# Supply and installation of real time control and data acquisition system and integration with a LabVIEW based DAQ software for NCCRD Microgravity Drop Facility

A data acquisition and control system for experiment module is to be provided and integrated with already existing LabVIEW (2018 version) based operating for the microgravity drop facility of IIT Madras. The experiments are conducted in drop capsules which are dropped from a 38 m drop tower. The controlling of the experiments and the drop sequence are done from the first floor laboratory. A wireless communication system is already arranged to facilitate the control operations of the capsule till the drop and a separate shock resistant wireless system is required on the falling capsule for controlling the experiment parameters, recording the data, storing it onboard as well as transmitting the data to the remote computer at the ground station. The requirements with a detailed description with necessary diagrams are provided in the sections below. The scope of the vendor will be in the development of 2 sets of capsule control system, which involves hardware development using controller chassis and data acquisition modules with necessary electrical arrangements for using several sensors. The control system shall be powered separately by a battery-UPS system. Relevant modification/upgrade of existing software are to be made ensuring complete backward compatibility with existing system. All the components should be able to withstand at least 30 g shock. The vendors are advised to thoroughly go through the document and discuss with the concerned to have a better understanding of the requirement.

## 1. Microgravity Drop Tower

A short description of the experimental facility is as follows. Microgravity drop towers are facilities that allow experiments to be setup in a state of free fall for a short duration. The experiments are conducted in cylindrical enclosures called capsules which are dropped from a 38 m drop tower and the drop sequences are controlled from the first floor laboratory. Each drop capsule consists of an inner and an outer capsule. The inner capsule, 60 cm diameter and around 130 cm tall, houses the experiment chamber and support instrumentation. The inner capsule is housed inside the outer capsule, 80 cm diameter and 2.5 m tall, which acts as an aerodynamic shield during the fall of the capsule. The data acquisition system is located inside the inner capsule. **THERE IS NO PHYSICAL CONNECTION BETWEEN THE INNER CAPSULE AND THE OUTER CAPSULE DURING THE DROP**. Finally the falling capsule is recovered safely by decelerating it using a deflating airbag system.

Experiment data is obtained from the drop capsule using onboard data acquisition system. This data has to be transferred to the user computer at the ground station (first floor level laboratory). A real time data telemetry unit should be used, that can withstand high shock loads. The images and videos from the high-g camera is stored onboard and transmitted to the ground station. The tele-command line has to be kept alive during the drop experiment with basic commands that can be routed to individual controls within the experiment. For releasing the drop capsule, a separate telemetry unit is already set up. For preventing any accidental release, a safety mechanism is also implemented. The data acquisition from the experiment module has to be synchronized with the operations of the release mechanism and the safety mechanism. These units are permanently fixed to the hoisting platform and hence will not be under free fall during the experiment.

## 2. Communication System

A combination of wired and wireless communication system is used to facilitate the control operations of the capsule till the drop, setting parameters inside the experiment chamber, recording the data, storing it onboard as well as transmitting the data to the host computer at the ground station. The whole unit is split into ***four major modules*** – Ground station module (**GROUND**), Release module (**REL**), Safety latch module (**SAF**) and experiment module (**EXP**) as can be understood from figure no. 1. The EXP module consists of the capsule control system, which forms the control manager for various operations within the inner capsule. The GROUND station communicates with the Capsule Control System (CCS) through electrical signals sent via wired networks and radio signals through Wi-Fi modems.

