Essential Details of Items/Services Required

1. **Schedule of Requirements:** List of items / services required are as follows –

Name/Description of Item(s)/Service(s)	Unit of Measure	Qty required
Software Development for Intelligence Exploitation system (IES)	Services	01

2. **Technical Details:**

2.1 SOW: Software Development for Intelligence Exploitation system (IES)

Abbreviations & Acronyms

SE - System Engineering
CABS - Centre for Airborne Systems
DRDO - Defence Research and Development Organisation
PO - Project Office
PM - Project Management
PD - Project Director
GoI - Government of India
ISR - Intelligence, surveillance and Reconnaissance
TD - Technology Demonstration
IAF - Indian Air Force
IPR - Intellectual Property Right
EMI - Electro Magnetic Interference
EMC - Electro Magnetic Compatibility
TED - Tender Enquiry Document
LRU - Line Replaceable Unit
CSCI - Computer System Configuration Item
HWCI - Hardware Configuration Item
CMMI - Capability Maturity Model Integration
SYSML - Systems Modeling Language
UML - Unified Modeling Language
TCEC - Techno-Commercial Evaluation Committee
IPR - Intellectual Property Rights
EMI - Electromagnetic Interference
EMC - Electromagnetic Compatibility
HMI - Human Machine Interface
SDD - System Design Document
ICD - Interface Control Document
LD - Liquidated Damages
RFP - Request for Proposal
ISO - International Organization for Standards
IEC - International Electro-Technical Commission
DPSU - Defence Public Sector Undertaking
MISRA - Motor Industry Software Reliability Association

2.1.1. Introduction

CABS proposes to execute a software development contract for 06 work packages for the ISR project, with an Indian Industry, meeting the industry partner qualification criteria brought out in this document. This tender is to engage a suitable industry partner who has already developed software with the GIS and image processing functionalities such as Image Enhancement, Pan Sharpening, Change Detection, Anomaly Detection and material mapping, Mosaic, Re-projection of images, Image Registration, Terrain/DEM Analysis tool etc.

There is a need to adapt this software to the ISR architecture and develop the software work packages of ISR using this software. There may be a need to customize the libraries which are already existing to meet ISR objective. CABS shall hold the IPR of the software and libraries/APIs which are developed/customized as part of the ISR project.

Five work packages are required to be developed as follows.

a) **Work Package 1** – Intelligence Exploitation System (IES)
b) **Work Package 2** – Mission Database Management System (MDMS)
c) **Work Package 3** – Mission Planning System (MPS) (as part of IES)
d) **Work Package 4** – Data Augmentation, Creation and labeling of images for training Deep Learning Models (as part of IES)
e) **Work Package 5 -** Documentations, complete integration and testing for all work packages of IES

This document describes the detailed Statement of Work to be carried out by the industry partner selected through the tendering process.

In order to meet the ISR project timeline, there is a crucial need to collaborate with industry partner for development of software work packages by following the Software Engineering principles.

It is proposed to engage a suitable Indian Industry partner with prior experience for software development work package. The development contract is for 18 months.

2.1.2. Purpose

The purpose of this Tender Enquiry Document (TED) is to solicit competitive sealed two-bid proposals from suitable **Indian industry partners** for Software **development for IES & MDMS** for Intelligence, Surveillance and Reconnaissance (ISR) applications at CABS, DRDO.

2.1.3. Architecture

Project architecture will have following components on 10G/01G Dual redundant gigabit Ethernet switch as shown in Figure 1.

a) Exploitation Servers
b) Storage Area Network (SAN)
c) Sensor Simulators
d) IEWS Console

