 0.12 g<sup>2</sup>/Hz
- Between 1000Hz and 2000Hz: linear from 0.12 g<sup>2</sup>/Hz to 0.01 g<sup>2</sup>/Hz

#### 3.3.2. Sine Vibration:

Sine vibration in three mutually perpendicular axes at a rate of 2 octave/minute. The sine vibration spectrum is:

- Between 5Hz to 20Hz : linear from 2.5 g to 15 g
- Between 20Hz to 100Hz : constant 15 g peak

#### 3.3.3. Mechanical Shock:

Mechanical shocks in each of the three mutually perpendicular axes with the following levels:

- ½ sine, 10g +/- 1g, 12ms, with 10 shocks per axis per direction.
- ½ sine, 100g +/- 10g, 3ms, with 3 shocks per axis per direction.

### 3.4 Parts and Materials:

Parts, materials and processes used in the IDCA shall be selected with low outgassing characteristics and with suitable surface finish ensuring minimum deterioration and maximum stability. Only non-magnetic materials shall be used for parts, except where magnetic materials are essential.

All materials shall have a Total Mass Loss (TML) of less than 1% and Collectable Volatile Condensable Materials (CVCM) of less than 0.1% when subjected to test conducted at +125°C and  $1 \times 10^{-6}$  torr for 24 hours.

In case the manufacturing process of IDCA includes special materials such as elastomers, grease, heavy metals, electrical components and soldering; the assembly process shall include suitable special baking procedure from outgassing consideration.

### **3.5 Marking and Identification:**

It is desirable that each delivered IDCA shall be marked with

- Part name/ Number.
- Date code or batch of Manufacture
- Pin-out identification and Indicator for Sensitivity to ESD

### **3.6 Packaging, Storage & Transportation:**

- (i) Each IDCA shall be packaged in order to protect the device against ESD, electrical, mechanical and environmental damage.
- (ii) Wherever required, the individual packages for the IDCAs and/ or transportation container shall be with nitrogen purging or vacuum sealing, to prevent contamination and corrosion.
- (iii) Packaging material should not be cause for corrosion on gold plating of the device body and leads.
- (iv) The shipping documentation shall be enclosed in the shipping package.

In addition to other mandatory shipping marking, the following additional marking shall appear on the shipping package in bold letters.

**“FRAGILE- HANDLE WITH CARE”**

**“ESD SENSITIVE”**

**“TO BE OPENED UNDER CLEAN ENVIRONMENT WITH ESD PROTECTION  
ONLY IN PRESENCE OF ISRO AUTHORIZED PERSONNEL”**

**“STORE IN A COOL AND DRY PLACE”**

### 3.7 Screening and Electro optical (EO) Acceptance Test Plan:

#### 3.7.1. Screening Tests:

In order to screen out manufacturing defects in production line, each IDCA shall be subjected to screening tests as given in Table – 3.1A & B below before final electro-optical acceptance tests given in Table-2.2 and section-3.7.3. The results of all tests and KIPs should be reviewed by supplier's internal QA and shall be a part of final screening report. SAC may also witness any of the KIPs at supplier's facility.

**Table - 3.1A IDCA Screening Tests (Before Cooler Mounting)**

S.N.	TEST	CONDITION	REMARKS
1	EO tests on IRFPA	As per Vendor's specifications	100%
2	1 <sup>st</sup> Key Inspection	Note-1	100%
3	Destructive Bond Pull Test	On specific bonding pads	100%
4	Fine Leak Test	Leak Rate < 1.10-8 atm.cc/s He	100%

**Table - 3.1B IDCA Screening Tests (After Cooler Mounting)**

S.N.	TEST	CONDITION	REMARKS
1	Visual Inspection	As per Vendor's specifications	100%
2	Random Vibration	8.6g RMS, 2 minutes per axis (-3dB of qual. Level § 3.3.1)	100%
3	Environmental Thermal Cycling	-40°C;+70°C 5 cycles / 2 hours (< 5°C/min)	100%
4	2 <sup>nd</sup> Key Inspection	Note-2	100%
5	Cooler Leak Test	As per Supplier's specifications	100%
6	Electrical Continuity Check	As per Supplier's specifications	100%
7	E-O Acceptance Tests	As per Table – 2.2 and Section 3.7.3	100%
8	3 <sup>rd</sup> Key Inspection	Note-2	100%

**Note-1:** In order to select the good quality of IRFPA for assembly, manufacturer shall confirm the cosmetic quality of IRFPA (w.r.t. visual inspection defects database) after selection of die based on E-O test.

**Note-2:** Manufacturer's internal QA shall ensure the integrity of the IDCA after environmental tests (vibrations, thermal cycling) and before packaging & delivery of the device.

Vendor shall generate a “screening traceability log” listing the details of tests conducted, quantity In / Out and date of each step. Vendor shall perform failure analysis on catastrophic failures, if any.

### **3.7.2. Additional Screening Tests:**

In order to have more confidence on quality and reliability of the supplied screened IDCAs, vendor shall perform following additional screening tests (as per Table-3.2 below) on one of the deliverable MWIR IDCAs without failure.

