# REPORT 4: CLOSURE REPORT

**Work experience of the project, and learnings**

**Milestone 22 April 2025**

| Date | 22-11-2025 | Team No. 25 |
|---|---|---|

| Proposed project title | Bridging the Gap: Automatic Boarding Ramp for Safer Public Transport |
|---|---|

The team (Team leader at top, others in alphabetical order)

| Enrolment no. | Name | Time spent with team ( hrs) | Time spent-Individual work (hrs) |
|---|---|---|---|
| AU25L40001 | DHAIRYA SANATHARA | 18 | 38 |
| AU2440126 | HIRVA VEKARIYA | 18 | 34 |
| AU2440024 | JAHNAVI PATEL | 12 | 6 |
| AU2440069 | SHAANAY KOTHARI | 10 | 5 |
| AU2440238 | TIRTH PATHAR | 14 | 6 |

Status of the project as on *EXPO 22 November 2025* (100 words)

By EXPO Day, our prototype was fully functional and able to extend and retract smoothly using the NEMA23 motor and lead-screw mechanism. The system demonstrated accurate stopping using limit switches, stable ramp movement, and user-friendly push-button control. The ramp successfully bridged the platform-train gap on the model and clearly showcased its benefits for elderly and differently-abled passengers. The overall structure was stable, reliable and safe for demonstration. While not a commercial version, the academic prototype effectively proved the working principle and generated strong interest and positive feedback from students, faculty, and visitors.

Major challenges during manufacturing and testing (3 most important)

| |
|---|
| Making a 3D design. |
| Calibrating limit switches to ensure accurate, repeatable stopping without false triggers and achieving perfect alignment of the lead screw and guide rods to prevent wobbling and friction. |
| Matching motor torque, ramp weight, and driver settings for smooth and stable movement |

Write about the functioning of the team (100 words)

| |
|---|
| TEAM FUNCTIONING: Our team functioning faced significant challenges throughout the project. Out of the full team, only two members were consistently active in designing, fabricating, and testing the prototype. The remaining members contributed minimally or not at all, which created an uneven workload and affected coordination. Most discussions, decisions, and problem-solving were handled by the two active members. Despite the lack of support, we managed to complete the prototype by dividing tasks effectively between ourselves and maintaining regular communication with the Lab Assistant and faculty. The project was completed successfully, but teamwork was not balanced. |
| LEADERSHIP PERFORMANCE: Leadership responsibilities fell mostly on the two technically active members, who handled task planning, lab coordination, mechanism decisions, and timely progress. However, the documentation team supported by completing written work, filling forms, and preparing the Expo material. Despite the uneven split, leadership ensured that both technical and documentation tasks were brought together efficiently by the final deadline. |

Performance acceptance test results (Columns 1 & 2 are to be same as in Report no. 1)

| Test No. | As per specification (Report No. 1) | Actual test result | Compliance level |
|---|---|---|---|
| 1 | Ramp must extend fully within 15-20 seconds | Extended in ~30.5 seconds | Not Really |
| 2 | Ramp should retract smoothly without vibration | Retraction smooth and stable but vibration at some points | Partially |
| 3 | System must auto-stop at both ends using switches | Limit switches worked reliably | Yes |
| 4 | Lead-screw movement must be straight and aligned | Achieved after adjustments | Yes |

Failure report (Please describe three most important failures that helped the design to become better)

| No. | Description of failure | Actions taken to prevent the failure |
|---|---|---|
| 1 | Lead screw misalignment causing jerky motion | Re-aligned guide rods, added support blocks, re-tightened brackets |
| 2 | Limit switches not triggering consistently | Adjusted position, improved wiring insulation, added debounce logic |
| 3 | Arduino Nano cable stopped working during testing, causing upload failures and delays. | Used a replacement cable, tested continuity, and ensured stable power delivery to avoid future failures. |
| 4 | Poor group involvement and almost zero communication, causing delays and extra workload for two members. | The two active members restructured the workflow, divided tasks internally, and proceeded independently to keep progress on track. |

Major failures that each of you experienced; and how you overcame them (or could not) ("*fight*") (3 most important)

| No. | Description of challenge and actions taken to overcome |
|---|---|
| 1 | Having full technical workload on two members due to lack of involvement from most teammates, Managing repeated design failures without group support and trying to maintain communication, but receiving minimal response or participation |
| 2 | Difficulty in wiring the limit switches — solved by redoing connections properly, labelling wires, and using grounding. |
| 3 | Mechanical Alignment and Stability Issues and Electronic Integration & Calibration Problems |

Write five most important learnings from the project as a team. (100 words)

As a team, the most important learning was understanding the value of responsibility and participation in a project. In reality, the technical work — including ideation, prototyping, fabrication, electronics integration, and testing — was carried out almost entirely by two members. Through this, we gained strong mechanical, electrical, and problem-solving skills, along with the ability to learn quickly through repeated failures. We also understood the importance of safety systems, practical engineering, and real-world constraints. A key learning was that unequal contribution can create challenges, but commitment and perseverance from even a few members can still drive a project to completion.

