



HYPERLOOP DEVELOPMENT COMPETITION SPECIFICATION

2024

Dear Participants,

Hyperloop is a transportation system that is being researched, developed, and prototyped by advanced countries. It is called the 5th generation because it aims to add a different dimension to land, sea, air, and rail transportation. The Hyperloop technology aims to provide transportation on land at supersonic speeds. Companies working at the initial commercial level are conducting research on technological subjects such as magnetic levitation, propulsion, autonomous and connected vehicles, and image processing, which have disruptive effects. With Hyperloop technology, it will be possible to travel distances of 2,000 km within a 2-hour time frame. Enabling the transmission of physical products between different points in such a short time will revolutionize transportation. It will offer a fast, safe, and environmentally friendly option that surpasses the limitations of traditional transportation systems.

As part of TÜBİTAK's vision to achieve its 2053 goals, efforts are being made to work on future transportation technology concepts in our country and increase awareness in these areas. In this context, we aim to enable our country's youth to start working on Next Generation Rail Systems and to be in a position to determine the standards in this field, which have not yet been set. By encouraging our country's young talents to work in this field, we aim to give them opportunities to showcase their visions and abilities. In line with this goal, we will organize the third Hyperloop Development Competition in 2024 as part of TEKNOFEST.

The Hyperloop Development Competition was announced for the first time in January 2022 as part of TEKNOFEST, with the aim of allowing university students in our country to work on next-generation transportation technologies. Within a short period of 7 months, the only infrastructure in the world open for continuous use by university students, with a length of 208 meters, was established at the TÜBİTAK Gebze Campus under the leadership of TÜBİTAK RUTE. The established infrastructure is the second longest development-oriented hyperloop tunnel in the world and also the longest test infrastructure used for this purpose in Europe. By utilizing this infrastructure, our country has taken its first step towards being a guiding force in the emerging hyperloop technology, thanks to the Hyperloop Development Competition held in 2022 under the leadership of TÜBİTAK RUTE, in partnership with TCDD and our private sector companies. In the first year of the competition, teams that achieved great success in levitation and propulsion, communication, and autonomous driving technologies competed inside the tunnel, creating a significant impact factor in terms of technology awareness nationwide and internationally. In 2023, 44 teams applied to our competition. Out of the 19 finalist teams that were successful in the technical design report, 17 participated in the final week.

Despite only being 2 years behind in the Ray Beyond project, which started in January 2022, many successes have been achieved. All countries and companies working in this field worldwide have begun to closely follow the work of our country's youth, examining the infrastructure on-site and participating in educational activities,

contributing and becoming part of the ecosystem. In addition, international competition committees have made updates to competition specifications to ensure the participation of our country's youth in the ecosystem based on the feedback received.

In the second century of our Republic, the main goals of our competition are to ensure that our young people focus on innovative technologies in line with the 2053 goals in Rail Technologies and to carry our competition to the forefront internationally by conducting the necessary work.

Within this scope, changes have been made to the rules of the race, and it has been determined that one of the systems developed by teams to generate thrust force through levitation or linear motor to participate in the race must be present in the capsule. A separate category has also been added to study different levitation technologies in the steel system. Each critical subsystem technology for developing the capsule will be listened to as a presentation from the teams during the race week and rewarded independently of the performance shown in the tunnel. This encourages teams to work more on the critical subsystems for developing the capsule. The planned updates for the upcoming years will allow the study of different technologies in the infrastructure. With these updates, the aim is to make the race more competitive and innovative.

Please review our updated specification document in detail with this vision and remember that you need to make your preparations by the rules specified in the specification. You can always contact us for any questions or suggestions regarding the specification.

As part of the National Technology Initiative, I would like to thank you, our valuable young people, for your efforts to bring domestic and national technologies to our country. On behalf of our institution and our country, I wish you success.

VERSIONS			
Version	Date	Description	Changes
Y2.V1.0	01.10.2022		2. Hyperloop Development Competition; First Release
Y2.V2.0	18.10.2022		C. General Rules and D. Ethical Rules are updated
Y2.V3.0	22.11.2022		A.2. Competition Schedule is updated.
Y2.V4.0	08.12.2022		A.3. Application Process is updated.
Y2.V5.0	15.12.2022		A.2. Competition Schedule is updated.
Y2.V6.0	11.01.2023		A.2. Competition Schedule, A.5.1. Technical Design Report - Capsule navigation system and sensor information, A.7. Awards are updated.
Y2.V7.0	24.02.2023		A.2. Competition Schedule, A.6 Supports, A.7. Awards, B 2.1. Mechanical Requirements (Capsule Rescue Attachment) are updated
Y2.V8.0	12.12.2023		A.5.1. Progress Report, A.5.2. Technical Design Report, A.7. Awards, B.2.6. Levitation System, C. Innovation Category are updated
Y2.V9.0	23.01.2024		A.2. Competition Schedule is updated
Y2.V9.1	20.02.2024		A.2. Competition Schedule is updated
Y2.V9.2	05.03.2024		A.2. Competition Schedule is updated
Y2.V9.3	19.03.2024		A.6. Supports and IV. Capsule levitation system are updated
Y2.V9.4	25.03.2024		A.2. Competition Schedule is updated

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2. ABBREVIATIONS

TÜBİTAK	: Scientific and Technological Research Council of Türkiye
RUTE	: Rail Transport Technologies Institute
TCDD	: Türkiye State Railways
AEB (DDK)	: Advisory and Evaluation Board
T3	: Turkish Technology Team

3. DEFINITIONS

Team Captain: The person who makes the team application, takes responsibility for the administrative and financial matters of the team, transfers the support to his/her personal account and is responsible for spending/invoicing the support amounts,

Team Deputy Captain: Person who assumes the task of Team Captain after the petition to be sent to the Directorate with the original signature of the Team Captain and Deputy Team Captain is accepted, in case the Team Captain is required to be replaced for compelling reasons

Team Member: Each university student of the team,

Commitment: The document prepared in accordance with the content and format determined by TÜBİTAK (Scientific and Technological Research Council of Türkiye) and submitted to the institution with original signature between the dates announced for the transfer of support,

Deed of Consent: Original signed document stating that the parents/guardians of the students younger than 18 years of age who participate in the competition bear all the responsibility and allow the student to participate in the competition,

Advisory and Evaluation Board: The committee appointed by TÜBİTAK, which determines the competition rules, performs the technical controls in the competition area, and decides the competition results/awards,

Announcement: Announcement text defining the event subject, scope, application conditions, amount of support, competition schedule and special issues related to the competition determined by TÜBİTAK,

Directorate: TÜBİTAK Rail Transport Technologies Institute

Capsule: The capsule to be designed and produced within the scope of the Hyperloop Development Competition,

A. ADMINISTRATIVE AND FINANCIAL RULES

A.1. Purpose and Scope of the Competition

The Hyperloop¹ Development Competition, organized for the first time in 2022 within the scope of TEKNOFEST, aims to raise awareness in the field of magnetic levitation (suspension) technologies among undergraduate and graduate students to develop innovative transportation capsules in which the effect of friction factor is reduced and to provide students with knowledge on new generation transportation technologies. The competition is organized to encourage teamwork and to lead the formation of competent human resources in this field by developing hyperloop technologies with practical applications.

The Hyperloop Development Competition, organized under the coordination of TÜBİTAK, is designed as a technology-oriented competition that will enable the development of different types of magnetic suspension and propulsion technologies. Through the competition, it aims to continue studying innovative transportation technologies, expressed as the 5th generation, at the level of university students. It aims to contribute to the development activities of university students with this competition, which is planned to contribute to the formation of human resources and technology in this field with the practical study of new-generation transportation technologies in Türkiye.

Hyperloop technology, which is foreseen to add a different level to conventional transportation technologies (rail, land, air, sea) and is referred to as the 5th generation among the new generation transportation technologies, is an innovative transportation system solution candidate based on different friction-reducing solutions and low-pressure media principles, especially magnetic suspension. This technology offers solutions at unusually high speeds in lead times and has the potential to play a strategic game-changer role in the field of logistics. In this field, it is important to encourage universities and R&D oriented institutions to develop these technologies so that our country can take an active role and be in a leading position.

During 2015-2019, competitions were held in which the feasibility of the hyperloop concept and the limits of capsule applications were tested with the participation of worldwide university teams, and significant contributions were made to the development of technology. Within the scope of the Hyperloop Development Competition, which was organized for the first time in our country in 2022, an infrastructure was established to design and test capsules that can compete with their international counterparts. In the first year of the competition, teams that succeeded in levitation and propulsion technologies among 16 finalist teams competed in the tunnel. A vital impact factor regarding technology awareness was created nationwide. The training provided to the teams also aimed to raise technology awareness. The third

¹ The name "Hyperloop" is registered to SpaceX.

year of the competition will be organized with a focus on vacuum, magnetic levitation, and innovative technologies.

TÜBİTAK organizes the competition with the support of TCDD and other stakeholders within the scope of TEKNOFEST. The implementation and supervision of the technical rules are carried out by the Advisory and Evaluation Board (AEB/DDK).

The terms cover the competition's rules, procedures, and obligations to be organized. The specification's content will be updated when DDK members deem it necessary and will be published again, indicating the revised change.

A.2. Competition Schedule

The competition calendar for the 2024 Hyperloop Development Competition, which is planned to be held within the scope of TEKNOFEST, is given below.

TÜBİTAK has the right and authority to organize and modify the relevant activity dates.

Table 1. Event schedule.

Activity	Date
Application Deadline	February 29, 2024
Progress Report Deadline	March 22, 2024
Announcement of Progress Report Results	April 15, 2024
Loading and Sending the Consent and Commitment Letter	April 15-19, 2024
Date for Transferring Support to Teams	April 22-26, 2024
Deadline for Teams to Withdraw and Member Changes	July 5, 2024
Submission of Technical Design Reports	July 5, 2024
Announcement of Technical Design Report Results	July 21, 2024
Competition Week	August-September, 2024
TEKNOFEST Vehicle Exhibition and Award Ceremony	August-September, 2024

A.3. Application Process

The following items will carry out the application process.