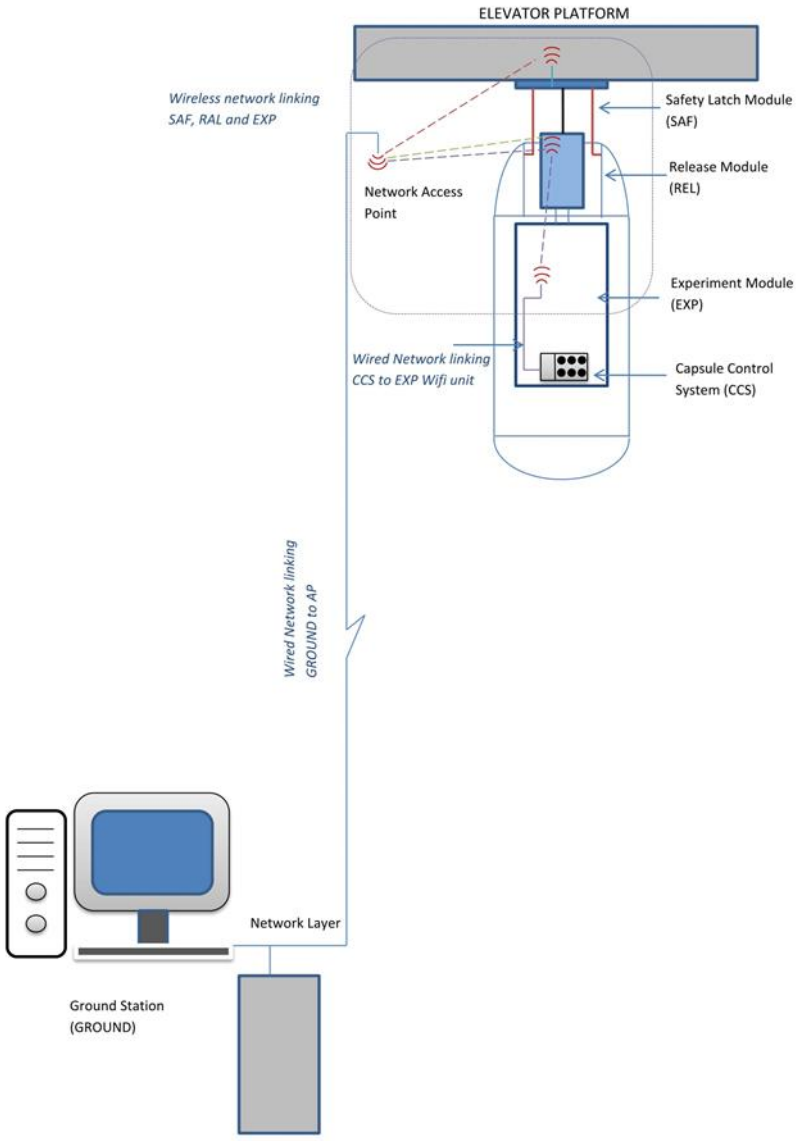


*Figure 1: Schematic of the drop tower communication system*

## 3. System Requirements

### a. Necessary hardware units

The micro-gravity facility at NCCRD, IITM has an operational experimental capsule operated by a LabVIEW based software. The requirement is for two add on capsule control units (hardware + relevant software upgrade). Precisely, the vendor has to procure the components for the capsule control system (controller chassis and DAQs), a wifi unit to establish communication with the existing router, power supply ( battery-ups system), necessary electrical accessories for power management for different sensors and other equipments and integrate them in the inner capsule. Some of the sensors are already arranged and certain items that has to be procured are listed separately. The components to be purchased has to match the shock rating requirements and space constraint in the capsule deck. Above all, compatibility with the existing software has to be ensured. However, the onboard controller chassis, DAQs and sensors can be upgraded versions with better features and relevant modifications to the software ensuring backward compatibility with the existing capsule unit. The software should be completely compatible with all capsule units (existing and new). In any case, the functionality of the existing capsules shall remain unaffected.