**Annexure 4-1 Project in pictures and video**

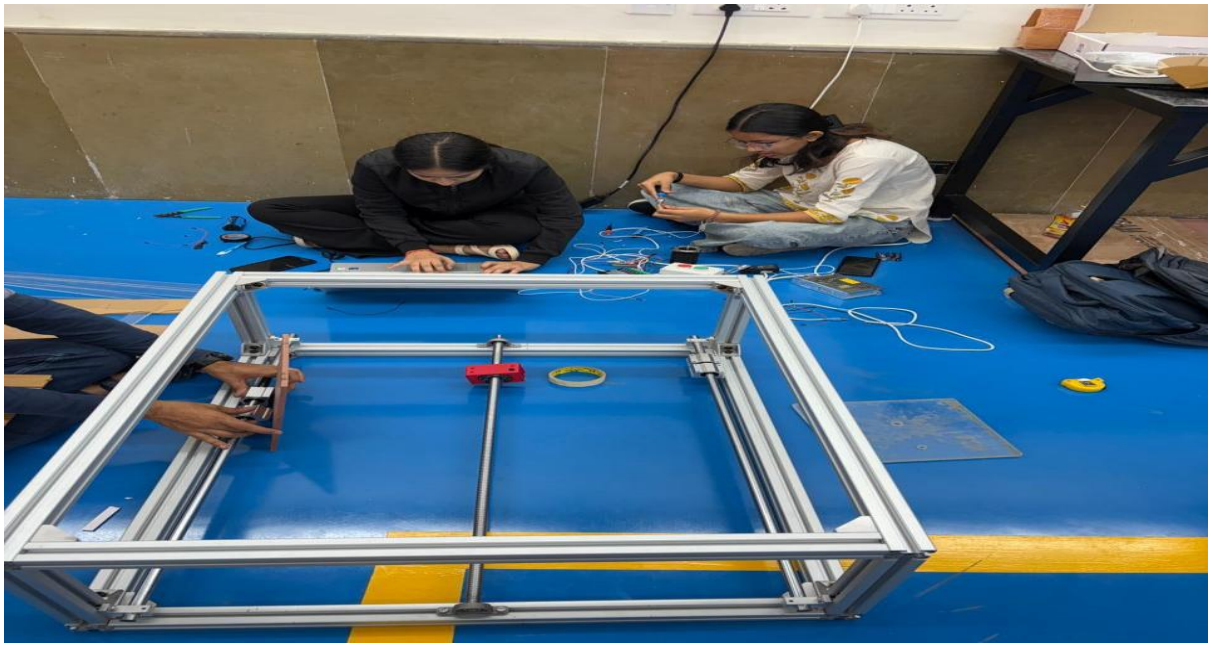
(a) With lots of pictures and a small descriptor for each, give details of the product displayed at the Open House.

(b) Include pictures of team members at various times of project activity.

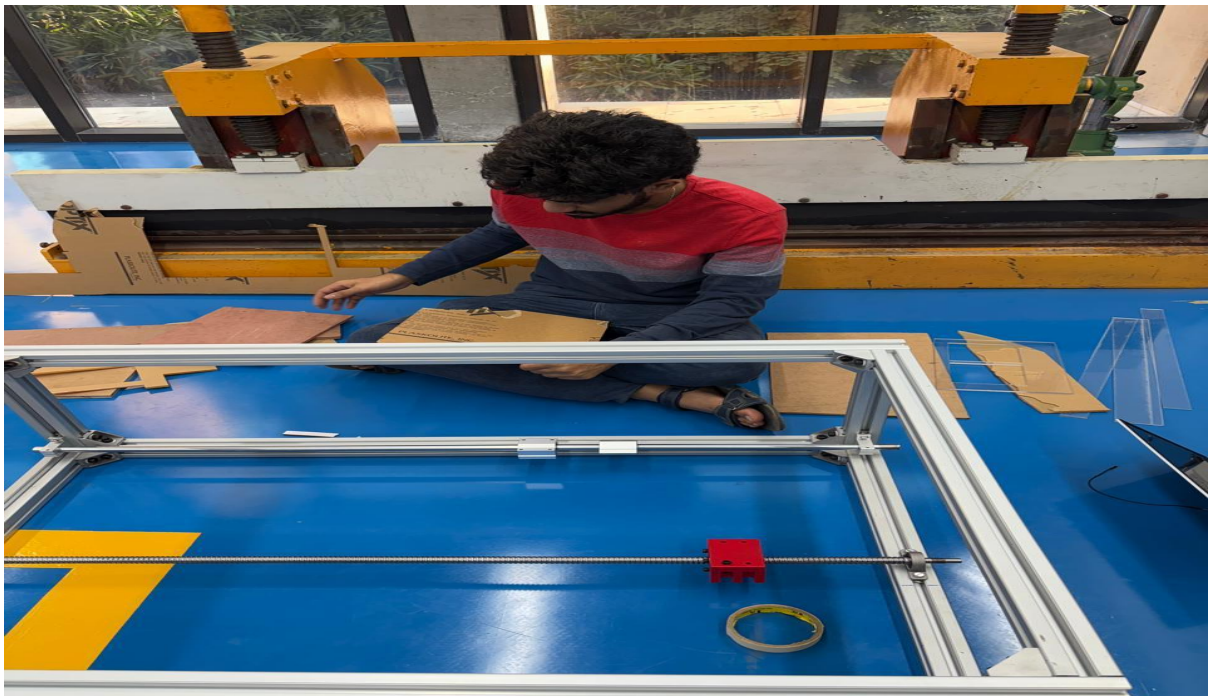
(c) Attach/insert a video clip of 1-2 minutes showing the working of the product. (Add commentary/subtitles).