- National and international associates, undergraduates, graduates, and PhD students can participate in the competitions as a team. A team consists of the team captain, consultants, if any, and members. The team captain makes the application.
- Applications are made online via the <https://www.t3kys.com> system. The follow-up of the processes (Application, Report Upload Deadline, form to be filled, etc.) is the duty of the communication officer, and the TEKNOFEST competitions committee is not responsible for delays and/or disruptions caused by the communication officer.

- Between the application dates, the team captain registers to the <https://www.t3kys.com> system, registers the advisor and team members in the system correctly and completely, and sends invitations to the e-mails of the advisors and members, if any. The invitation from the "My team information" section of the application system is accepted, and the registration is completed. Otherwise, the registration will not be completed. No printed documents are required from the teams in the application.
- An academic or technical person who is an expert in the field can be a consultant in teams. Consultant registration, if any, must be made in the application.
- Teams consist of at least eight (8) and a maximum of fifty (50) people, including the team captain and the advisor, if any. The team must have a team captain, but not necessarily an advisor.
- The team may consist of students from different universities. The team captain provides the coordination and necessary communication.
- It is recommended that teams be formed from students from different classes, considering the increase of scientific and technical achievements, encouragement of teamwork, and the team's sustainability in the following years.
- A team captain cannot captain more than one team. Team members cannot take part in another team. The team captain or members are eliminated from the competition if the contrary is determined.
- The team captain makes all correspondence with TÜBİTAK.
- When the application is completed, the system gives each team an application number. Each team must come up with a team name of their own. No other team can use this name. TÜBİTAK may request a name change from the teams applying with the same team name as the team that applied later.
- All the students' responsibilities in all the preparatory work and the competition area, including the application registration, belong to the team captain.
- Team captain, academic advisor, and member changes, if any, occur after all members accept the "Remove member" option on the application system before the teams are supported.
- Change of team captain can be made as follows in exceptional cases accepted by TÜBİTAK, after the transfer of support, provided that it is an exceptional case and documented:
 - Petition (in accordance with the sample published on www.teknofest.org)
 - Delivery report (in accordance with the sample published on www.teknofest.org) is prepared (signed by the current and new team captain).
 - Invoices of the expenses made from the support and the receipt showing that the remaining amount, if any, has been transferred to the new team captain,
 - Commitment signed by the new team captain,

- The scanned version of the petition, delivery report, invoices, and letter of undertaking are uploaded to the relevant field on www.teknofest.org. Signed copies of the documents are sent to the address of TÜBİTAK RUTE R1 Blok, Barış Mah. Dr. Zeki Acar Cad. No:1 Gebze/KOCAELİ by post. The change request occurs when all members accept the "Remove member" option from the application system after RUTE approves all documents.
- The team captain can make team member changes through the application system until the date specified in the competition schedule. The change takes place upon the request of the team captain and the member students confirming their e-mails. If the enrolled student is under the age of 18, the scanned version of the Consent Form signed by the parent/guardian is uploaded to the www.t3kys.com system.

A.4. Training Program

- The Training Program is delivered through online videos or face-to-face training. Administrative rules are also included in video training, as well as the technical rules.
- The training program details will be determined and shared with the teams. There may be additions to the training content according to the needs of the teams. In this case, the teams will be given the necessary information during the training program period.

A.5. Report and Evaluation Process

- Two reports will be submitted: a Progress Report and a Technical Design Report. The requested technical information should be provided in detail under the relevant headings in the reports.
- The report template will specify the score details for each heading in the report.
- Report preparation guidelines are published on www.teknofest.org.
- The report can be prepared in Turkish or English. It is mandatory to use a single language in all report content.
- The report is uploaded to the application system in PDF format with a maximum size of 60 MB between the specified dates. Otherwise, the team will be eliminated from the competition.
- The report should be prepared in A4 format, 12-point size, Arial font, with a line spacing of 1.15, and with top, bottom, and side margins of 2.5 cm. The Progress Report should have a maximum of 100 pages, and the Technical Design Report should have a maximum of 200 pages.
- The report is evaluated within the scope of scientific and technical criteria specified by AEB members who are experts in their fields. The team's score is determined by summing the points of all AEB members.

- Successful teams in the report are announced on www.teknofest.org.
- If ethical violations such as plagiarism and copying are detected in the report, the report will not be evaluated, and the team will be eliminated from the competition. This rule is applied regardless of category/competition in applications to institutions such as the same university/club/society.
- After the report results are announced, the teams' captains who wish to object to the results must submit their objections and justifications in writing. Objections can be submitted at www.t3kys.com. The Advisory and Evaluation Board evaluates objections, and the results are notified to the teams by e-mail. Results cannot be appealed a second time.
- Teams must make their objections by the date communicated by TEKNOFEST after the report score results are announced. Otherwise, objections will not be considered.

A.5.1. Progress Report

- The primary purpose of the progress report is to ensure the "basic suitability" of capsule designs and contribute to guiding teams in implementing their designs correctly.
- According to the participation limits of the competition, in the evaluation process of the applications, it may be necessary to make selections that are suitable for the capacity of the competition area in case of high participation. This process will be carried out by reviewing progress reports to evaluate the interest in and participation of the competition.
- The score obtained from the progress report will affect the scoring in the performance ranking. The progress report should include the following headings. The limit scores for each heading are given in the table below.
- Support will be provided to teams that exceed the determined point limit. Teams that do not receive support can continue their development work independently and submit a technical design report to participate in the competition. Still, they will not be eligible for prize evaluation.

Table 2. Progress report score table.

Progress Report	
Title	Score
Estimated capsule sizes	10
Estimated capsule weight (including all subsystems)	10
Estimated capsule power consumption	10
Capsule navigation system	10
Capsule levitation (suspension) system	10
Capsule propulsion and stability system	10
Capsule braking system and the anticipated capsule speed profile	10
List of energy sources on the capsule and detailed information	10
Capsule safety equipment and activation procedures	10
Budget Table	10
TOTAL	100

1. Current list containing application number, team name, and information of team members and advisors

- The relevant section in the report template is filled with the information of the team's name, team members, and advisors. If there have been any changes in the team members during the process from application to report submission, the table is updated accordingly.

2. General information about capsule design

- General information about capsule design should be presented under this heading. Teams have the right to revise their designs in the next stage. Therefore, estimated values of the requested information can be included in the report. This report should include the following information. Teams may add additions to these headings:

a. Estimated capsule sizes

- Teams are expected to communicate the maximum lengths of the capsule they will design in the x, y, and z axes. It is recommended to indicate these lengths on the technical drawing of the capsule.

b. Estimated capsule weight (including all subsystems)

- Teams are expected to calculate the total weight, including all subsystems, of the capsule they will design and provide an approximate estimate along with the details.

c. Estimated capsule power consumption

- Teams are expected to calculate the amount of energy consumed by the capsule they will design at a determined speed (e.g. 100 km/h). Additionally,

teams are expected to provide information on how to supply this energy to the capsule under this heading.

d. Capsule navigation system

- Teams are expected to provide information on how they will obtain the position of the capsule inside the tube (at which meter it is located) and the speed information.

e. Capsule levitation (suspension) system

- Teams are expected to explain how they plan to build the magnetic levitation system under this heading.

f. Capsule propulsion and stability system

- Different propulsion systems, such as wheel drive, magnetic propulsion, or compressed gas, can be used to move the capsules. Teams should specify the propulsion systems they prefer to use for moving their capsules before and after the race (e.g., manual pushing, transportation with a dolly, etc.) and during the race (considering the vacuum conditions inside the tunnel) in their progress reports.
- Teams are expected to explain how they will ensure the stability of the capsule as it moves along the track.

g. Capsule brake system and predicted capsule speed profile

- Teams are expected to explain how they will design a braking system that meets the criteria specified in the rules for the capsule to slow down and stop.
- Scenarios for the anticipated capsule velocity profile during the race should be presented with Speed/Time and Distance/Time graphs. An emergency scenario should also be created, considering the maximum braking performance, and the relevant Speed/Time and Distance/Time graphs should be provided.

3. List of energy sources on the capsule and detailed information (e.g. pressurized tanks and batteries)

- Teams are expected to provide information about the energy sources they will use to operate the capsule.

4. Capsule safety equipment and activation procedures

- Teams are expected to explain how the system they designed for braking the capsule works, how it can be controlled remotely, and how the capsule will safely come to a stop in case of any malfunction.

5. Budget table

- Teams are expected to describe the budget items they need to produce the capsule they aim for in a table format with brief explanations.

A.5.2. Technical Design Report

The Technical Design Report should include the following headings. The limit points for each heading are given in the table below.

Table 3. Technical design report score table.

Technical Design Report	
Title	Score
Capsule design, analysis and manufacturing	10
Capsule power consumption and energy sources	10
Capsule navigation system and sensor information	10
Capsule levitation system	30
Capsule propulsion and stability system	10
Capsule brake system and capsule speed profile projection	10
Thermal, aerodynamic, and vacuum analysis of the capsule	20
Capsule safety equipment and deployment procedures	10
Communication and data/image transfer	20
Electromagnetic levitation for dynamic modeling	10
Budget table	10
TOTAL	150

Up-to-date list with application number, team name, team members, and advisor's information

- The relevant part in the report template is filled with the team's name and information about the team members and advisor. If there has been any change in the team members during the period from application to report submission, the table is filled with the current information, taking this situation into account.

Table 4. Example team information template.

No	Name Surname	University and Department	Class	Member Role
1				Advisor
2				Captain
3				Member
4				Member
5				Member
6				Member
7				Member
8				Member

I. Capsule design, analysis and manufacturing

- The table below is filled with the current information of the competition capsule.

Table 5. Sample vehicle features summary table.

