CAIC TROPHY

TECH GC 2025

Track-Switching Mechanism for Hyperloop

HYPERLOOP

Introduction & Motivation

Hyperloop is a revolutionary transport system that combines cutting-edge technology to achieve ultra-high-speed travel with efficiency and minimal energy consumption. Here's how it works:

- **Low-Pressure Environment:** The hyperloop operates in a near-vacuum tube (pressure nearly 600 Pa), significantly reducing air resistance. The pressure inside the tube is much lower than atmospheric pressure, allowing the pod to move at high speeds with minimal energy loss.
- **Magnetic Levitation (Maglev):** Hyperloop pods achieve levitation using magnetic forces. Magnets on the pod interact with F-beams on the track, lifting the pod and eliminating contact-based friction. This magnetic levitation also stabilizes the pod during its motion.
- **Propulsion System:** The central Inverted T-beam serves as a guide rail and interacts with a Linear Induction Motor (LIM) mounted on the pod. This LIM provides the necessary thrust to accelerate and decelerate the pod along the track.
- **High Speed and Efficiency:** By combining reduced air resistance, no rolling friction, and efficient propulsion, hyperloop systems can achieve speeds of up to 1200 km/h in full-scale models. Energy consumption is also optimized compared to traditional modes of transport.
- **Lateral Stability and Guidance**: Electromagnets are used to ensure the pod remains aligned within the tube, providing lateral stability even at high speeds.
- **Safety and Fail-Safes:** The hyperloop design incorporates advanced sensors, feedback systems, and emergency mechanisms to monitor the pod's position and performance, ensuring passenger safety during travel.

Problem Description

Design a track-switching mechanism for hyperloop pods that can:

- Enable a seamless transition between two parallel tracks.
- Function efficiently at high speeds (~200 km/h for scaled-down simulation).
- Be compatible with magnetic levitation or air-cushion systems used for pod levitation

Track System Description

The hyperloop track consists of two F-beams and one inverted T-beam:

- **F-Beams (Levitation):** The pod achieves levitation using magnetic interaction with two parallel F-beams made of ferromagnetic material. These beams support and stabilize the pod's vertical position.

- **Inverted T-Beam (Linear Induction Motor - LIM):** The central Inverted T-beam, made of aluminium, acts as the guide rail and provides propulsion through a Linear Induction Motor (LIM) mounted on the pod.

The track-switching mechanism must account for these components, ensuring that the pod can transition seamlessly between tracks while maintaining levitation and propulsion

Key Requirements

Mechanical Design:

- A CAD model of the mechanism showing how the switch will physically redirect the pod.
- The mechanism should allow for high-speed operation without significant deceleration.
- Distance of levitation to be maintained at 1 cm.

Electrical Integration:

- Design the electrical control system to operate the track-switching (e.g., actuators, sensors).
- The mechanism should prioritise energy efficiency and fail-safes.
- Ensure seamless communication on track switching from operator. [OPTIONAL]

Materials and Scalability:

- Use materials suitable for the hyperloop's low-pressure environment (~600 Pa).
- Describe material choices in the context of weight, strength, and vacuum compatibility.
- Include insights on scalability for full-size hyperloop systems.

Lateral Guidance:

Include considerations for lateral stability and precise guidance, to ensure smooth and controlled track-switching, minimizing disruptions to the pod's trajectory at high speed.

Additional Inputs:

- Describe scalability considerations in the context of full-size hyperloop systems.
- Include explanations for mechanical and electrical aspects of actuation in the report and presentation.

Solution Deliverables:

- Deliver a detailed technical report (10-15 pages) explaining the design, working principles, material choices, and control system.
- **CAD Model:** Teams must create a detailed CAD model of a Hyperloop track switching system, focusing on structural stability, aerodynamics, and feasibility.
- Include a presentation summarising the design and demonstrating its functionality through animations or videos.
- Use MATLAB and Simulink for simulations and control system design. Simulation results can be asked for verification during the evaluation.
- Mention all the additional assumptions considered in the report.