(b)


*Team member performing precision grinding on metal components using a bench grinder to prepare parts for the ramp mechanism. Safety gloves and goggles were used throughout the operation."*



Team members assembling and wiring the control electronics of the automatic ramp system, including Arduino, limit switches, and motor driver connections."



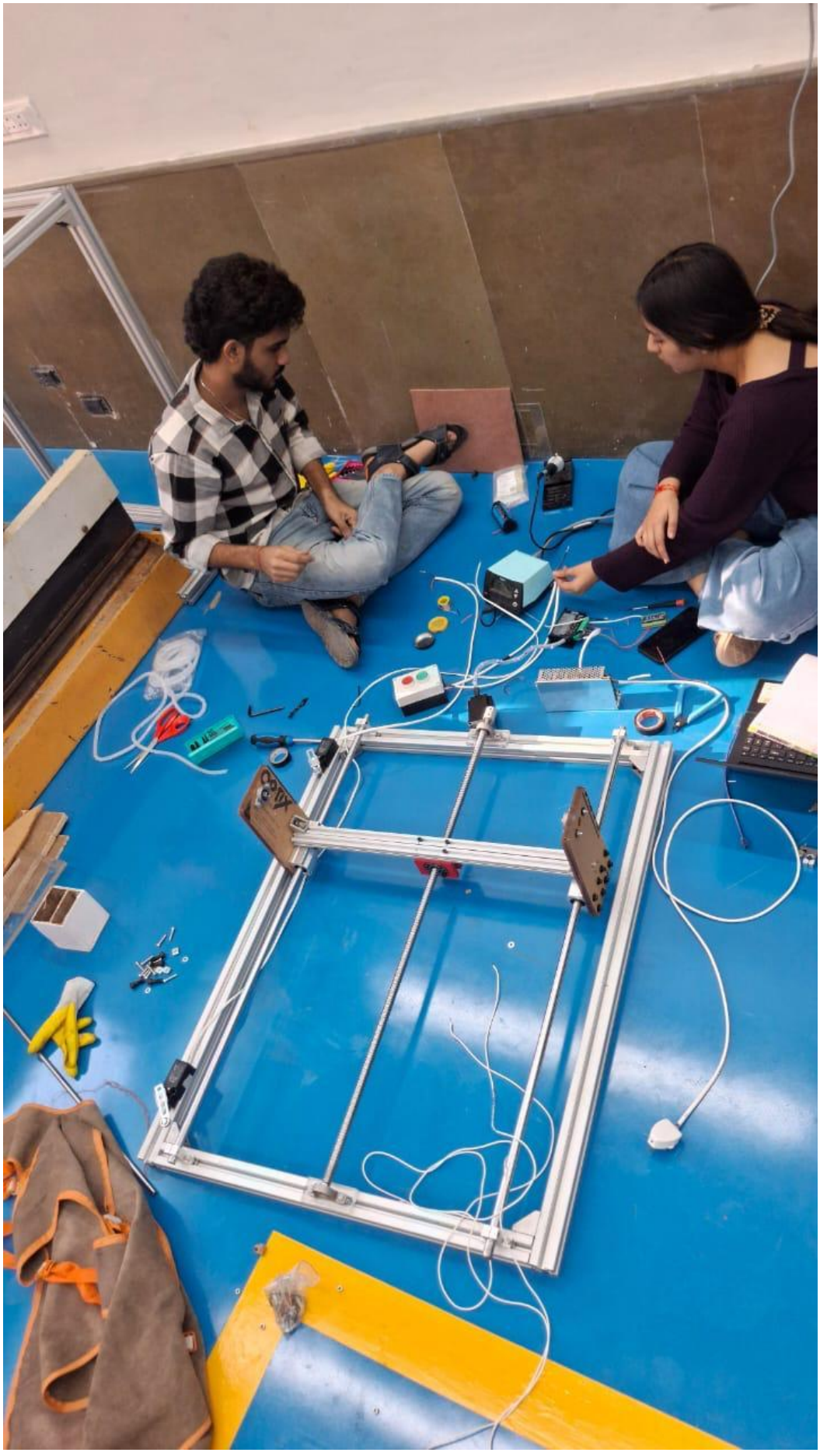
*"A team member marking and preparing wooden prototype parts while aligning them with the aluminum extrusion frame of the ramp mechanism."*

*Team member cutting the steel lead screw to the required length using a Bosch metal-cutting saw, ensuring precise fit for the linear motion system."*

*Team member cutting the steel lead screw to the required length using a Bosch metal-cutting saw, ensuring precise fit for the linear motion system."*

Team members performing final assembly of the ramp mechanism, connecting the stepper motor, leadscrew, control unit, and testing the system layout

(b)



( c) link for the video

automatic ramp system.mp4

Annexure 4-2 DFM, DFA, DFS

(a) List the modifications you made while making the product that facilitated the manufacturing, DFM Design for Manufacturing

(b) List changes you made that overcame assembly/disassembly issues to make the product better; DFA Design for Assembly.

(c) List changes you made based on safety considerations; DFS Design for Safety.

a) DFM - Design for Manufacturing

Modifications were brought in to increase the ease of manufacture, lower costs and increase the speed of production.