Feature	Unit	Remarks
Length	mm	Max. length including shell
Width	mm	Max. width including shell
Height	mm	Max. height including shell
Capsule weight	kg	
Chassis & Shell Material	Material type	
Hardness of Brake Shoe	HRC	
Propulsion System	Linear Motor, Pressure Tube, other	
Electric Motor	Type	
Electric Motor Power	kW	
Number and Type of Pressure Cylinder	Number	
Battery Rated Voltage	V	
Battery Rated Power	Wh	
Communication	Type	

- In this section, which includes general design details and analysis, the work carried out should be explained in detail, supported by visuals. Explanations on at least the following topics related to the design and analysis of the capsule are expected:

a. Detailed design summary of the capsule

- Location information, technical drawing, and assembly details of the hyperloop rescue attachment should be located at the capsule's rear, supported by 3D CAD data visualization.
- Information about the location of the Network Access Module (NAM) in the capsule, installation details and cable routes.
- Demonstration and explanation of the location of the subsystems in the capsule supported by 3D CAD data visuals.
- Demonstration and detailed explanation of the work done on the chassis and shell, supported by 3D CAD data visuals.
- Details shows to physically push the capsule when it is not working so that it can move through the tunnel.

b. Capsule dimensions

- Demonstration of capsule dimensions in technical drawing format.

- Design of the pipe cross-section, considering the pipe diameter, all restricted areas and equipment area, and representation of the capsule within this cross-section.

c. Other limitations of the capsule

- The capsule is expected to be designed with the most aerodynamically favorable geometry together with other constraints. For this purpose, a design process starting from analytical approaches and supported by CFD is required to be followed and reported in detail. In this context;
 - The necessary network structures should be created for the method, geometry and analysis followed.
 - The discretization and solution methods used and the turbulence models selected should be explained.
 - Drag force and lift force calculations and conclusions should be reported.

d. Capsule weight

- Detailed determination of the total weight of the capsule with its subsystems.
- Schematic representation of the position of the subsystems in the capsule together with their center of gravity.
- Representation of the center of gravity of the capsule and evaluation of the suitability of the center of gravity position.

e. Capsule materials

- Information about the types of materials used, their places of use and reasons for preference.

f. Structural analysis

- The magnitude and location of the forces acting on the capsule must be shown (including data from CFD analysis)
- Fixing details should be shown.
- Information about the materials used should be given.
- Information about the types of elements used should be given.
- Mesh structure should be shown.
- Analysis results should be interpreted and reported.

g. Manufacturing

- Teams are expected to explain how they produced the capsule and the steps during manufacturing.
- Images from the manufacturing and assembly stages, manufacturing plan, technical drawings and videos (links can be provided) of the part, system and capsule should be detailed under this heading.
- Manufacturing is expected to be specific to the tooling.
- Manufacturing cost and method should be explained in detail.

II. Capsule power consumption and energy sources

- In this section, the average and maximum power values consumed by all energy consuming subcomponents in the capsule to be used in the competition should be given, and the total energy that the system will consume under the predicted operating conditions should be calculated.
- After the calculations are made, the power and energy values should be listed in the table.

Table 6. Sample subcomponent-power consumption table.

Component	Maximum power [W]	Average power [W]	Total energy [Wh]
Sub system 1			
Sub system 2			
...			
Subsystem n			

- In this section, the specifications of the battery pack designed according to the calculations will be given. The information in the two sections should overlap with each other.
- Teams are expected to disclose information about the energy sources they will use to keep the capsule moving.
- In this section, the following battery-specific details are expected to be included.

a. Physical characteristics of the battery pack

- Dimensions and 3D drawing
- Placement inside the capsule
- Materials used and their properties

b. Electrical characteristics of the battery pack

- Chemistry and electrical properties of cells used in batteries
- Number of cells used in the battery, connection configuration
- Energy and power ratings of the battery (maximum output power, maximum charging power, etc.)

c. Safety

- IMS features
 - Placement of temperature sensors
 - Safety equipment (contactor, fuse, etc.)
 - Safety algorithm details.
- One phase 220 V AC, 50 Hz mains voltage line will be in the competition area. Capsules must be supplied with their own charger/converter. For this reason,

sufficient information about the charger to be used is also expected to be included in the report.

- Competitors who will use a pressure vessel to move the capsule are expected to meet the pressure vessel requirements specified in the Propulsion System heading.

III. Capsule navigation system and sensor information

- The system that will help the competing teams to obtain the average speed and location information of the capsules they have developed is explained in this section. The braking distance of the capsule can be decided according to this information obtained.
- The specified tunnel length for the competition is 208 m. The first 5 meters of this length is reserved for the capsule's placement in the tunnel, while the last 17 meters are reserved for capsules that cannot stop at the end of the competition, and no speed and position information will be received. The remaining 186 meters is the space required for the competing teams to accelerate and stop. Those lengths may be updated to extend the competition zone based on the capability of the infrastructure. The graph in Figure 1 can be examined for the mentioned layout.



Figure 1. Tunnel layout.

- On the Hyperloop competition zone (5 m after the tunnel entrance), a 5 cm thick reflector strip will be placed every 4 m after the first 6 m (5 m after the tunnel entrance). Each reflector strip will be placed in the upper 180 degree (9-3 o'clock) part of the tunnel. The reflector placements can be seen in Figure 2 **Error! Reference source not found.** representing the pipe cross-section. The reflector mentioned will have a red color micro-prismatic reflection feature.
- The 180-degree area where each reflector strip will be placed for the last 100 meters of the Hyperloop competition zone after the first 86 meters will be divided into two 90-degree sections. The 90-degree area on the right side of the tunnel will continue to be a red stripe, while the 90-degree area on the left will be covered with a yellow reflector strip. The colors of the strips will be changed for the last 100 meters. The micro-prismatic property specified for the red reflector strip will be the same for the yellow reflector. Thus, both the yellow and red reflectors used in the tunnel are micro-prismatic.
- Within the last 100-meter zone, the first 4-meter frequency will be divided into 5-centimeter intervals of 20 pieces. The remaining 2.05 meters of this 4-meter distance will be without stripes. Reflector strips placed in this way will indicate that the last 100 meters of the tunnel are entered.
- Similarly, when the last 48-meter distance is entered, the first 4-meter frequency will be divided into 5-centimeter intervals of 10 pieces. The remaining 3.05 meters

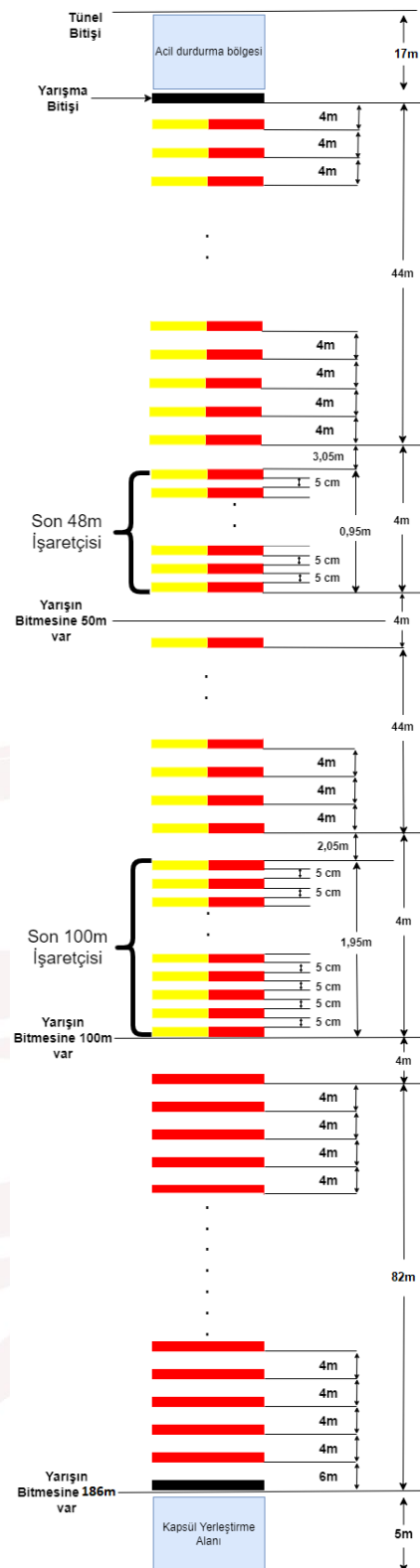
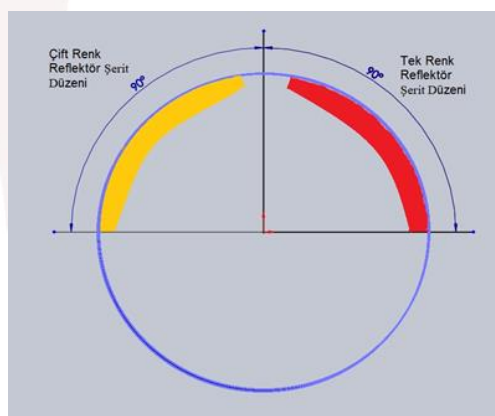
will be without strips. Reflector strips placed in this way will indicate that the last 48 meters of the tunnel are entered.

- All tunnel lighting will be made white from the upper part of the tunnel at the standard room level. The tunnel's interior color is black. A detailed illustration of the reflector placement can be seen in Figure 3.
- An inductive method alternative may also be offered for obtaining speed and position information by making the necessary updates in the specification depending on the work to be carried out in the infrastructure.

Capsule navigation rules:

- Competitor teams are expected to instantly determine the positions and speeds of the capsules they designed in the tunnel by using the colored reflectors shown in Figure 3.
- The sensor(s) to be used in the reflector counting process are left to the preferences of the competing teams.
- It is expected that the highest speed information specified by the teams will overlap by $\pm 5\%$ with the speed information measured by TÜBİTAK.
- In the technical design report, it is expected to provide detailed information on the sensors/sensors to be used in the capsule navigation system, how the measurement will be followed in cases such as missing the measurement while reading the reflector strip, and how the capsule speed and position information will be obtained.
- Teams are required to provide detailed information by considering the following items.
 - Features of the sensor/sensors selected for the navigation system.
 - Specifications of other sensors/sensors such as temperature sensor.
 - Tabulation of the angle of placement of the sensors/sensors to be used for the navigation system with respect to the tunnel, their position on the capsule, their distance from the tunnel wall and the maximum operating distance of the sensors/sensors.
 - The type of information (frequency, wavelength, digital value, color information, etc.) and how this information will be converted into speed and position.
 - Block diagram of the path to be followed in case the sensor/sensors to be used for reflector strip reading cannot read the reflector strip.