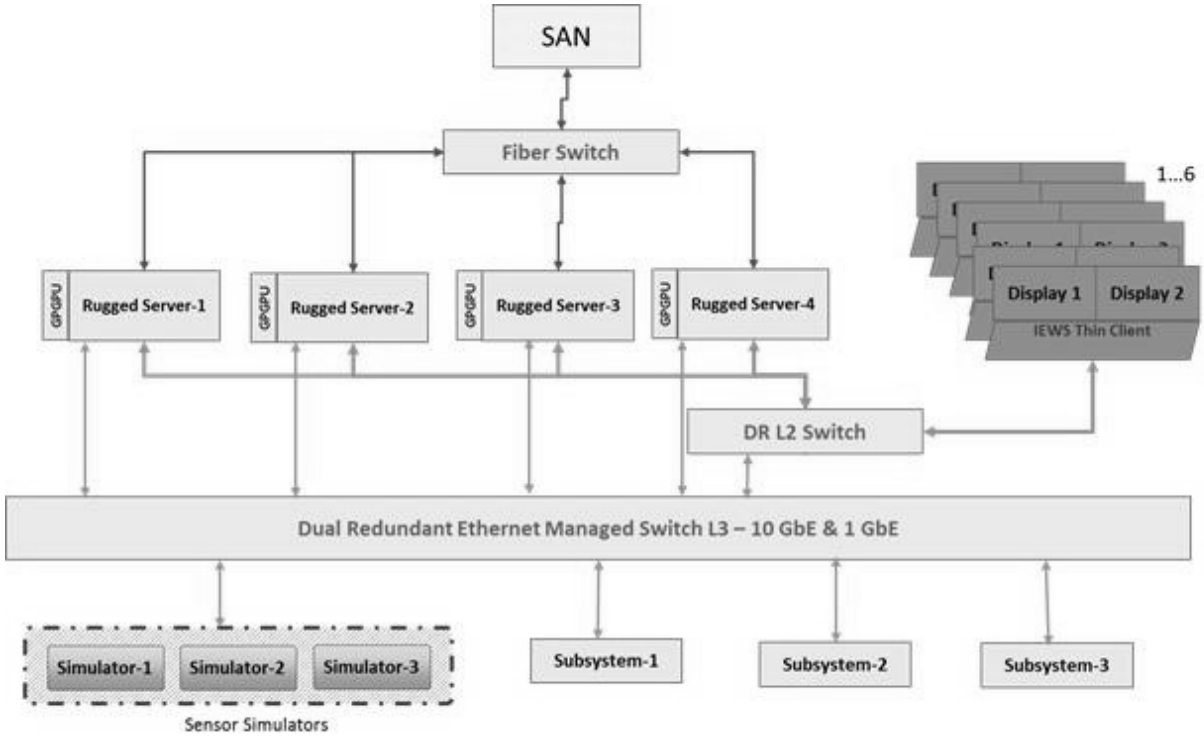

Figure 1: ISR Architecture

Mission software are proposed to be hosted on virtual machine (VM) on four number of rugged server using bare-metal hypervisor. These applications need to be hosted in clusters, with fault tolerance and high availability. Load balancing also plays a vital role in processing and for utilization of optimal bandwidth. Virtualization of compute, storage and network can deliver mission critical experience.

2.1.3.1. Exploitation Servers

Exploitation Servers as a hardware configuration item (HWCI) is a high end server and having high end processing. Four number server with same configuration are employed. These servers are configured with bare metal hypervisor and different virtual machines for IES, MDMS and IEWS are employed for fault tolerance and high availability.

VMs are employed with clustering onto the servers to achieve high availability. Watchdog are also employed to check the fault on each VMs. On occurrence of fault, same VM from same/other server boots up and load balancer routes all the communication with this VM.

Hardware shall be provided to Industry partner for development of these applications and it is not a part of this contract.

Following are the VMs envisaged on sever.

a) IES
b) MDMS
c) IEWS
d) Mission Controller

Figure 2: Applications deployed on Hypervisor

2.1.3.2. Software Load Balancer

The software load balancer takes the incoming requests from IEWS and assign to the particular IES based on policy.

2.1.3.3. Storage Area Network (SAN)

SAN is used for common storage for storing various images coming from the SAR, EO/IR sensor. The storage unit has removable media for transferring pre and post mission data from ground. The VMs manages all the data on the SAN.