- Simplified Mounting of Lead Screw

Rather than using a complicated three part bracket a single L shaped steel bracket was used. This substitution reduced the machining operations, made the drilling easier and thus reduced the overall cost.

- Standardized Bolt Sizes

Only M6 and M8 bolts were used throughout the design. This selection required the fewest changes of tools and allowed for faster assembly time as well as easier sourcing of hardware components.

- Utilization of Readily Available Materials

The ramp and base frame were made out of aluminum and mild steel which are conventionally available materials. As a result of this, special processes were not needed, materials cost was lowered and fabrication at a conventional workshop was simplified.

- Rectangular Ramp Plate in Place of Contoured Shape

The original design had a curved edge which was replaced with a simple rectangular plate. This modification made the cutting and bending work easy and removed the use of CNC machining and accelerated the entire production process.

- Redesigned Motor mount For 2D cutting

The original design called for three-dimensional machining. The last setup was done with a 2D flat laser cut plate and welded support. This was a redesign to reduce cost and fabrication time.

- Limit Switch Brackets Standardised

Instead of custom-formed shaped brackets, standard L-clamping was implemented. Their universal availability made such an alignment easy and replacement was easy.

(b) DFA – Design for Assembly

Changes were made to make it easier, faster and more reliable to assemble and disassemble.

- Modular Subsystems

The system was divided into three modules, the electronics module, the motor plus lead screw module and the ramp module. Each module can be independently assembled, which is better for troubleshooting efficiency.

- Quick-Access Wiring Layout

All types of wiring are run in an external channel as opposed to being run internally through the frame. This approach eliminates the need to open the frame and makes replacement of drivers and switches.

- Plug-and-Play Connectors

Male - female connectors were chosen for motor wires, limit switches and push buttons. Soldering is not necessary during maintenance so assembly and disassembly can be done quite quickly.

- Ramp Attachment without Welding (using Bolted Joint)

The earlier plan had the ramp welded to the carriage. The new plan makes use of bolting, facilitating alignment, making easy replacement of a damaged ramp, as well as eliminating the need for grinding or rewelding.

- Motor Mounting with Slotted Holes

Slotted holes work to provide micro - adjustments of lead - screw alignment, motor pulley alignment. This capability helps to improve the accuracy of the assembly process and reduces the possibility of rework.

- Electronics Secured on a Plate that Can be Removed

An Arduino, TB6600 driver and power supply is put on a single removable plate. The entire plate can be separated with 4 screws and can be serviced quickly and can ensure a clean and safe layout.

(c) DFS – Design for Safety

Modifications were made to enhance user, operator and machine safety.

- Dual Limit Switches Installed

A limit switch is provided at forward and backward ends of ramp. This configuration ensures that over-travel is prevented, and thus the motor, ramp and operators are protected.

- Emergency Stop Button Added

An emergency stop button has been built in. If the ramp moves in an unexpected manner or if it hits an obstruction, the operator can instantly stop operation of the ramp, preventing both injury and mechanical damage to the ramp.

- Diminished Ramp Speed (Software Controlled)

The motor step delay has been changed to provide smooth motion. This modification avoids the jerks to happen suddenly and provides extra security to people near the ramp.

- Aluminum Ramp (Light Weight & Safe Edges)

The ramp is made out of aluminum with chamfered edges so that sharp corners are avoided. This design minimizes the risk of injury and makes handling easier.

- Over current protection for motor driver

Current setting of TB6600 driver has been calibrated below the maximum rating of the Motor. This way, overheating is prevented and fire hazards are mitigated.

- Mechanical End-Stop as Back up

A mechanical end-stop is a secondary safety measure, which actually prevents the carriage from overextending physically, if a limit switch fails.

- Stable Wide Base Frame

The base frame has been widened to increase stability. As a result, the ramp stays stable so that elderly or disabled passengers are always safe.

- Concealed Wiring

Wiring is run in wiring channels, which helps to prevent accidental pulling and to minimise the chances of short circuits.

**Annexure 4-3 Assembly and Disassembly**

(a) Include a detailed illustrated procedure for **assembly of the product**. Do mention precautions that need to be followed (e.g., tightening sequence of nuts/bolts/screws, over- and under-tightening, greasing/oiling, etc.); attach a small video for assembly.

**1. Base Frame Preparation**

1. Cut the MDF baseboard to the required size.
2. Mark drilling points for:
    - Lead screw support blocks
    - Linear guide rod brackets (SK10)
    - Motor mount
    - Ramp mounting slots
3. Open holes with the aid of correct drill bits.
4. Clean the surface to remove dust or leftover cutting particles.

**Precaution:**

- On the markings, make sure that they are straight.
- Make sure not to over tighten screws in MDF because it will crack.

**2. Installation of Linear Guide System.**

1. Install SK10 linear bearing brackets parallel to each other.
2. Insert the guide rod, 10mm chrome-plated, into the brackets.
3. Firmly screw the SK10 in a cross direction.

**Precautions:**

- Make sure that the rods are all parallel; otherwise friction may develop.
- Do not tighten too hard in order not to bend the rod.

**3. Installation of Bearings and Lead Screw Assembly.**

1. Install the KFL000 bearing of pillow block bearings (10mm) at the front.
2. Install the KP001 pillow block bearings (12mm) at the rear to the lead screw.
3. Cross the bearings with the 16 mm ball screw (lead screw).
4. Lock the ball-nut housing onto the ramp mounting plate.