NOTE: Explanation and interpretation of the information provided in the pictures and tables on these topics (desired performance, advantages, etc.) are expected. Details of the measurement method will be shared.



IV. Capsule levitation system

Teams are expected to explain how they plan to perform levitation (suspension) under this heading. Teams can participate in the competition with one of the two types of levitation mentioned below.

Teams that want to levitate on an aluminum rail can demonstrate their levitation systems by racing in the 208-meter race tunnel if they pass the pre-race checks successfully. Teams that want to design levitation in the steel system should demonstrate it in the infrastructure that TÜBİTAK plans to build or in the test setup prepared by the teams themselves, or in the form of a video presentation with analysis outputs, as the geometry of the race tunnel is not suitable for this type of levitation.

Teams that want to design levitation in the steel system can race in the 208-meter race tunnel without a levitation system in their capsules. However, in order to qualify to enter the race tunnel, they must demonstrate, as described in section A.7.1 Performance Awards, that they generate propulsion force with a linear motor due to the absence of levitation systems in pre-race checks.

IV.a Aluminum levitation system

In the Technical Design report, the following information regarding the suspension system is expected to be included by the teams:

- Calculation of the loads on the system (total weight to be suspended (At least as much as the vehicle/capsule weight), dynamic loads, etc.).
- Determining the suspension method (linear hallbach array, rotary hallbach array, compressed air etc.) and explaining why this method is preferred.
- Acceleration, suspension, and deceleration strategy if using linear hallbach structure.
- Dimensioning of the suspension system (total lifting force, lifting height, etc.).
- Design, calculations, and analysis (electromagnetic analysis or fluid analysis (for compressed air)).
- Evaluation of analysis results (examining whether the values obtained in the analysis results meet the requirements).
- Analyzing the amount of heat generated by the levitation system on the rails.
- Test results (optional).
- Images from manufacturing(optional).

The calculations and analyses made should be explained in detail here. The compliance of the analysis results with the requirements must be indicated. It should be shown that the levitation system will not damage the tunnel rails (conditions such as friction etc.), and the heating it will create on the tunnel rails should be stated in the report.

The levitation system should be designed in such a way that it does not cause a temperature rise of more than 30°C on the guide and carrier rails; if necessary, the cooling system should be integrated.

The calculation of the temperature increase that will occur in the rails and the guide due to the levitation system should be given in detail in the report.

Using parts produced from 3D printers in the levitation system is not recommended. Especially for the tools that will use rotating disk structures, it must be shown that the necessary precautions have been taken and the relevant parts are enclosed so as not to cause any safety hazard (part breakage, ejection, etc.) for the parts to be used in the levitation system. It must be shown that the necessary precautions have been taken and that the relevant parts are enclosed.

IV.b Steel levitation system

The race track is 208 meters long and consists of aluminum plates and rail pieces placed on concrete inside a steel tunnel. Therefore, only electrodynamics levitation systems can be applied inside the tunnel. However, teams wishing to design an electromagnetic levitation system need to provide information about the levitation system they intend to design under this heading. The following information is expected at least regarding different levitation systems under this heading:

- Selected suspension method (EMS, H-EMS).
- Differences between the selected suspension method and other levitation systems.
- Calculation of loads on the system (calculation of total weight to be suspended (At least as much as the vehicle/capsule weight), dynamic loads, etc.).
- Dimensioning of the suspension system (total lifting force, lifting height, working air range etc.).
- Design, calculations, and analysis (electromagnetic analysis).
- Evaluation of analysis results (examining whether the values obtained in the analysis results meet the requirements).
- Analyzing the amount of heat generated by the levitation system on the rails.
- How to ensure control software for the levitation system and stability of the capsule.
- Safety methods to be taken in the levitation system (magnet detachment, vehicle sticking to the track, high temperature, etc.)
- Applicability of levitation system to Hyperloop capsules.
- The energy consumption of the levitation system under the anticipated operating conditions.
- Test results (optional).
- Images from manufacturing(optional).

V. Capsule propulsion and stability system

Under this heading, the issues to be discussed are presented below in bullet points:

- In the design of the propulsion system, the teams will calculate the loads required for their systems, and the parameters, such as force, speed, size, etc., required for the propulsion request will be specified. Then, the method to be used for the propulsion system will be determined.
- Sets to provide thrust with a linear motor:
 - Depending on the calculated loads, motor requirements (force, speed, voltage, etc.) will be determined.
 - Any limits, such as size, volume, weight, etc., will be specified.
 - Electrical and electromagnetic design and analysis of linear motors.
 - Motor thermal analysis and cooling method will be explained. Calculation will show that the temperature increases that the motors will create on the rails do not exceed 30°C.
 - Linear motor mechanical analysis will be explained.
 - If a linear motor is to be purchased ready-made, how the motor selection (power, voltage, force, etc.) is made will be explained.
- Teams stating that they will move their capsules with pressurized gas propulsion system; "B. TECHNICAL RULES" main heading " B.2.5. specified in the following items in a way that will meet the explanations and requirements in the sub-title " B.2.5. Propulsion System of the Capsule " of the B. "TECHNICAL RULES" main heading.
 - Technical specifications of the pressurized gas they plan to use (chemical composition of the gas, temperature, and pressure values in compressed state, and volume),
 - Certificate of gas to be brought to the competition area (teams will provide the sufficient amount of certified gas they plan to use and must bring it to the safe area established in the competition area before the competition. Necessary support will be provided for filling the containers in their systems.)
 - 2D fluid diagram describing the system (installment drawing)
 - The list containing the technical details of the elements to be used (pressure vessel, valve, manometer, electromagnetic valve, electronic pressure gauge, electronic temperature gauge, accumulator, nozzle etc.) (if it is to be supplied from the market, the documents showing the technical details specified by the manufacturer),
 - Engineering calculations (fluid mechanics, heat and strength calculations) and manufacturing technical drawings of the pressure container, accumulator (if used), pipes, sealing elements, fittings to the capsule and nozzle and/or nozzle carried out analytically as well as numerical or finite element & volumes methods,
 - Installation technical drawing and material list of the system,

- TNT equivalence and burst distance calculations for the pressure vessel in the system,
- The scenario regarding the transportation of the system from the workshop to the competition field and the plan to show that the external mechanical and/or thermal loads that may arise during this transportation process will not affect the system and the measures that can be taken to control the operability of this plan (fixing apparatus such as fixtures, data collection from instruments such as temperature gauge, pressure gauge, accelerometer, etc.).
- Teams that will use a method other than those mentioned here shall describe the method they will use in detail. Also, they must demonstrate (by calculations and analyses) that the method they will apply will not harm the infrastructure.
- Teams are expected to explain how the capsule will maintain its stability as it travels on the rail. In the Technical Design Report, the teams are expected to provide the following information about the stability system they will design.
 - Calculation of the loads on the system (capsule lateral loads, dynamic loads, etc.)
 - Determining the stability method (linear hallbach array, rotary hallbach array, compressed air, wheel, etc.) and explaining why this method is preferred
 - Dimensioning of the stability system
 - Design, calculations, and analysis (electromagnetic analysis or fluid analysis (for compressed air))
 - Evaluation of analysis results (examining whether the values obtained in the analysis results meet the requirements)
 - Analysis of the heating caused by the stability system on the rails
Teams should clearly define the design and manufacturing steps of braking systems.
 - Test results (optional)
 - Manufacturing visuals (optional)
- Guiding can be done by structures such as wheels or as electromagnetic. The guidance system can be active or passive.
- Teams can use the rail inside the tunnel to guide their capsules; however, the systems of the tools must not cause mechanical damage to the rail. The wheels of the sets that will use wheels, etc., must be selected from materials that will not cause physical damage to the rail (crush, abrasion, etc.).
- Teams that will use electromagnetic guidance will need to demonstrate (must be calculated and reported) that the temperature rise that the guidance systems will create on the rail does not exceed 30°C.

VI. Capsule brake system and projected capsule speed profile

- This section should give details of the design and calculations. Teams are expected to define and calculate the following design features. Circuit diagram of Hydraulic/Magnetic/Pneumatic lines depending on the drive elements in the system.
 - Braking distance, time, acceleration values during braking, and Speed/Time, Distance/Time graphs of these calculations,
 - Braking distance, time, acceleration values during braking, and Speed/Time, Distance/Time graphs of these calculations,
 - Design details of mechanical parts, including all elements of the brake system,
 - Force calculations during braking, pressure values in transmission lines,
 - The temperature of the parts in contact with the rail during braking and the heat value transmitted to the rail by these elements,
- The design of the mechanical parts in the brake system and the analysis of the elements used outside the standards should be included in the report,
- Scenarios of the capsule speed profile envisaged during the competition must be realized in the simulation environment. Speed/Time, and Distance/Time graphs that will cover each moment during the movement of the capsule in the tunnel should be given. An emergency scenario should be created considering the maximum braking performance in case of emergency, and the relevant Speed/Time and Distance/Time graphs should be given.

VII. Thermal, aerodynamic and vacuum analysis of the capsule

- The following sections on the thermal management of the capsule should be described:

a) Thermal analysis

- It is expected to calculate the highest temperatures that will occur in the critical subsystems after the thermal load that will occur during the movement of the capsule inside and outside the tunnel.
- The measures taken are expected to be explained if high temperatures are observed.
- Since the inside of the tunnel can be vacuumed, thermal management should be suitable for working in a vacuum environment. Teams are responsible for cooling their equipment (heat-generating components such as motors, drives, batteries, etc.) under vacuum.

b) Vacuum acceleration and strength analysis

- It is expected that the strength analysis of the capsule under vacuum, together with the electronic components, battery, and the required subsystems, will be carried out, and the results will be explained in detail.

- In particular, teams using products such as pressure tubes, etc., should calculate according to vacuum operation.
- It is expected that the structural analysis of the capsule for the braking condition will be carried out, and the results will be explained in detail.