Test Track:

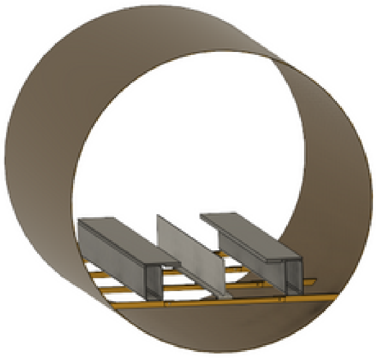

Figure 1: Track in our 422m tube

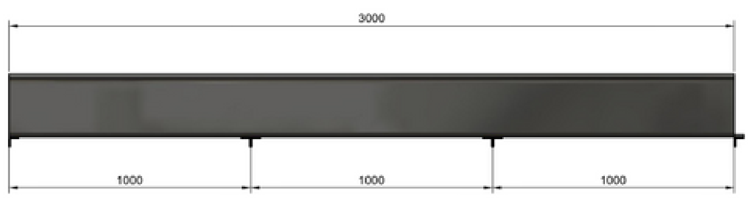

Figure 2: Side view of track (all values in mm)

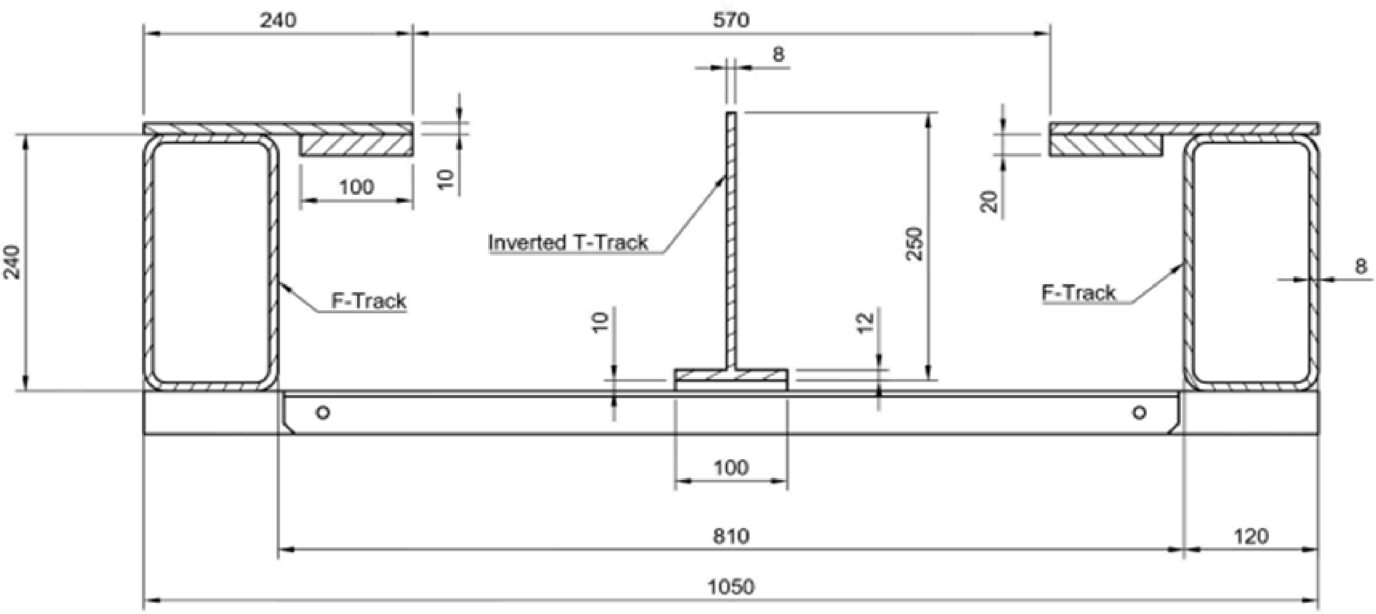

Figure 3: Cross-section of track (all values in mm)

Test Track Specifications

Components	F-Track		Inverted T-Track
Thickness	10mm plate	20mm plate	8mm
Material	Mild Steel (**IS 2062 E250 GR. B)**		Aluminium (**Al6061 T6**)

Dimensions:

- The track consists of 6m sections.
- The levitation track consists of an F-cross section with a 10mm thick top plate connected to a 20mm thick plate (ferromagnetic material) The F-track is bolted to a support block at every 6m.
- The inverted T-track is the propulsion track. The T-track is bolted to a support block or L-plates at every 1m.
- Vertical sections of the F-track are painted along the length with black and white stripes (figure 4) for the encoder to measure the speed of the pod.