**Details of necessary units**:

| **Sl. No:** | **Units (Items 1-9 has to be procured by the vendor)** | **Quantity** | **Specifications/Descriptions** |
|---|---|---|---|
| **Controller Chassis** | | | |
| 1 | Compact RIO control chassis | 2 | NI 9057 or better |
| **DAQ Modules in the order of preference** (specification listed is minimum requirement, can be better) | | | |
| | | | |
| 2 | Analog input for voltage pressure transducer | 2 | NI 9220 or better |
| 3 | Thermocouple module | 2 | NI 9213 or better |
| 4 | Analog Output module | 2 | NI 9264 or better |
| 5 | 16 Ch DI/DO module | 2 | NI 9375 or better |
| 6 | Digital I/O module , 5 V TTL | 2 | NI 9401 or better |
| 7 | Accelerometer module | 2 | NI 9234 or better |
| | | | |
| | **Sensors** | | |
| | | | |
| 8 | Laser Distance Sensor | 2 | Analog Output 0 – 10 V, 500 mm sensing range 12 – 30 VDC operation, high g shock rating |
| | | | |
| **Power Supply** | | | |
| | | | |
| 9 | Battery-UPS for experiment module | 2 | 24V DC,12 Ah, Dimensions less than 202x202x110mm |
| | | | |
| **Existing sensors/ equipments used per capsule are given below** (these are listed for a general understanding of items used inside the drop capsule) | | | |

| | | | |
|---|---|---|---|
| 10 | Mass Flow Controller | 3 | Specifications will be shared later |
| 11 | Thermocouples | 8 | 8 nos. S type |
| 12 | Heat flux sensor | 1 | Specifications will be shared later |
| 13 | Radiometer | 1 | Specifications will be shared later |
| 14 | Pressure transducer | 1 | Piezo resistive current transducer |
| 15 | Pressure transducer | 1 | Strain gauge based transducer |
| | **Camera** | | |
| 16 | High g Camera | 1 | IDT NX3S4 |
| 17 | IR camera-surveillance type | 1 | Operating voltage -12 V |
| | **Other components** | | |
| 18 | DC fan and regulator | 1 | 12 V |
| 19 | Nichrome heater coil | 2 | 24 V, 7-8 A |
| 20 | LED Lights | 1 | 12 V |
| | **Access Point** | | |
| 21 | Wireless Access Point | 1 | MOXA AWK 4131A |
| | **Host PC (Computer)** | | |
| 22 | System Specifications | 1 each | HP Z230 Tower Workstation, Processor – Intel(R) Xeon(R) CPU E3-1226 v3@ 3.30 GHz, 16384 MB RAM, NVIDIA Quadro K620, OS – Windows 7 Professional 64-bit<br><br>Optiplex 7460 AIO, Processor – Intel (R) Core(TM) i7-8700 CPU @ 3.20 GHz (12 CPUs), 16384 MB RAM, Intel(R) UHD Graphics Family, Windows 10 Pro Education 64-bit |
| | | | |

Note:

- Distribution/terminal locks, switch-battery charge/discharge control, connector for battery-charger and Electrical accessories required for the integration of the specified hardware shall be provided by the vendor. If at any point of installation, items are found to be of inferior quality, it will not be acceptable and will have to be replaced without any additional cost.
- The installation of units shall be rugged. Items like battery, UPS, and other components which may be consumed over time shall be installed in a replaceable manner, without disturbing other components.
- There should be a provision to get the remaining battery life status and check the health condition of the battery periodically.
- Voltage regulation should be proper. It has to be ensured that all components are receiving required input voltage at all operating conditions.
- The vendor is required to provide separate quote for individual DAQ modules. These will be considered optional for purchase along with the proposed tender or may be purchased at a later stage. However the quote has to be submitted along with the tender proposal.

**b. Capsule Control System (CCS) Requirements**

1. The system will carry out the automated execution of the drop sequence during the experiment and perform data acquisition from different sensors.
2. The system will stream data wirelessly from the experiment module to the host PC located in the ground station, where the data will be recorded.
3. The data acquisition and control will be implemented using National Instruments' CompactRIO platform. There will be Analog I/O and Digital I/O modules to interface different subsystems.
4. The system will be powered by a rechargeable battery with suitable regulators. The battery will power the Compact RIO, Sensors, Flow controllers, Fan, Heater circuit, high-speed digital camera and a surveillance type IR camera.
5. Since the experiment duration is less than 3 s, the maximum performance parameters for a short duration operation has to be provided.

A block diagram of the data acquisition in cRIO and overall communication architecture is given in the figure.