VIII. Capsule safety equipment and deployment procedures

- a. The dimensions of the lifting apparatus that will allow the capsule to be placed on the platforms in the competition area and their location on the capsule must be specified.
- b. During the lifting of the capsule using a lifting apparatus, it must be possible to take into account the center of gravity and to carry the capsule in a balanced manner.
- c. Lifting apparatus may be of mountable type or permanent apparatus. It should be noted that if they are mountable, the competitors must supply additional apparatus.
- d. Capsules weighing 80 kg or less may be carried by hand. In this case, the maximum weight lifting limit allowed per person will be 20 kg. There should be clearly marked lifting points for each person on these capsules.
- e. In addition to the general braking system of the capsule, the details of the emergency braking system planned to be activated for sudden stopping in emergencies should be specified.
- f. This must be stated explicitly if the capsule's general braking system is also used for emergency stopping.
- g. How the brake system(s) are activated must be stated. A second energy source other than the main energy source must be used for emergency brake system activation.
- h. All malfunctions/problems that may occur in the entire capsule and in each subsystem should be listed, and action plans for these malfunctions/problems should be tabulated.
- i. It is expected to have a control interface that allows the general status of the capsule to be monitored and the regular operation of all subsystems can be displayed together with the data received from the sensors.
- j. Explanation of the procedure to be applied in the event that the capsule is de-energized or disconnected from the control computer.
- k. The battery management system must monitor the main energy source of the capsule and must have components to ensure that the system is switched to safe mode when limit values are reached. Capsules containing energy sources without a battery management system will not be allowed to enter the tunnel.
- l. Capsules containing pressurized cylinders must have a relief valve element that allows discharge in case the pressure rises. Capsules that do not have this element or do not have equipment that allows the discharge of excess pressure in the system will not be allowed to enter the tunnel.

- m.** It is expected to be explained that the capsule can remain intact in case of a sudden pressure change in the tunnel.
- n.** The procedure for implementing the capsule emergency stop command is expected. Details of whether the emergency stop procedure takes actions to activate, deactivate, or gradually increase in intensity should be provided.
- o.** The presence of a system for extinguishing a fire that may occur on the capsule will provide extra evaluation points. The absence of such a system does not constitute an obstacle to tunnel entry.
- p.** The teams are expected to share their calculations of the capsule's safe acceleration, braking, and stopping scenarios, including their position relative to the tunnel.
- q.** It is expected to provide information about the equipment on the capsule and the procedures to be applied on how to remove the capsule from the tunnel in case it is immobilized in the tunnel.

IX. Communication and image transmission

- For the safe communication of the capsule with the remote-control computer, the teams are expected to provide detailed information on the following items.
 - a.** The location where the NAM (Network Access Module), which will be given to each team by TÜBİTAK on the day of the competition, will be mounted on the capsule, the location of the approved extension antenna if used, and the IP Cam location, if used
 - b.** Wiring information of the capsule control computer to be connected to the NAM and IP Cam-if used-
 - c.** Power cable and connector information from capsule battery to NAM
 - d.** Cable to be connected from the capsule chassis to the NAM and to create equipotential (chassis ground)
 - e.** Capsule control computer and remote-control computer network configuration
 - f.** Detailed information about the mandatory parameters, capsule stop command, and communication package structure in the capsule control software developed for the remote-control computer.

X. Dynamic modeling for electromagnetic levitation

- Under this heading, it is requested to model the electromagnetic levitation system of a capsule in the context of hyperloop technology using the Simulink environment. The integrated control system parameters (PD, PI, PID, etc.) should be addressed in an original manner, covering a maximum of 2 pages.

XI. Budget table

- The budget table showing the expenditures made within the scope of the competition should be attached to the Technical Design Report, showing the

quantity and unit price information. Expenditure incurred and anticipated expenditure should be included in the table.

A.6. Supports

- Preparation Support is the aid to be transferred to teams found successful in the Progress Report for them to be able to build or develop their vehicles and procure the necessary parts.
- The amount of preparation support is 80.000 TRY.
- No support will be provided to teams that fail in the Progress Report.
- In order for financial support to be paid, Team Responsible must fill and sign the Letter of Commitment, stating that all the responsibilities and rules of the competition have been accepted, and submit the document to TUBITAK official during the registration in the competition area.
- The team captain must request the Letter of Consent of the parent/guardian for all members under the age of 18 and delivered in the race area.

A.7. Awards

- The prizes in the table below indicate the total amount to be given to the teams that are entitled to receive awards, no individual awards will be made. First, second and third place prizes will be divided equally according to the total number of team members (excluding the advisor). Team advisors who are entitled to receive an award cannot benefit from the first, second and third prize amounts below, and the awards to be given to the advisors are also specified in the table below.

Table 7. Awards.

Award	Definition	Amount
Performance Awards	First Place	200.000,00 TRY
	Second Place	150.000,00 TRY
	Third Place	120.000,00 TRY
Innovation Awards	Electromagnetic Levitation System Development	30.000 TRY
	Propulsion System Development	30.000 TRY
	Infrastructure Development	30.000 TRY
	Communication System Development	30.000 TRY
	Mechanical System Development (brakes, integration, capsule)	30.000 TRY
Steel Levitation Award		30.000 TRY

Award	Definition	Amount
Advisor Awards	First Place	9.000 TRY
	Second Place	7.500 TRY
	Third Place	6.000 TRY

A.7.1. Performance Awards

- Teams will be evaluated based on the total score they receive from the progress report, technical design report, and competition categories. The evaluation criteria and scoring limits are specified in the table below.
- Teams that successfully complete the Report and Evaluation and pre-competition Technical Inspection processes specified in the handbook qualify to race in the tunnel. Among the successful teams in the tunnel, the top three teams with the highest score will be eligible to receive a performance award.
- If the best team that completes the test tunnel in accordance with the safety procedures and passes 120 km/h speed in the tunnel is entitled to participate in an international competition to be organized in the relevant field, the travel expenses of 8 people from the team will be covered.

Table 8. Evaluation topics and upper limits of scores.

No	Evaluation Topics	Score Upper Limits
1	Progress Report	100
2	Technical Design Report	150
3	Competition	400
<u>TOPLAM:</u>		650

- Teams will be examined with pre-competition checks. Teams that pass the checks will qualify to compete in the 208-meter tunnel.
- For teams to participate in the competition in 2024, it is mandatory for them to be able to generate propulsion force using either levitation or linear motors. Teams that cannot demonstrate either of these two features in their vehicle will not be given the opportunity for a speed test.
- Performance evaluation will be based solely on report scores. In case of inconsistency between the Capsule and Technical Design Report, the given report score will be renewed, or penalty points will be applied to the relevant score. Pre-competition checks will be conducted according to the headings in the table below.
- The vacuum test will be conducted based on the teams' preference after the race. The physical vacuum test will not contribute to the scoring.

Table 9. Technical control evaluation headings.

Technical Checks	
Heading	Status (Pass/Fail)
Capsule Security	
Measurement	
Acceleration and Braking	
Levitation System*	
Propulsion System	
Navigation System	
Communication System	
Vacuum Test*	

- The distribution of points to be used in the evaluation based on competition regions/sections is given in the table below.

Table 10. The distribution of points for the competition sections.

Kısım	Puan
Levitasyon	100
Elektromanyetik İtki	50
Haberleşme	30
Hız	150
Konum	70
Güvenlik Bölgesi*	0
TOPLAM:	400

- 0.4 points will be scored for each 1 meter of travel in the tunnel. A maximum of 70 points will be awarded for 186 meters of travel.
- The safety zone inside the tunnel will be at 186. meter. Capsules stopping after this position will be deducted 3 points for each meter.*
- DDK can change the limit points and formulation if it deems it appropriate.,

A.7.2. Innovation Awards

- Teams can compete for an innovation award by presenting during the race week about the sub-systems they have developed. These sub-systems are listed in Table 11.
- The presentation dates will be determined for the competition week. After the presentation and question-answer stages to the DDK, innovation awards will be given to the most successful team or teams.

Table 11. Presentation and topic distribution.

No	Evaluation Title
1	Electromagnetic Levitation System Development
2	Propulsion System Development
3	Infrastructure Development
4	Communication System Development
5	Mechanical System Development (brakes, integration, capsule)

A.7.3. Steel Levitation Award

In the steel system, teams that develop levitation will be evaluated based on the score in their technical design report and their implementation performance. The team that is deemed most successful will also be presented with a steel levitation system award.

If multiple teams manage to achieve a steel levitation system, the ranking of successful teams will be determined based on the lowest energy expended per kilogram during levitation.

A.7.4. Award Transfer

- Financial Support and Awards of the finalist teams participating from abroad (including Azerbaijan and TRNC) will be paid to the Team Responsible in cash in the competition areas or TEKNOFEST area.

B. TECHNICAL RULES

B.1. Tunnel Features

The test tunnel consists of aluminum plate and rail parts placed on concrete in a steel tube, as well as communication/image transmission systems and safety systems. At the exit point of the tunnel, there is a damping line in case of capsule failure. The competition tunnel will rest on concrete cradles equipped with steel-reinforced plain bearings.

TÜBİTAK Hyperloop test tunnel parameters:

- **Tunnel Outer diameter:** 1168 mm
- **Inner diameter:** 1148 mm
- **Wall thickness:** 10 mm
- **Length:** 208 meters (total tunnel length) ~178 meters (competition track length)
- **Bottom plate material:** Aluminum 6101-T6
- **Bottom plate roughness:** 125 RMS
- **Bottom plate thickness:** 12,7 mm
- **Concrete height:** 150 mm
- **Rail material:** Aluminum 6061-T6
- **In-tunnel pressure:** Minimum 0.1 bar(absolute), maximum open air pressure

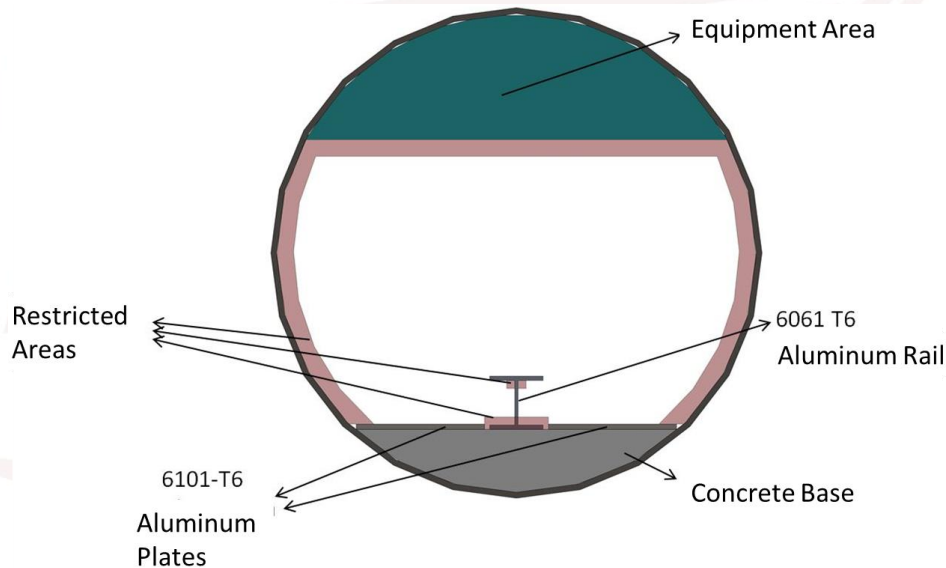


Figure 4. Tunnel section-1.