**Precautions:**

- Apply- Use grease/light machine on screw thread.
- Ensure the ball nut moves freely without resistance.
- Bearings should be fixed on a tight even manner so as to eliminate wobble.

**4. Installation Motor and Coupling.**

1. Place the NEMA23 motor on the motor mount.
2. The rigid aluminium coupling (6.35x10mm) is used to connect the motor shaft and the lead screw.
3. Screw the grub screws of the coupling.

**Precaution:**

- Shafts: Shafts should also be ensured to not vibrate and this may happen because the shafts were not aligned.
- Squeeze tight coupling screws (do not strip off threads).

**5. Ramp Installation**

1. Attach the flat ramp plate to the ball-nut mounting bracket.
2. Ensure that the ramp is not lean in nature.
3. Tighten all ramp screws.

**Precautions:**

- Do not overtighten; allow free movement.
- Ensure that ramp is in a center position and does not scratch frame.

**6. Electronics Assembly**

1. The driver, Arduino Nano and 12V SMPS are mounted on the bottom frame as TB6600.
2. Link TB6600 (A +, A−, B +, B 2) to motor wires.
3. Connect limit switches to Arduino input pins.
4. Connect push buttons (extend/retract + emergency stop).
5. Lastly, connect the system to Industrial SMPS (12V 4A) in order to power the system.

**Precautions:**

- Keep a unified point of all relations.
- Keep low-voltage signal wires away from high-current wires.
- Double-check wiring before powering ON.

**7. Testing & Calibration**

1. Power the system.
2. Run the motor at slow speed initially.
3. Test forward ( & extension) movement.
4. Test backward (& retraction) motion.
5. Test limit switches- Test limit switches are triggered manually.
6. Adjust motor speed and distance using code.
7. Perform full extension + full retraction 5–10 times.

**Precautions:**

- Keep hands away from moving ramp during testing.

- Emergency stop button When the unexpected movement occurs, press the emergency stop button immediately.

(b) Include detailed illustrated procedure for **disassembly of the product**. Do mention precautions that need to be followed (e.g. untightening sequence of nuts/bolts/screws, etc.); attach a small video for assembly.

**1. Power Off & Safety Check**

1. Use a strip of piece of aluminum to short the 12V DSM connector to ground.
2. Remove all wiring connections (motor, switches, Arduino).

**Precaution:** Never open electrical parts while powered ON.

**2. Remove the Ramp Plate**

1. Take off the screws that hold the ramp in place.
2. Slide the ramp reclinингly.

**Precaution:**

- Support the ramp while loosening screws to avoid sudden fall.

**3. Remove the Motor & Coupling**

1. Loosen the coupling grub screws.
2. Divide lead screw and motor shaft.
3. Unscrew the motor from its mount.

**Precautions:**

- Avoid bending the coupling.
- Do not pull the motor sideways forcefully.

**4. Take off Lead Screw and Pillow Bearings.**

1. Unscrew KP001 and KFL000 bearings.
2. Slide the lead screw out gently.
3. Take out ball nut housing, when necessary.

**Precautions:**

- To avoid damaging precision threads, be careful not to drop the lead screw.
- Ensure that the screw has a ball nut to hold back ball bearings.

**5. Remove Linear Guide Rod & Brackets**

1. Loosen SK10 brackets.
2. Slide out the chrome rod.
3. Remove SK10 blocks.

**Precaution:**

- Keep rods wrapped in cloth to avoid scratches.

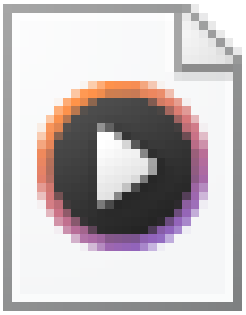
**6. Base Frame Disassembly**

1. Remove screws holding MDF board components.
2. Loose mounts, holders and support plates.

**Precaution:**

- MDF is fragile; avoid overtightening or cracking edges.

**Here is the small video for assembly.**



Video.mp4

**Annexure 4-4 Safety and product liability audit**

(a) Write possible ways in which intended and unintended actions of the user can result in injury.

**a.) Possible User Injuries (Intended & Unintended Use)**

**1. Mechanical Movement Hazards**

- User may stand too close and get their foot/fingers pinched while the ramp extends or retracts.
- If a user steps on the ramp while it is moving, they may slip or lose balance.
- Children may treat the ramp as a toy and get hurt during motion.

**2. Electrical Risks**

- Contact with bare wires or connections can result into slight shocks.
- Spillage of water on the electronics may cause short-circuit risks.
- When it is operating long, the power supply can become heated.

**3. Structural & Load Hazards**

- Bending or instability can occur due to overloading of the ramp (more than a few, or heavy luggage).
- Standing at the ramp edge may lead to imbalance.

**4. Sensor or Motor Failure Risks**

- Limit switch failure can result in over-extension resulting in collision with the platform.
- Blocking of the limit switch by the user with an object can lead to misfunction.
- Minor injuries can be sustained by touching moving parts (lead screw/coupling).

(b) How would you be responsible for this, legally?

**Legal Responsibilities & Liability**

**1. Manufacturer Liability**

You (the designers/ manufacturers) are legally liable in the case that:

- The ramp harms an individual when used normally.
- There is a design defect (e.g. lack of emergency stop) that causes damage.
- The low-quality parts end up collapsing in normal conditions.