2.1.3.4. Sensor Simulator

The Synthetic Aperture Radar (SAR) Simulator shall simulate a SAR based airborne radar. It generates SAR images of the scene. The Ground moving Target indicator (GMTI) simulate moving track on ground and generates. EO/IR sensor simulate the EO/IR sensor and provide simulated images for exploitation.

2.1.3.5. IEWS

IEWS is six number of dual display console with Virtual Display Infrastructure (VDI) implementation on servers. The IEWS applications for ISR are deployed as virtual instance on the server side to ensure east-west network traffic with IES for image processing, Fault tolerant, High Availability and are given as virtual desktops to IEWS users over a separate L2 switch.

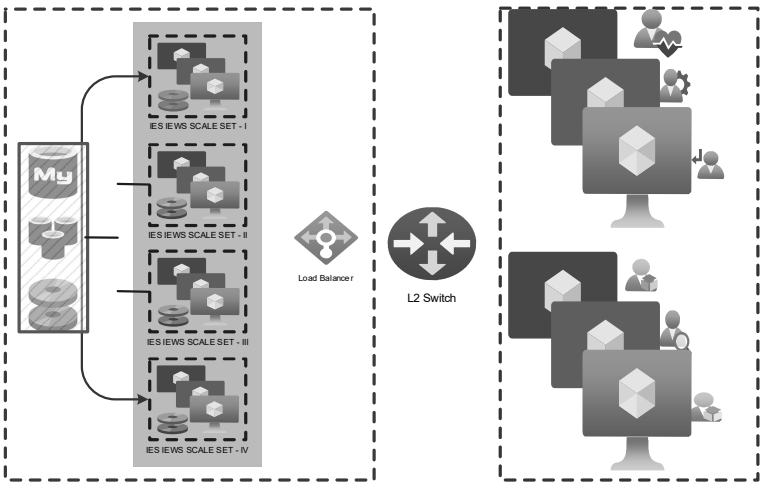

Figure 3: Mission Suite Architecture depicting converged storage, Databases, virtualization, load balancing and VDI

2.2. Technical Specification

2.2.1. Work Package for software development

Table 1: Work Package 1, 2, 3, 4 & 5

Work Package 1, 2, 3, 4 & 5		
S. No.	**Activity**	**Expected Outcome / Deliverables**
a.	Project Planning	Software Development Plan (SDP) with detail GANT Chart.
b.	Requirement Management as per automatic IBM SE tools.	Software Requirement Specification Document (SRS)
c.	Software Detailed Design	Software Design Document (SDD)
		Interface Requirement Specification (IRS)
d.	Software Verification	Software Verification Plan(SVP)
		Software Test Plan (STP)
		Software Test Description (STD)
		Software Unit Test Report (UTR)
		Software Requirement Based Testing-Software Test Report (STR)
e.	Risk assessment and mitigation	Risk Management Document
f.	Perform software version management and configuration management	Software Configuration Management Plan(SCMP) Document
g.	Preparation of other document	User Manual
		Installation Manual
		Problem Reports
		Software Quality Assurance Plan (SQAP)
		Plan for Software aspects of Certification(PSAC)
		Hardware-Software Integration Test (HSIT) Documents
		Software-Software Integration Test (SSIT) Document
		Reliability, Availability and Maintainability Plan Document
h.	Tasks related to software certification	Memory Usage Report Unit Test Report etc.
i.	Traceability between requirements at System level, subsystem and LRU level, up to test plan and test reports.	System and Subsystem level Traceability report
j.	Preparation of the Software development framework/environment for software development.	Availability of Software development environment/framework