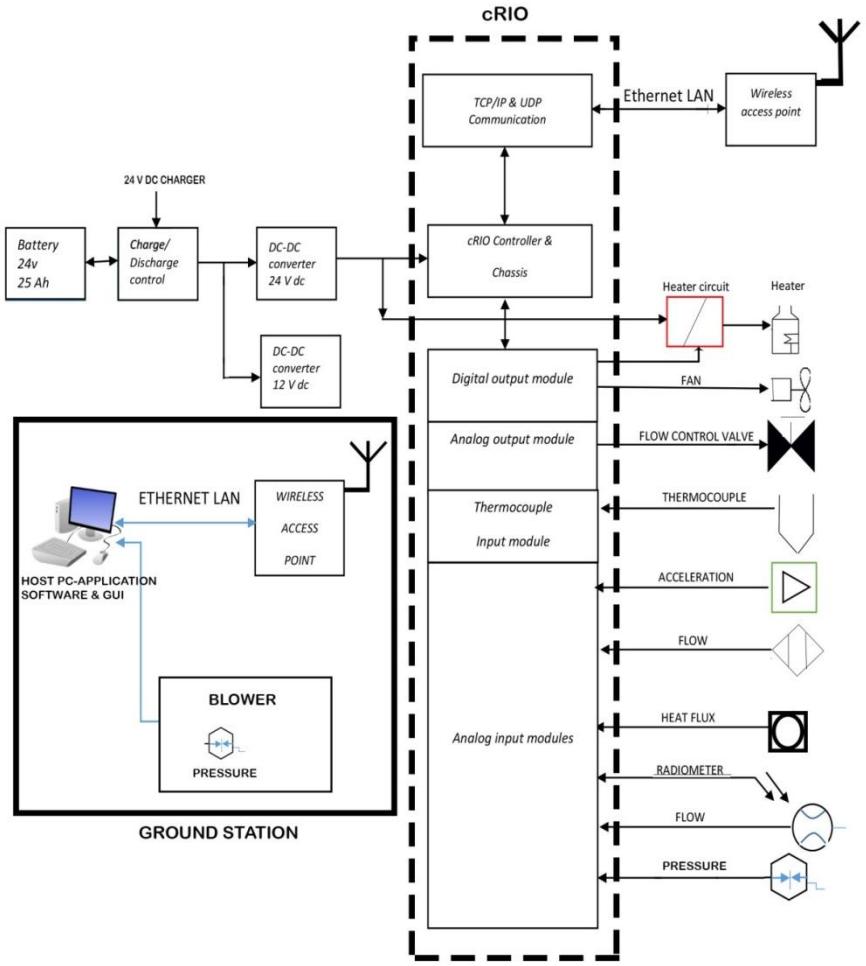


*Figure 2: Block diagram of the Capsule Control System*

### c. Application Software

- The application software provides the GUI for operating the Microgravity tower facility.
- It is used for the control and data acquisition of Release Module, Safety Module and Experiment Module.

**Functionalities:**

- User access control: The application software has features to login and access the system for authorized users.
- System Hardware configuration: The software has a panel to configure the I/O interface modules, depending on the sensors and instruments connected to it. The panel also features calibration options for the channels.
- Modes of Operation: The DAQ software has two modes of operation viz. acquire mode and record mode.
    i. Acquire mode: This is a view data mode [Refer sequence 1 in figure 3]. This preparatory mode allows the user at the ground station to view acquired sensor data and check the configured parameters, define set points and troubleshoot if required.
    ii. Record mode: The activation of the record mode starts with the countdown [Refer sequence 2 in figure 3]. The data logging of the parameters starts immediately after activating the record mode.

- Control Panel: The control panel acts as the HMI during the experiment. User can start, stop and monitor the status of test in this panel.
    i. The control panel has options to start and stop the data acquisition in release module, safety module and experiment module.
    ii. It is possible to set channel specific sampling rate and the number of samples for every sensor.
    iii. The main control panel has an icon, which upon clicking opens a new window allowing calibration of all sensors.
    iv. It has options to control and operate the actuator valves in release module and safety module.
    v. It can acquire and display data from the proximity sensors in the release module and safety module.
    vi. It can acquire and display data from the pressure transducer at the blower end throughout the experiment.
    vii. It can trigger the solenoid coil of the gate valve system.
    viii. The experiment module control panel acquires and displays data from Accelerometer, Thermocouples, Heat flux sensor, Pressure sensor, Flow sensor and Distance Sensor.
    ix. The control module energizes the heater coil through heater circuit and ignites the fuel, at the beginning of the fall.
    x. The flow is maintained at the desired rate, during the experiment.
    xi. The data acquisition and recording is triggered along with the count down. The recorded data is transmitted and stored in the hard disk of the host-PC.

xii. The high g camera images/video are stored onboard the camera and the same is simultaneously sent to the host PC.