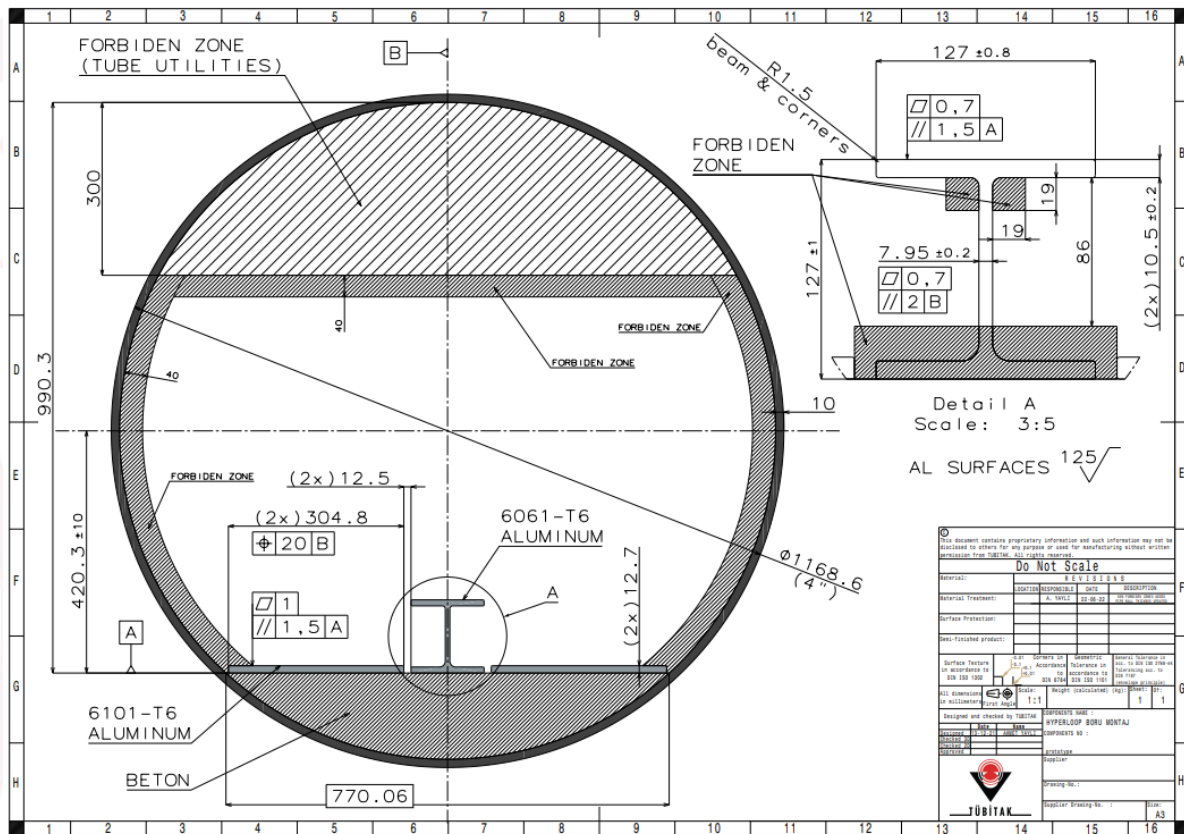


Figure 5. Tunnel technical drawing.

The cross-sectional dimensions of the aluminum rail and aluminum lower rail piece, which will be on the right and left of the rail on the concrete in the tunnel and fixed to the concrete, are given in Figure 5.

Temperature measurements will be taken at specific points within the competition tunnel. Tunnel temperature will vary depending on the weather during the competition week; design and analysis should consider that the indoor temperature may be anywhere between the maximum and minimum temperature range on the competition date. Teams can request the working pressure of their design inside the tunnel (it is recommended to consider that convection cooling at low pressures will be very inefficient). Designs that are not carefully evaluated or thermal hotspots are not reduced may not hold up to the end of the vacuum pumping period. The pumping time to reach the minimum pressure rating of 0.1 bar is estimated to be approximately 25-35 minutes. Capsules should be able to compete at atmospheric pressure.

The inside of the tunnel is dark in the shade of black. Teams should pay attention to this situation when choosing which sensor to use.

B.2. Capsule Requirements

This section contains the technical requirements of the capsule. Information/requests are given under a total of 5 sub-headings. These aspects should be taken into account in capsule design into consideration.

B.2.1. Mechanical Requirements

- Teams can propel the capsule using compressed gas or magnetic propulsion. The capsule should be physically pushable and moveable at low speeds when it is not in operation.
- The capsule must be designed to be suitable for physical transport or using lifting equipment, and the total weight of the capsule must not exceed 250 kg.
- How the capsule will be transported should be designed, taking into account the outer shell of the capsule. Especially during putting on and taking off the rail, transportation equipment (handles, grips, etc.) that are under the shell and cannot be reached are not useful. In addition, the space required for the rail should be considered when designing the shell.
- The dimensional limits of the capsule have been kept wide to encourage design diversity. The length of the capsule cannot be less than 300 mm and greater than 3500 mm. The capsule should be designed to fit the pipe section shown in Figure 4. All critical dimensions and tolerances required for the capsule section design are given in Figure 5.
- The back of the capsule must be equipped with capsule rescue attachment detail so that it can be pulled out of the tunnel in case the capsules remain in the tunnel during the competition or cannot return to the starting point at the end of the competition. This detail can be permanent or attached later; in this case, this detail should be brought with the capsule by the teams.

Hyperloop Capsule Rescue Attachment

- In order for the capsule to be withdrawn safely if it remains in the tunnel, there must be a plate on the back of the capsule, the details of which are given in the figure below.
- The plate, chassis connections, and the chassis itself must resist the pulling force (at least two times the braking force calculated in the capsule brake calculations) to be applied from the teeth shown in the picture.
- The thickness of the plate and the tooth depth must be at least 10 mm.
- Steel or aluminum can be used as plate material. Helicoil should be attached to the tooth sockets if materials other than these are used.
- There should be no protrusions on the surface (rescue surface) of the plate facing the tunnel entrance cover so that the adapter piece required to recover the capsule can be attached. The other surface can be designed and fixed by the teams in

accordance with the capsule and how it is connected to the capsule. During this connection, the teams that will make the bolted connection should be careful not to create any protrusions on the recovery surface of the plate. Bolt heads must be embedded in the plate.

- The adapter part to be given to the teams by TÜBİTAK before the competition will be mounted on the plate in the capsules using the M8x1.25 holes indicated in the figure below.

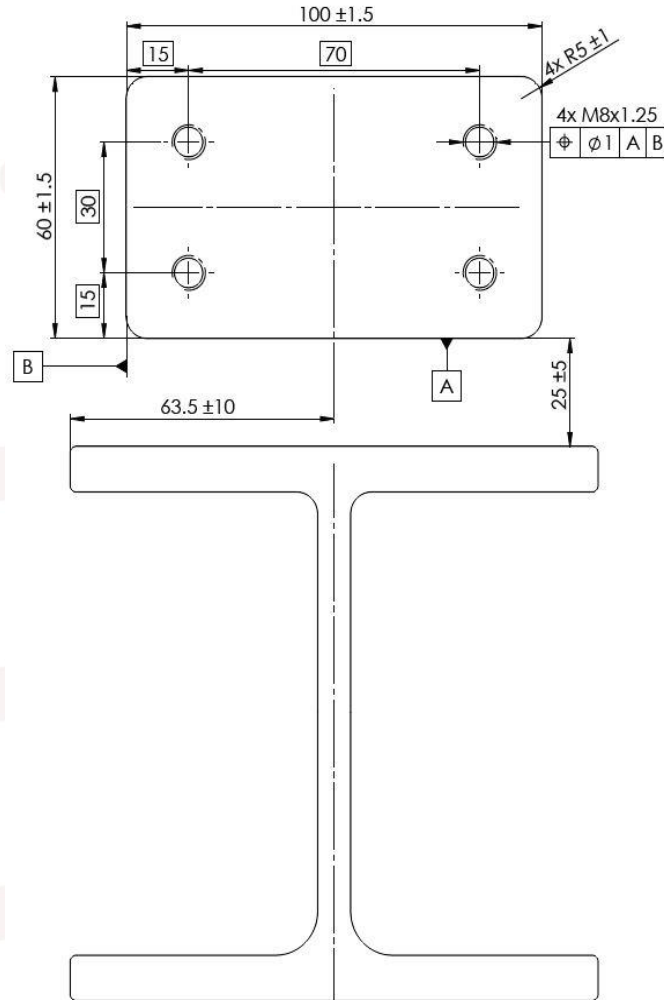


Figure 6. Capsule rescue attachment.

- Permanent or removable lifting eyebolts must be provided on the capsule to allow capsules weighing more than 80 kg to be transported in the competition area and to be placed on and off the platforms.
- A Network Access Module will be given to all teams during the competition. Teams have to reserve a place in their capsules where the Network Access Module can be mounted. The Network Access Module plate should be mounted inside the capsule parallel to the concrete surface inside the pipe, and the kits should provide 4 M6x1, 20mm high mounting holes as shown in the Network Access Module drawing. The

size of the plate specified as 300 mm is the size of the capsule in the direction of progress.