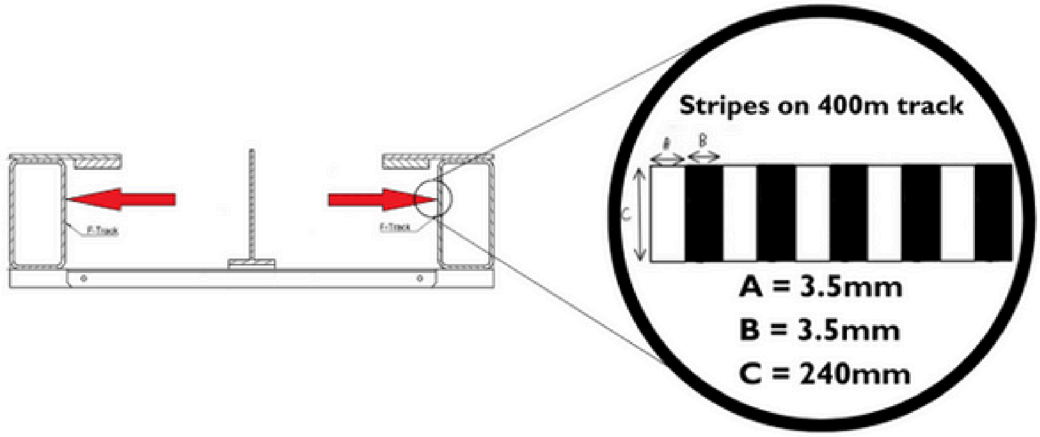

Figure 4: Stripes along the length of the track(red arrow indicates the location)

Vacuum Tube

Dimensions:

- Diamter: 2meter
- Pressure: 1000 Pa
- Maximum payload: 2000 kg
- Material: IS 2062 E250 GR. B

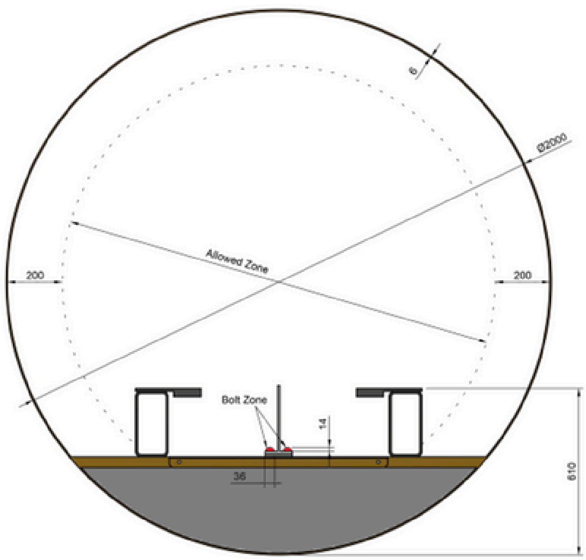

Figure 5: Cross-section of Vacuum tube (all values in mm)

Evaluation Criteria:

Parameter	Description	Weightage
Feasibility and Innovation	Practicality and originality of the design, including innovative approaches to challenges.	20%
Mechanical Design	Robustness, efficiency, and accuracy of the switching mechanism (including CAD models and simulations)	20%
Electrical Systems	Energy efficiency, reliability, and effectiveness of control systems with seamless communication. BONUS points: If system is fail proof	20% BONUS: 10%
Scalability	Viability of scaling the design for real-world hyperloop networks, with proper consideration of materials and cost.	20%
Lateral Guidance	Effectiveness of electromagnets in maintaining lateral stability and alignment during transitions.	10%
Report Quality + Presentation	Technical depth, clarity, and explanation of design principles, including justifications for material and system choices.	10%

Resources

Track and Tube - Click here

Hyperloop Alpha Paper - Click Here

Team Size:

A team of maximum 6 members will be allowed to register

All The Very Best ....!!