**2. Negligence Liability**

You are responsible if:

- Limit switches and warnings are not provided.
- Installing is not done correctly.
- There are no clear instructions on how to use it.

**3. User Misuse (Not Your Liability)**

You are not liable in case injury occurs due to:

- Disregard of the warnings (e.g., stepping in the process of movement)
- Destruction of electronics through deliberate interference.
- Overloading of excessive weight.
- Kids abusing the ramp as a plaything item.

**4. Duty to Warn**

To lower the legal risk, you will have to provide:

- Clear warning labels (“Keep distance”, “Do not stand during motion”)
- Operating instructions
- Safety labelling on the equipment.

**5. Compliance Responsibility**

Before real deployment, the system must pass:

- Railway safety standards
- Electrical safety checks
- Certification of load testing.

Failure to pass these can bring legal problems in spite of the design success.

# Annexure 4-5 User manual

(a) Prepare a one (or two)-page instruction manual for the user on how to use the product; do include nice and clear sketches. Make it in English and in one Indian language.

Here is full guide on how to use our automatic train ramp. The motor attached to this ramp will be directly connected to the main control room of the train where 2 switches will be provided to operate the ramp.one switch is for resume/ emergency off and other one is for backward/forward movement of ramp. Also, this ramp will only be operated by loco pilot (train driver). So, all instructions are given here is for loco pilot.

हमारे ऑटोमैटिक ट्रेन रैंप को इस्तेमाल करने के तरीके के बारे में पूरी गाइड यहाँ दी गई है। इस रैंप से जुड़ी मोटर सीधे ट्रेन के मेन कंट्रोल रूम से कनेक्ट होगी, जहाँ रैंप को ऑपरेट करने के लिए 2 स्विच दिए जाएँगे। एक स्विच रिज्यूम/इमरजेंसी ऑफ के लिए है और दूसरा रैंप को आगे-पीछे करने के लिए है। साथ ही, यह रैंप सिर्फ़ लोको पायलट (ट्रेन ड्राइवर) ही ऑपरेट करेगा। इसलिए, यहाँ दिए गए सभी इंस्ट्रक्शन लोको पायलट के लिए हैं।

When the engine will stop

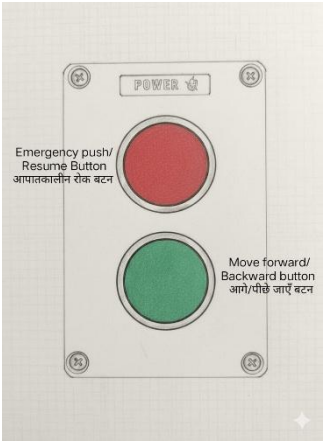
## इंजन जब बंद होगा

You will see **two switches** on the control panel:

आपको कंट्रोल पैनल पर दो स्विच दिखाई देंगे:

i.) Red switch - लाल स्विच

ii.) Green switch - हरा स्विच



Normal Operation

## सामान्य संचालन

Step – 1 > Extend the ramp (Forward movement)

रैंप को आगे बढ़ाएं

Press and release **green button** one time to move ramp forward.

रैंप को आगे बढ़ाने के लिए हरे बटन को एक बार दबाएं।

Step – 2 > Retract the ramp (backward movement)

रैंप को पीछे की ओर ले जाएं

when all passengers get on the train press and release green button once again so ramp will be move backward.

जब सभी यात्री ट्रेन में चढ़ जाएं तो एक बार फिर हरा बटन दबाएं, इससे रैंप पीछे की ओर चला जाएगा।

## Emergency case

## आपातकालीन मामला

If in case of emergency you need to stop ramp in between backward/forward motion then press and release **RED button** once so it will stop ramp. And then press and release **RED button** again so it will resume ramp motion.

अगर इमरजेंसी में आपको रैंप को पीछे/आगे की गति के बीच में रोकना हो, तो लाल बटन को एक बार दबाकर छोड़ दें, इससे रैंप रुक जाएगा। और फिर लाल बटन को दोबारा दबाकर छोड़ दें, इससे रैंप फिर से शुरू हो जाएगा।

**Annexure 4-6 Repair/Service manual**

(a) Give step-by-step instructions for troubleshooting for the user. Arrange in a two-column format Problem - What to do. Give in English and in one Indian language.

(b) Provide programming codes/software manuals if your project involves programming and software implementation.

a.)

| Sr. No | Problem | What to Do (Step-by-Step Instructions) |
|---|---|---|
| 1 | Ramp not moving at all | • Check all wires are connected to the TB6600 and Arduino<br>• Check the green button is working<br>• Check if the SMPS power supply is turned ON |
| 2 | Motor vibrates but does not rotate | • Tighten all screw terminals on the TB6600<br>• Increase the pulse delay (if pulse delay less than 15 micro second) |
| 3 | Ramp moves only in one direction | • Check the direction pin wiring from Arduino to TB6600<br>• Ensure direction logic is correct<br>• Check the direction switch input pin on Arduino |
| 4 | Motor gets too hot | • Reduce current setting on TB6600<br>• Ensure the motor is not overloaded or stuck |
| 5 | TB6600 driver not responding | • Confirm proper 12v input to driver<br>• Check IN, DIR, PUL pins connection<br>• Replace driver if burning smell or visible damage is present. |
| 6 | Emergency pause not working | • Check red button wiring<br>• Test by temporarily shorting the emergency stop it |
| | | |