- The general dimensions of the Network Access Module and the Network Access Module plate are given in Figure 9 and Figure 10. The teams are responsible for accessing the encapsulated Ethernet and power cables to the volume reserved for the Network Access Module. Also, teams using in-capsule cameras will be responsible for the camera Ethernet cable reaching the module. The Network Access Module can be closed for aerodynamic purposes, but attention should be paid to the material's electromagnetic permeability. (For detailed information, see B.2.4 Communication with Capsule)
- A safety relief valve should be added in case the pressure in the propulsion and brake systems exceeds the targeted pressure value in pressurized cylinders.

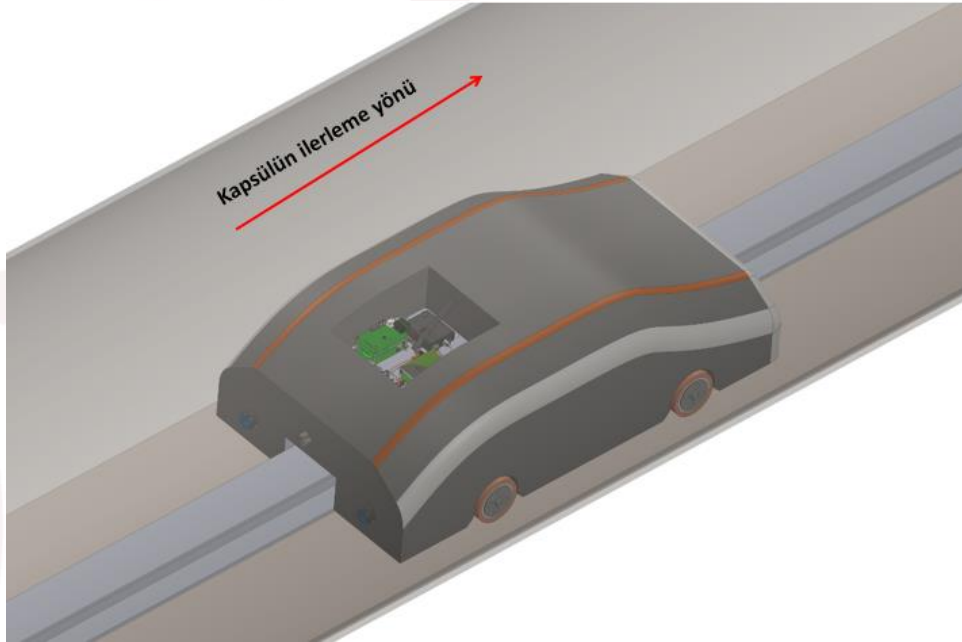


Figure 7. View of the network access module assembled capsule.

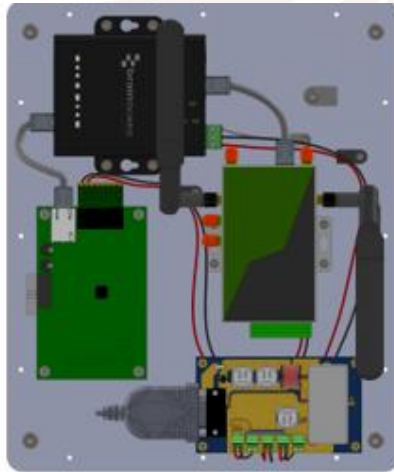


Figure 8. Network access module.

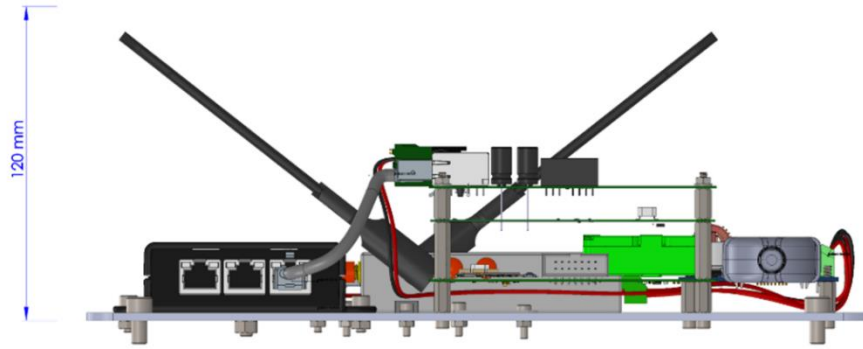


Figure 9. Network access module height.

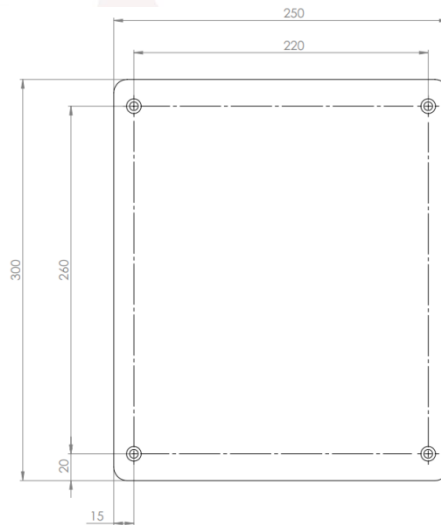


Figure 10. Network access module plate mounting holes dimensions.

B.2.2. Capsule Motion System for Test and Repair

The developed capsule should be designed to be able to move in both directions, even when the levitation and propulsion system is not active, within the scope of the tunnel entrance, safety control, and preliminary evaluations. Various methods such as physical pushing, lifting or remote control can be used to move here.

B.2.3. Brake System

The capsule must be able to come to a complete stop with the braking system. Aerodynamic, magnetic, and mechanical braking systems can be used as braking systems. All these systems must work together in an emergency to stop the capsule. A braking system on the rails will not be provided to the teams. Each capsule must have its own braking system, and it is the team's responsibility to ensure the safety of the capsule.

- The force applied to the rail in the mechanical brake system should be distributed symmetrically over the rail T-zone. One-way mechanical brake applications on the rail will not be accepted.

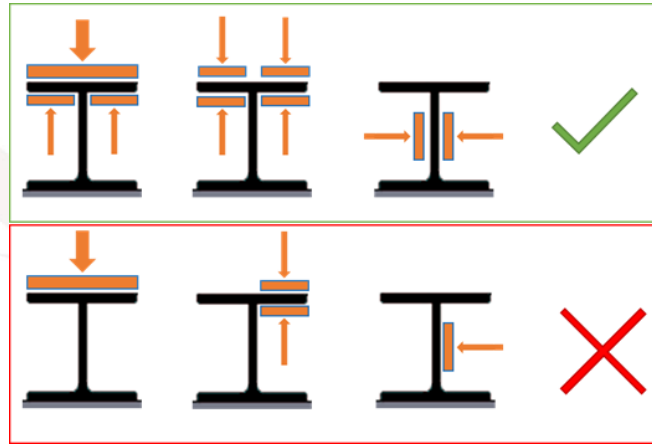


Figure 11. Force to be applied to the rail by the mechanical brake system.

- The surface hardness value of the braking equipment in contact with the rail in the brake systems to be made through metal-to-metal friction must be lower than the rail hardness value.
- The heat generated by the braking effect should be designed so that the rail temperature does not rise more than 30°C.
- Teams should report the analysis results to show the scenario of stopping the capsule in motion.
- The g-force acting on the capsule during braking should be calculated for each moment during the movement, considering the maximum acceleration performance, and displayed with a graph. The deceleration-acceleration of the designed capsule should be measured by the speed sensor during the brake test and displayed simultaneously.
- According to the mechanical and geometric properties of the rail, the moment acting on the capsule under the maximum braking force should be calculated and the results should be reported.
- In case of using a mechanical brake system, the hydraulic fluid sealing of the brake mechanism with a hydraulic circuit must be met in accordance with the standards.
- In the case of hydraulic brake use, in order to prevent the brake main center from moving more than the normal operating condition as a result of operating fluid leakage, it is necessary to cut off the electricity of all critical components on the capsule with a switch to be placed behind the brake main center and to reduce the possibility of fire if the capsule cannot stop. This system will be checked before the competition.
- The emergency button should be able to be controlled from outside the tunnel and should completely stop the capsule in case of need.

B.2.4. Communication with Capsule

The main purpose of communication is to transfer useful data and commands between the capsule and the team safely and stably, providing relevant controls and determining performance criteria. This situation reveals the importance of communication link quality. Since the Hyperloop tunnel is made of steel and both ends are closed during the competition, it exhibits the feature of a Faraday cage.

Therefore, conventional wireless communication equipment used in free space cannot be used efficiently. To overcome this situation and increase the communication link quality and performance, system communication is supported by installing beam emitter cables along the hyperloop tunnel.

With the network connection to be established between the capsule and the remote-control computer on the day of the competition, the teams will be able to send and receive control commands and sensor data bi-directionally and wirelessly. Network Access Module (NAM) will be provided to each team by TÜBİTAK to ensure the relevant communication on the day of the competition.

The rules and information required to communicate between the capsule and the remote-control computer in the hyperloop tunnel are given below. In addition, a test environment similar to the network structure used for in-tunnel communication will be presented to the teams beforehand to make communication pre-checks faster during the competition period.

i. Hyperloop communication system architecture

NAM (Network Access Module) will be installed in each competitor capsule within the framework of the relevant communication architecture. There are 2.4 GHz wireless router, vibration recorder, 5 port network switch, DC-DC power supply and power connectors on the module. The structure of the relevant NAM is given in Figure 12.