**Table - 3.2 Additional Screening Tests at IDCA Level (After Cooler Mounting)**

<b>S.N.</b>	<b>Test</b>	<b>Condition</b>	<b>Remarks</b>
1	Sine Vibration	As per spec given in Section-3.3	After Step-1 of Table-3.1B
2	Random Vibration	As per spec given in Section-3.3	Replaces Step-2 of Table-3.1B
3	Mechanical Shock	As per spec given in Section-3.3	After Step-2 of Table-3.1B
4	Pre Burn-in E-O measurement	As per suppliers specification	After Step-6 of Table-3.1B
5	Burn-in	240 hours at +70°C	Before Step-7 of Table-3.1B
6	Pre to Post Burn-in Drift calculation	Drift criteria to be mutually agreed upon.	After Step-7 of Table-3.1B

### **3.7.3. Electro-optical Acceptance Tests:**

Each deliverable IDCA shall undergo final Electro-optical acceptance tests under standard test operating conditions specified in Table-2.1 before delivery to SAC. All the parameters specified in Table-2.2 shall be measured and reported in IDCA Acceptance Test Report (ATR).

In addition to parameters specified in Table-2.2, typical value of following sensor array and ROIC parameters shall also be provided along with the delivery of IDCA:

- ✓ Average pixel responsivity
- ✓ Quantum efficiency as a function of wavelength
- ✓ Photo response non-uniformity
- ✓ ROIC conversion gain
- ✓ ROIC readout noise
- ✓ ROIC power dissipation at maximum operating frequency
- ✓ ROIC output impedance and video drive capability
- ✓ Analog video settling time

- ✓ Recommended operating conditions, absolute maximum / minimum on all electrical inputs
- ✓ Maximum input supply line rms-noise and bandwidth.

## **Section-4 Documents Required**

**4.1.** Following information shall be provided as a minimum to SAC along with the proposal:

- Point to point compliance and actual value offered for all the parameters / requirements specified in sections-2 and 3.
- IDCA technical datasheet giving general description of the IDCA along with optical, electrical, mechanical and thermal interface details including mounting / heat removal provisions and vibration isolation.
- Facilities available for realization.
- IDCA assembly sequence.
- Any industrial/aerospace/space heritage of the proposed IDCA and/or its parts.

**4.2.** Following information shall be provided within 1 month of order placement:

- IDCA technical datasheet giving description of IDCA components, IDCA optical, electrical, mechanical and thermal interfaces, typical values of IDCA parameters (specified in Table-2.2 and section-3.7.3)
- Detector ROIC electrical interface control document
- Cooler electrical interface document
- Detector command and control electronics electrical interface document
- Cooler drive electronics electrical interface document
- IDCA optical, mechanical and thermal interfaces in the form of engineering reports, drawings etc.
- IDCA envelop in STEP format
- IDCA test procedure

**4.3.** Following information shall be provided along with the delivery of each IDCA:

- Screening report.
- Electro-optical Acceptance test report.
- Inspection report of mechanical and optical interfaces including Certificate of Conformance.
- IDCA handling, operating and storage procedure.

## Section-5 Deliverables and Delivery Schedule

Quotation shall be provided for screened vacuum compatible MWIR IDCAs meeting the requirements given in section-2 and 3 for the following deliverables with delivery schedule. SAC reserves the right to finalize the quantities before ordering.

S.No.	Deliverables	Quantity	Delivery Schedule
1.	Vacuum compatible MWIR IDCAs	6 nos.	T0 + 24 months
2.	Additional Screening Tests on one MWIR IDCA with Screening Report (as per section-3.7.2)	1 no.	T0 + 24 months
3.	External Command and Control Electronics (C&CE) along with flex-rigid PCB and interconnecting harness for operating MWIR IDCA detector	1 set	T0 + 15 months
4.	External Cooler Drive Electronics (CDE) along with interconnecting harness for operating MWIR IDCA cryocooler	1 set	T0 + 15 months

T0 – Date of order placement or availability of export license, whichever is later

As mentioned in the table, vendor shall quote for one lab model Command and Control Electronics (C&CE) and one lab model Cooler Drive Electronics (CDE), both external to the IDCA, for operating and testing the IDCA under lab conditions. Vendor shall also provide at least one set of all the cables, harnesses, flexi-PCB, connectors etc. required to interface C&CE and CDE with IDCA and data acquisition system / frame grabber.

## Section-6 General Terms and Conditions

1. The external Command and Control Electronics (C&CE) and Cooler Drive Electronics (CDE) shall be compatible with the detector and cryocooler of the offered MWIR IDCA.
2. Purchase order will be placed on only single vendor supplying all the items mentioned in section-5.
3. Partial shipment of items is acceptable. However, total delivery period for each item shall not exceed the delivery schedule of the item defined in section-5.
4. Payment term shall be on pro-rata basis i.e. as per supplied quantity.
5. Warranty: Standard 12 months warranty after delivery at SAC.