b.) We used Arduino nano for simulation. We uploaded following code in it.

```
const int dirPin = 2;
const int pulsePin = 3;

int pbuttonPin = 6;// connect output to push button
int LEDPin = 9;// Connected to relay (LED)

int val = 0; // push value from pin 2
int lightON = 0;//light status
int pushed = 0;//push status

// Limit switches
const int limitF = 7;   // forward limit switch
const int limitB = 4;   // backward limit switch

// Full Step settings
const long pulsesPerRev = 1000;
int pulseDelay = 15;

char command = 'R';   // default STOP

void setup() {

  pinMode(pbuttonPin, INPUT_PULLUP);
 pinMode(LEDPin, OUTPUT);
 digitalWrite(LEDPin, HIGH);// keep the load OFF at the begining. If you wanted to be ON, change the HIGH to LOW


 pinMode(dirPin, OUTPUT);
```

```
 pinMode(pulsePin, OUTPUT);

 pinMode(limitF, INPUT_PULLUP);   // uses internal pull-up
 pinMode(limitB, INPUT_PULLUP);

 Serial.begin(9600);
 Serial.println("Enter F = Forward, R = Reverse, S = Stop");

 digitalWrite(dirPin, LOW);
}

void loop() {
//-----------------------------------------------------------------------------------------------------
 val = digitalRead(pbuttonPin);// read the push button value

 if(val == HIGH && lightON == LOW){
  Serial.println("BUTTON PRESSED
1111111111111111111111111111111111111111111111111111111111111111");









   pushed = 1-pushed;
   delay(100);
 }

 lightON = val;
```

```
    if(pushed == HIGH){
      command = 'F';
      Serial.println("Light ON");
      digitalWrite(LEDPin, LOW);

    }else{
      command = 'R';
      Serial.println("Light OFF");
      digitalWrite(LEDPin, HIGH);

    }

//-------------------------------------------------------------------------------------

 // Serial Input
 if (Serial.available() > 0) {
  command = Serial.read();
  command = toupper(command);
 }

 // Read limit switches (LOW = pressed)
 bool forwardLimit = (digitalRead(limitF) == LOW);
 bool backwardLimit = (digitalRead(limitB) == LOW);

 // ----- LIMIT SWITCH LOGIC -----
 if (forwardLimit && command == 'F') {
  Serial.println("FORWARD LIMIT HIT! STOPPING.");
  command = 'S';
 }
```

```
if (backwardLimit && command == 'R') {
  Serial.println("BACKWARD LIMIT HIT! STOPPING.");
  command = 'S';
}

// ----- STOP -----
if (command == 'S') {
  return;  // Stop motor immediately
}

// ----- SET DIRECTION -----
if (command == 'F') {
  digitalWrite(dirPin, LOW);
}
else if (command == 'R') {
  digitalWrite(dirPin, HIGH);
}

// ----- RUN MOTOR -----
for (long i = 0; i < pulsesPerRev; i++) {

  // Read limit again inside loop
  forwardLimit = (digitalRead(limitF) == LOW);
  backwardLimit = (digitalRead(limitB) == LOW);

  // Stop if limit triggered mid-motion
  if ((command == 'F' && forwardLimit) ||
      (command == 'R' && backwardLimit)) {
```

```
      Serial.println("LIMIT TRIGGERED DURING MOTION! STOPPING.");
      command = 'S';
      break;
    }

    if (command == 'S') break;

    digitalWrite(pulsePin, HIGH);
    delayMicroseconds(pulseDelay);
    digitalWrite(pulsePin, LOW);
    delayMicroseconds(pulseDelay);
  }
}
```

**Annexure 4-7 Happy and frustrating part**

1) Each team member should write happy times/happy parts of the project activities.
   1) Dhairya Sanathara :-
      - Gained a completely new and hands-on experience.
      - Had fun with assembling different parts and seeing everything finally come together.
      - Felt happy when the final 3D design got ready with the help of Vrushab sir.
      - Enjoyed solving a real-world issue through our project
      - Overall, the practical learning was the best part

   2) Hirva Vekariya :-
      - Felt great applying what we have learned to a real-life working model.
      - Loved working with electronics specially making the ramp move using motor control.
      - Successfully fixing the limit switches and adjusting speed control felt rewarding.
      - Enjoyed working with the teammates who were genuinely willing to work.

   3) Jahnavi Patel :-
      - The happiest part was when the electric parts finally started working after many errors.
      - Initially didn't expect the system to work, so watching it works successfully was a big achievement.
      - Felt rewarding when the prototype started giving respond.

   4) Shaanay Kothari :-
      - Felt happy with machining, measuring and making the ramp work.
      - Liked assembling the structure and working of the physical structure.
      - Loved finalizing the mechanism that actually works.
   5) Tirth Pathar :-
      - Brainstorming was best part of this project.
      - Contributing to a project that solves the real-world problem was meaningful.
      - Felt satisfied when everything started aligning with what we have thought.
      - Bringing the parts of the project from the shop was fun.

2) Each team member should write frustrating times/frustrating parts of project activities.