Work Package 1, 2, 3, 4 & 5		
S. No.	**Activity**	**Expected Outcome / Deliverables**
k.	The industry partner shall do the coding and implementation for IES, MDMS and Mission Planning.	Source Code with appropriate comments, logical grouping of modules
l.	The industry partner shall do the integration for IES, IEWS, MDMS and Mission Planning module with other subsystem at test rig.	Integrated Software
m.	The industry partner shall carry out Simulations/Computations/Analysis of algorithms and generate reports based on the requirement provided by CABS team.	Documents having simulation result/Analysis results
n.	The brief description of the functionalities has been provided here. The details will be provided after SO is placed during requirement capturing phase (SRS Stage). Finalized SRS document would be used as basis for further development. Industry partner shall be willing to develop additional functionalities if required in due course of time period to meet the project objectives.	
o.	Development agency is required to submit source code of each modules/functionalities developed/customized specifically for CABS during this project along with relevant documentation and basis of development of the modules.	
	The Industry partner shall use the latest/stable version of library/software component/ database to develop the application.	
	The Developed code/module should be reusable in nature. If any change is required in the function it should be done with the source code easily.	
p.	The Industry Partner shall develop these applications using GPGPU programming wherever required.	
q.	IES shall include following features:	• The software shall have facility to generate target folder during and post mission. • The software shall provide capability to perform analysis of the Mission data. • The software shall provide miss-distance using collected imagery. • The software shall provide target co-ordinate computation using collected imagery. • The software shall support standard exploitation file formats and conversions.

Work Package 1, 2, 3, 4 & 5		
S. No.	**Activity**	**Expected Outcome / Deliverables**
		(For example TIFF, GeoTIFF, BigTIFF, NITF, BigGeoTIFF, JFIF (JPEG), DTED etc) • Provide dual fault tolerance capability to handle failure of system. • The software shall provide image pyramid generation method using preferably gpgpu. • The software shall provide Time synchronization. • The software shall provide Health Monitoring. • The software shall provide System State management of subsystems. • The software shall have best Data logging mechanism to log the data to debug the system. • The Industry Partner shall develop the software based on the architecture defined by CABS project team. It is envisaged to use virtualization technique, VDI, load balancer, database cluster and application cluster to achieve the solution with fault tolerance and high availability. • The software shall have a separate module to manage the various System State and health monitoring.
The following functionalities are required to implement by the industry partner.		
	Change Detection	
r.	• Design and Implementation of change detection methods for detection of changes between two bi-temporal images/shape/chart of the same area. • These bi-temporal images could be multispectral EO/IR images (with Red, Blue, Green, NIR, SWIR, and MWIR bands) or Synthetic Aperture Radar (SAR) images and could be of different spectral resolution captured from same/different sensors.	Change Detection feature: • Change detection to the common area of the given bi-temporal images • Incorporate mis-registration error to some extent in change detection method • Incorporate spatial filters to filter out the change detection result based on area, elongation, compactness etc. • Incorporate normalization of one image with respect to other image. • Provide tools to remove unwanted changes to the operator such that cloud. • Provide method to remove the change based on material (vegetation/non-vegetation/water/shadow etc.) • Provide interactive threshold to the operator for magnitude difference method • Industry partner shall perform survey for freely available data with respect to EO/IR and SAR and test the methods on these data to meet the objective. • Industry partner shall implement different change detection methods for SAR and EO/IR imagery such as ✓ Unsupervised change detection ➢ Image Differencing ➢ Image regression ➢ Image rationing ➢ Change vector analysis ➢ PCA, EM, clustering ➢ Vegetation change etc. ✓ Supervised change detection (AI based Methods) • Industry partner shall simulate the multiple methods and submit the detail report on the result with the CABS project team. • Prepare technical report/document for different method algorithms • Implement Change detection methods for SAR ✓ Coherence change detection ✓ E-Z Coherence Change ✓ Time Series CCD ✓ Mosaic Series CCD ✓ Displacement Mapping ✓ Time series displacement Service ✓ Radar Incoherence etc.