- Post Processing Panel: The post processing panel has standard data analysis options, for the recorded data files.

  i. Time domain data display and analysis
  ii. Frequency domain data display and analysis
  iii. Single & Multi Plot Averaging
  iv. Plot Peak-detection
  v. Threshold crossing detection
  vi. Multi plot ratio analysis

Features of generated file

1. Each drop session creates a new folder with new file name. The main folder is recognizable with the drop session date. Separate logging file is recognizable with the session date as well as time.
2. There is an option to export the saved file in excel or notepad.
3. There is a provision to change the default recording format as per the user requirements. The number of channels may increase or decrease with change in experiments. The user has the flexibility to use more channels if required.
4. Only the channels configured for logging is saved. For example if temperature data is not needed for a particular experiment, the data from the channels corresponding to that is not saved.

### d. Drop Sequence

This section explains the sequence in which various operations have to be carried out prior to the release of the drop capsule. Essential electrical connections and safety parameters are to be checked, once the capsule is assembled inside the drop shaft. After the final check, a countdown sequence starts to initialize the drop, in which, the timing clocks need to coordinate tasks between instruments in a way that provide hardware synchronization. User will still have the option to abort the mission if any malfunction is detected. A flow chart is provided for the drop sequence.

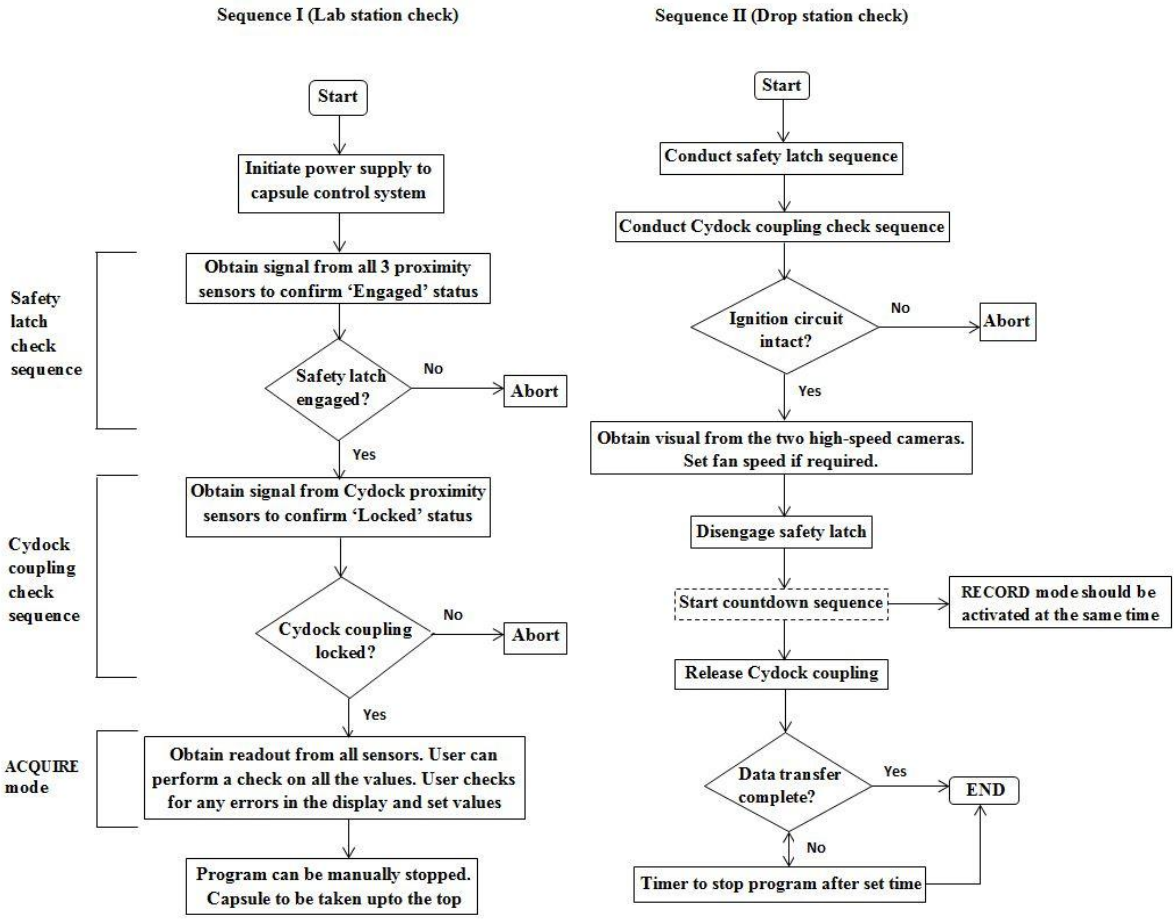


*Figure 3: Flowchart depicting the sequence of operations and checks leading to the drop*

**<u>Eligibility Criteria, General Terms and Conditions</u>:**

1. The present current capsule unit operates on LabVIEW software 2018. Any development on front end and other analysis software should be done using LabVIEW Software 2018 version or above. Backward compatibility with existing capsule unit is to be ensured.

2. Necessary modifications to the software, to migrate to upgraded hardware components shall be done in such a way that the functionality of the existing capsule system remains unaffected or is taken care of. The extent or scope of modification if required shall be discussed prior to the submission of the quote.

3. Software should be designed by the certified LabVIEW architect and developed by certified LabVIEW developer. The bidder must have certified LabVIEW architects and certified LabVIEW developers as full time employees of the company. Certificate shall be enclosed at the time of submission of quote.