   1) Dhairya Sanathara: -
      - Faced lots of issue because of less coordination and low input of some members.
      - Fixing the cage for ramp and mechanical parts consumed more time then expected.
      - Slowed progress because the Fab shop was not providing material needed on time.
      - Getting confused as different mentor suggested different mechanisms to use.

   2) Hirva Vekariya :-
      - At multiple stages of the project team coordination was very low.

- Fixing the wires was frustrating because many it usually breaks with little movement of whole electronic parts.
- As many mechanisms were being discussed it was difficult to finalize the mechanism and the design.
- Managing the electronica and ensuring that everything is working smoothly was a frustrating part.

3) Jahnavi Patel :-
    - The most frustrating part was that the electronic parts were not working due to some technical issues.
    - The driver repeatedly gave errors, delaying the testing process.
    - One of the limit switches failed, causing confusion and extra work.
    - Troubleshooting took more time than expected.

4) Shaanay Kothari :-
    - Difficulty in aligning the mechanical movement.
    - Time management was the most frustrating.
    - Coming with final design of the project was stressful.
    - Waiting for the components to come and dealing with the last minute issues were difficult.
5) Tirth Pathar:-
    - Sourcing the materials was difficult.
    - Exchanging the default parts which we bought was frustrating.
    - Miscommunication with the members made some work harder than it should be.

**Annexure 4-8 Customer/User Feedback**

(a) Provide details of customer/user feedback in the format below:

| Sl. No. | Customer/User | Questions asked | Customer/User comments |
|---|---|---|---|
| 1 | Anmol (EE) | • Centre of mass<br>• Weight capacity | • More useful<br>• Improve it with a better motor<br>• Add rollers/wheels to reduce belt friction |
| 2 | Rameya Srinivasan (Web) | • Time to climb (waiting)<br>• Inclination & slope calculation<br>• Cost comparison (other mechanisms) | • Shows civic sense |
| 3 | Jwalin | - | • Nice idea<br>• Good execution<br>• Well done |
| 4 | Vanni | - | • This project deserves 5/4<br>• Amazing product<br>• Great effort |
| 5 | Shyam | - | • Good implementation |
| 6 | Vidyut Modi | • Weight<br>• Endurance of structure<br>• Material used for support | • Nice work<br>• Good effort |

**Annexure 4-9 Acknowledgements**

(a) Write a paragraph acknowledging people who helped you in any way in your efforts. Please meet the individual persons and express your gratitude to them.

We express our sincere gratitude to **Prof. Jinraj Joshipura** for his continuous guidance, valuable insights, and encouragement throughout the project. We are deeply thankful to **Vrushabh Zunjorkar Sir (Tinkering Lab TA)** for his exceptional technical support, timely troubleshooting assistance, and for helping us refine our mechanism at every stage. We would also like to thank **Sunil Kale Sir** for arranging essential tools, instruments, and materials whenever required, ensuring that our work never stopped due to resource constraints. Our heartfelt appreciation extends to the **Technical Department staff, Tinkering Lab team, peons, and security personnel** for helping us with physical setup, material handling, and providing a smooth working environment. Lastly, we would like to acknowledge the support of our peers, especially **Kahan Shah** and **Agam Sharma**, who stood by us, assisted whenever needed, and contributed to the collaborative energy behind the project's completion. We are grateful to everyone who helped make this project possible.

**Annexure 4-10 Future trajectory: Next steps** (you may give individual responses)

(a) Would you like to take the product further? If yes, what would you like to achieve?
(b) Would you want to explore patenting the product?
(c) Are you enthused enough to make a start-up on this idea, or any other team's idea?
(d) If you had to do the project all over again how differently would you do it?

**(a) Would you like to take the product further? What would you like to achieve?**

Yes, we strongly wish to take this product forward. Our goal is to develop a **full-scale, robust, and railway-ready version** of the automatic ramp with higher load capacity, stainless-steel construction, improved safety systems, and seamless integration with real train coaches. We aim to refine the mechanism, reduce cost, enhance durability, and create a reliable prototype that can be tested in real station environments. Ultimately, we want to transform this academic prototype into a **market-ready accessibility solution** that improves safety for millions of passengers.

**(b) Would you want to explore patenting the product?**

Yes, we are highly interested in applying for a patent. Our mechanism, safety system, and deployment approach offer unique engineering improvements over existing solutions. Filing a patent would help us secure our intellectual property and protect our design as we move toward commercialization. It also opens opportunities for collaboration with Indian Railways, metro systems, and technology partners.

**(c) Are you enthused enough to make a start-up on this idea?**

Yes, we are genuinely motivated to develop this into a **start-up**. The problem we are solving—platform-train gap safety—is a massive issue in India and many other countries. A start-up would allow us to scale the product, bring in professional engineering support, and build multiple variations (standard, premium, sensor-enabled, fully automatic). With the right mentorship and funding, we believe this concept has strong potential to become a **commercial accessibility and safety product**.

**(d) If you had to do the project all over again, how differently would you do it?**

If we had the chance to redo the project, we would begin with clearer team roles, stronger internal coordination, and more structured planning. We would also start prototyping earlier, run controlled experiments on different mechanisms, and document failures systematically. Technically, we would spend more time on precision alignment, professional fabrication, and designing a stronger frame. With the experience gained, we would aim for a faster build cycle, more accurate testing, and a cleaner final product suitable for real-world trials.