Work Package 1, 2, 3, 4 & 5		
S. No.	**Activity**	**Expected Outcome / Deliverables**
		• Industry partner shall provide UI to visualize an area (using multiple images of same area)over a time period as timelapse and also accommodate change detection for same area. • Industry partner shall willing to implement any best suitable method for change detection in due course of software development timeline. • Support for Visual Change detection with Swipe/Blend/Flicker option
s.	Classification	**Unsupervised Classification includes:** • ISODATA • Band ratio calculation using NDVI • Implement many indices like (Vegetation indices, mineral indices, water indices, soil indices etc.) • Perform Geophysical calculation • Image Segmentation • FLS lambda schedule segmentation • RGB clustering • Grouping Tool to label classes and clusters **Supervised Classification includes:** • Signature Editor to collect training examples • Mapping all other pixel into class value
	Automatic Target Detection (ATD)	
t.	Design and Implementation of Automatic Target Detection from Imagery data obtained from the SAR and EO/IR images. Target of interest could be aircraft, vehicle, building, runway, tank, missile launcher etc.	ATR features: • Perform Target detection based on Area of Interest (AOI) defined by User. • Record the detected classes of target, bounding boxes, confidence scores and their count as metadata into database for further reference. • Perform basic query like no. of object detected in defined area with class etc. • Filter the detected object based on various criteria like confidence score, class name, object shape, AOI (Area of interest) etc. • Industry partner shall implement the Deep learning model for detection of target (For Eg. Yolo (v3, v5), RCNN, F-RCNN, ORCNN, HOG, SSD, SPP etc.). Industry partner shall implement the Deep learning model for semantic segmentation such as U-Net or other best suitable algorithm). • A default model will be adopted during this implementation, However the user should also be facilitated with the choice of algorithm. • Design and Implementation of Anomaly detection using EO/IR and SAR imagery. Identify the camouflaged military installations and equipment of enemy forces by digital image processing of Multispectral satellite data.
	Automatic Target Recognition	
u.	Design and Implementation of Automatic Target Recognition from Imagery data obtained from the SAR and EO/IR. Target of interest should be type of aircraft, type of vehicle, type of tank, type of ship etc. For Example, Sukhoi-27, Mig-29, Tejas Mk-1 for aircraft (i.e. type of	• Perform Automatic Target Recognition on detected Target. • Record the recognized target into database for further reference. • Industry partner shall implement the Deep learning model for detection of recognition (For Eg. Alex Net, VGG, ResNet, Xception Inception, ResNeXt, Efficient Net and any other hybrid network or other best suitable algorithm). • A default model will be adopted during this implementation, However the user should also be facilitated with the choice of algorithm .

Work Package 1, 2, 3, 4 & 5		
S. No.	**Activity**	**Expected Outcome / Deliverables**
	aircraft), not like only aircraft.	
v.	**Common Operating Picture** (Design and Implementation of Common operating picture functionality)	• The software shall use IMINT (SAR, GMTI, EO/IR images) and SIGINT (electronic and communication intelligence) information and provide integrated situation awareness. • The software shall present geo-coded images received from sensor such as SAR, EO/IR (Multispectral and Hyperspectral) on geographic base map. • The software shall maintain a catalogue of all the images with metadata from the present mission and archives from previous missions and other sources in compatible formats. • The software shall present the selected images/vector layer from the catalogue on the base map as foot prints and images. • The software shall allow the operator to define an area of interest for performing search query on imagery in catalogue corresponding to the area of interest. • A default model/method will be adopted during this implementation, However the user should also be facilitated with the choice of algorithm. • This module shall able to fuse the data from the various sensors which capture different target characteristics, to generate an informative common operating picture with high resolution, that tries to capture all the relevant features from the various sensors into a single fused image.
w.	**WP - 2: Mission Database Management System (MDMS)** (Design and Implementation of Database Module)	1 Industry partner shall design and implement database for the mission suite of project ISR for saving the record of mission planning, user data, operation data etc. 2 The Industry partner shall design and implement the database such that it can handle the sensor raw data, the previous sortie data, satellite data, other data from repository and processed data. 3 The Industry partner shall design and implement the database such that it can process raw image and record its metadata in database and update the database if any changes/transaction is done on by the user. 4 The Industry partner shall implement the database such that it can manage database for mission plan data. Mission Planning data includes pre-flight messages (PFM) data required for different subsystem, tactical data item (TDI) (fixed point, area, flight plan etc.) and previous flight path way point based on mission objective. 5 The Industry partner shall design and implement the database such that it can facilitate the operator to search and access the data using metadata describing sensor, location, time of collection and related artefact detail about data collected by system sensor suite. 6 The Industry partner shall design and implement the database such that it can facilitate operator to create and update on-board mission planning. 7 The Industry partner shall design and implement the database such that it can facilitate uploading and downloading of Mission Data before and after the flight sortie. 8 The Industry partner shall design and implement the database such that it can record transaction detail like ATR, ATD, CD, COP etc. for further reference. 9 The Industry partner shall design and implement the database such that it can handle requirement of access control user access to the application, record user activity in database etc. 10 Management of meta-data catalog for all intelligence product and artifacts under management. 11 The industry partner shall implement the synchronization of database between all airborne segment of multiple ISR platform with ground segments