4. The bidder must be an authorized system integrator for National Instruments and should have necessary technical expertise in development of similar integrated system using LabVIEW with real time controller and cRIO modules in the past. Authorization letter from National Instruments shall be enclosed at the time of submission of quote.

5. Client list with full address including detail of contact person with phone no. email etc. to whom the similar hardware and related software was supplied in the past 5 years should be provided by the vendor.

6. Total demonstration of the supplied system should be done at purchaser site.

7. Issues related to integration of hardware and all categories of software bugs that may occur within a period of one year from the date of handover must be rectified free of cost.

8. 7 man-days shall be provided for modification of/addition to the delivered software, should the need arise.

9. The bidder should attend the pre-bid meeting on 03/03/2021 at 10 am in NCCRD, IITM and also make a site visit to qualify for submitting the tender. The time and venue of the meeting will be as specified in the tender website.

10. The project should be completed and delivered with necessary testing within a span of 6-10 weeks from the date of purchase order release. The delivery of the product will not be accepted without the hardcopy (and soft copy) of manual for hardware with detailed list of parts with proper numbering, technical drawings for the electrical wiring and troubleshooting. A software user manual (which includes troubleshooting) shall also be provided. Any errors thereafter can be corrected and the same may be submitted after the acceptance of the product.

11. The installation and commissioning of the hardware should be done together with the delivery of the product preferably during single visit.

12. Two weeks of testing period shall be allowed by the vendor before acceptance of completion of work is ratified.

13. A 1 year warranty period shall be provided by the vendor which will be counted from the date of commissioning of the product.

14. The vendor should also mention cost of AMC beyond the warranty period.

15. The tenderer shall meet the all technical specifications for the item that is being bid for. Any additional features in excess of those specifications will be appreciated. The additional features should be mentioned along with the technical description, wherever appropriate.

16. Any instrument/sensor specification provided by the vendor has to be duly confirmed by either attaching a data sheet of the instrument to be procured or the concerned part number along with the make.