Work Package 1, 2, 3, 4 & 5		
S. No.	**Activity**	**Expected Outcome / Deliverables**
		12 The industry partner will host common database across all running instances of IES, IEWS & MIMAS. 13 The database itself shall be hosted in redundant mode for reliable 24X7 operations. 14 The industry partner shall implement database will fault tolerance capability.
x.	**Wp-3: Mission Planning System (MPS)** (Design and Implementation of Mission Planning System (MPS))	• An optimal flight plan and scheduling the sensor (EO/IR and SAR) are required to meet the mission objectives effectively. The industry partner shall implement an intelligent planner to achieve this by maximizing the coverage, coverage rate with minimum revisits to the regions based on the platform constraints and terrain data. • The industry partner shall implement the mission planner that can take account of various restrictions (restricted airspace, altitude constraints and detectability) in the search region. • The industry partner shall implement Optimal mission planner which takes operator input such that resolution, area, lat-long etc. and gives various mode of operation (WFOV, NFOV) and mode of collecting image (point, line, area, stereo) for the EO/IR sensor. • The industry partner shall implement mission planner which takes operator input such that resolution, area and lat-long and shall suggest the mode of operation (W-strip, Q-strip, Spot-I, Spot-II, Spot-III etc.) and generate the flight plan (waypoint altitude, leg speed, ground distance from AOI etc.). • The Industry Partner shall implement MPS for creation of Mission data and loading into different subsystems. • The Industry partner shall develop the application for mission data transfer from ground and airborne segment. • Data flow control at application level for the data transfer between airborne segment to ground segment through datalink.
y.	**WP-4: Data Augmentation, Creation and labeling of images for training Deep Learning Models**	**Labeling: -** • The Industry partner shall Label images with predefined class of label and create label csv file for image classification problem • The Industry partner shall Create/update bounding box csv file for the object detection problem in an image for predefined class of object • The Industry partner shall Label images with image caption and generate caption CVS file for image captioning problems. **Data Augmentation: -** • The Industry partner shall enrich dataset by using different augmentation algorithm. Like if dataset contain 100 images then increase it to 1000, 10000, so on. • The Industry partner shall provide function of image augmentation algorithm for using this augmentation algorithm in model training on fly. • The Industry partner shall maintain and create/update ground truth/label/bounding box csv file while performing augmentation as per augmentation algorithm.
aa	**Wp-5: Complete integration, testing and Documentations**	The Industry Partner shall perform 1. Preparation of Software Test Plan (STP) 2. Testing of each software module and generate report for example a. Memory Usage Report b. Unit Test Report etc. 3. Preparation of Software Test Report and Description 4. Integration of Software modules (IES, MDMS, IEWS, MIMAS, sensor simulator and other subsystem) at Rig for integration and testing facility for various builds. 5. Generation of document as per CEMILAC/ IEEE 12207.

Work Package 1, 2, 3, 4 & 5		
S. No.	**Activity**	**Expected Outcome / Deliverables**
		6. Generation of documents as mentioned in list of deliverables.
bb	The industry partner shall provide continuous support for updates in the framework & defined for the project.	
cc	The industry partner's experts shall carry out the development through a defined workflow implementation using IBM tools.	
dd	The industry partner shall complete all the activities adhering to the schedules mutually decided as part of the development.	
ee	The potential industry partners shall present their solution to the SoW during the Pre-Bid meeting.	