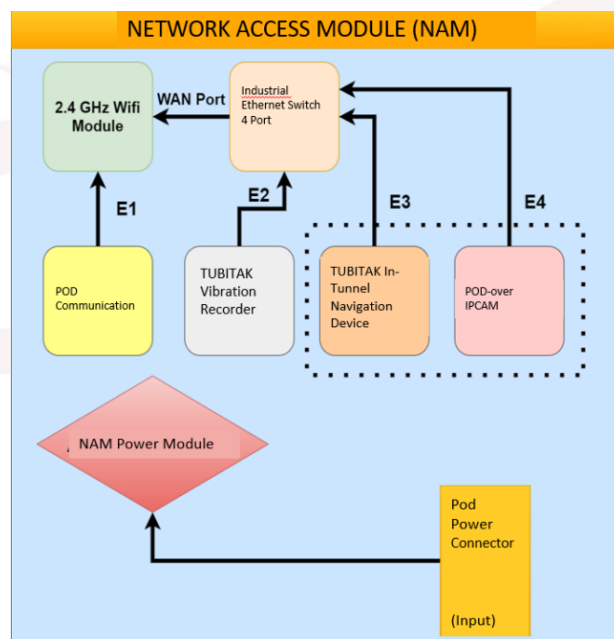


Figure 12. Hyperloop NAM architecture.

The system architecture for the beam emitter cable to be installed in the tunnel and the network devices to be connected to the network to be formed is given in Figure 13. In the related architecture, the beam emitter cable is installed in the 200-meter-long tunnel, as stated in Figure 14, and the 2.4 GHz and 5 GHz communication channels of the router are fed from two MiMo type terminals. In this way, the losses in the signals sent by the network device driving the beam-spreading cable along the line are tolerated end-to-end, and the signal quality is increased.

The 2.4 GHz band is set for the communication of the systems on the capsule, while the 5 GHz band is set for the communication of the wireless cameras in the tunnel. Besides, while the maximum bandwidth provided in 2.4 GHz is 300 mbps, this value rises to approximately 900 Mbps in the 5 GHz band. If the capsules are planned to reach higher speeds, the communication infrastructure can be upgraded by choosing a 5 GHz router to provide better communication quality and higher bandwidth. TÜBİTAK has the right to change the specified communication band selection if it wishes.



Figure 13. Connection of beam emitter cable to network device.

HYPERLOOP COMMUNICATION ARCHITECTURE

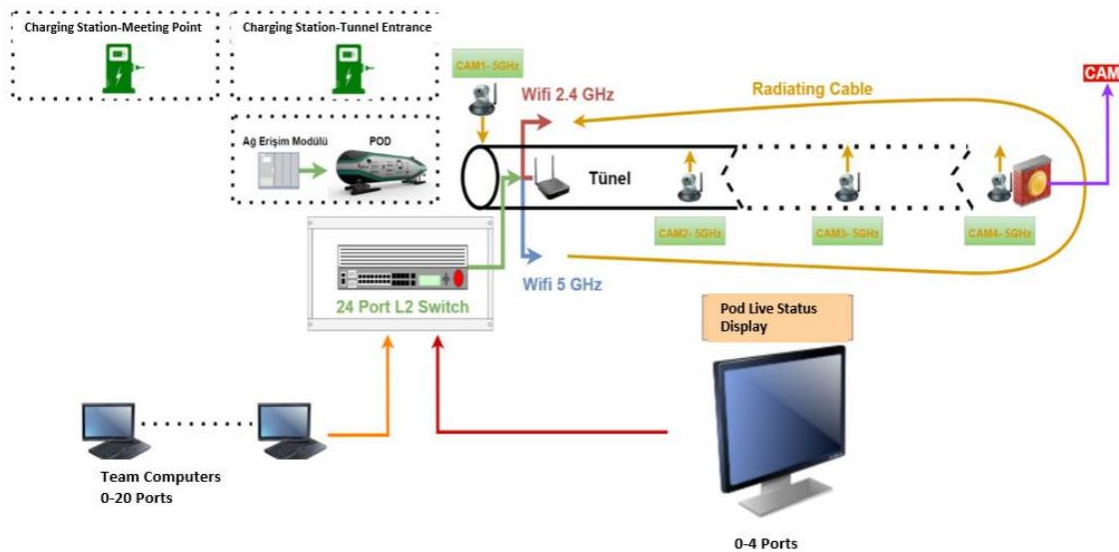


Figure 14. Hyperloop communication architecture.

ii. Hyperloop communication rules

- The connection to the capsule will be via an Ethernet network bridged between the tunnel entrance area and the capsule. TÜBİTAK will provide all the necessary infrastructure for the specified ethernet network and will use a beam-spreading cable extending along the upper part of the tunnel. Through the infrastructure provided, the teams will be able to establish communication between the tunnel entrance area and the capsule directly via the local network.
- The bandwidth allocated to the capsule is subject to change, but the expected bandwidth requirements should not exceed 20 Mbps.
- The network delay between the capsule and the tunnel entrance area is expected to remain <10ms.
- Network access to the capsule is expected to be continuous while the capsule is in the tunnel entrance area or inside the tunnel. If the network connection is interrupted for any reason, the capsule must enter a safe state.
- The connection to the specified network will be provided only by the team's equipment, which is the turn to enter the tunnel. This situation has been determined to prevent communication conflicts that may occur between teams.
- Since the teams will not be provided with any general-purpose internet use on the day of the competition, the teams are required to provide their internet connection with their own GSM-based router, hotspot devices, etc., when necessary.

iii. IP addressing

- Teams will be allocated a static 8-bit subnet 192.168.1.0/20. Teams will be able to allocate IP addresses in the specified subnet as they wish. There will be no DHCP or DNS servers on this network. No external connection to the network shall be made in any way. Teams will not be able to bridge or remotely access the specified network.

iv. Tunnel entrance area network access

- Teams will be provided with a 24-port ethernet switch in the tunnel entrance area. The specified ethernet switch will only be used for network access to the capsule. Teams will be able to determine for themselves how these ports are allocated.

v. Capsule network access

- The 300 x 250 x 120 mm NAM and all necessary network bridge equipment will be provided to the teams in the tunnel entrance area. Teams will mount the NAM parallel to the tunnel floor, facing the rear upper surface panel of the capsule. Also, care must be taken to ensure that there are no metallic obstructions behind or above the panel on which the specified NAM is mounted.
- Teams should provide M6x1-20mm mounting holes in the locations shown in the NAM drawing. A gap of 2 cm is expected under the NAM with the layout panel. If

propulsion is provided by compressed air, the NAM should not be placed below this section. The weight of the NAM is around 1.3 kg. If the NAM is to be placed inside the capsule for aerodynamic or other purposes, fiberglass-like materials with low RF emission loss at 900 MHz and 2.4 GHz should be used. Materials such as carbon fiber are likely to cause significant attenuation of RF signals, resulting in communication losses. Hence, these and similar signal-attenuating materials should not be used to position the NAM in the capsule.

- Power input to the panel will be provided with a DB9 male panel mount connector. NAM (Pin 5 ground; Pin 9 power), which has a power consumption of around 40 W, should be supplied with a 12-36 VDC voltage by the capsule. The panel will have 5 RJ45 ethernet sockets. Teams are expected to connect the capsule's network to these sockets and optionally connect a mini IPCAM (2 MP, HD 1080 x 1920P, max Fps: 30, with POE) that will provide an additional bonus.

vi. Alternative NAM assembly

- An NAM mounted as recommended, includes antennas in the appropriate mounting configuration to enable communication, but this may not work effectively for all capsules. Hence, teams can choose to purchase and use their own extension antennas at the NAM provided. In this case, teams can mount the NAM at any convenient spot on their chosen capsule.
- The approved antenna is indicated in the link for teams that want to use their own antenna:
<http://www.l-com.com/wireless-antenna-900mhz-to-25ghz-multi-band-2dbi-1-4-wave-blade-antenna>
- Two of the specified antennas must be mounted on the capsule. When mounting the antennas, their front faces should be on the top and positioned 90 or 180 degrees between them to increase the link quality. Besides, it should be ensured that the viewing areas of the mounted antennas to the upper side of the tunnel are not obstructed by any conductive objects.

vii. Content of telemetry between the capsule and remote control computer

- The obligatory data to be included in the payload transmitted bi-directionally between the capsule and the remote control computer (the capsule control computer of the Teams) are listed below, respectively. On the test tunnel where capsule controls will be carried out before the competition, the relevant TÜBİTAK personnel will check whether the aforementioned data is received correctly on the remote control computer user graphic interface (GUI).
- If the required data cannot be provided in the relevant parameter controls, the report score of the teams will be reduced. Apart from the mandatory data to be displayed on the GUI, there is no harm in adding different parameters to the GUI.

1. The parameters given below will be displayed on the GUI with a minimum update rate of 1 Hz:
 - a. Position in the tunnel (X, Y and Z)
 - b. Speed inside the tunnel (X, Y and Z)
 - c. Acceleration inside the tunnel (X, Y and Z)
 - d. Capsule orientation (roll, pitch and yaw)
 - e. Capsule pressure (Available only if pressurization is used)
 - f. Temperature taken from at least two points on the capsule
 - g. Power consumption
2. Capsule stop command: It is imperative that the capsule be stopped safely by sending a remote command. Therefore, the stopping process can be done with software and hardware content, or it is appropriate to do it by activating the physical units immediately with the relevant command.

B.2.5. Propulsion System of the Capsule

No tower or launcher-like propulsion system is integrated into the structure to activate the capsules in the tunnel where the competitions will be held. Therefore, teams will use their own propulsion systems to move their capsules. I

In order for the capsules to be moved, they must be movable at low speeds during non-competition moments, regardless of the propulsion systems selected. This movement must be physically possible by pushing the capsule, physically lifting it, or using remote control. All parts of the propulsion system of the capsule must be with the capsule throughout the competition (taking it into the tunnel, completing the competition, and taking it out of the tunnel), so no parts or modules from the capsules should be left inside the tunnel.

The capsules can be removed from the tunnel on their own or they can be pulled out with towing apparatus that will allow them to be pulled from the entrance and exit of the tunnel.

Advanced electric motors (high speed or linear induction or linear synchronous etc.) can be used to move the capsules. The electric motors and propulsion system parts selected by the teams must comply with the technical specifications shared in this document regarding the competition tunnel (electromagnetic effects, physical structure properties such as the geometric dimensions of the rail, pressure inside the tunnel, etc.). The technical data and (if any) certificates of the electrical-electronic parts to be used should be documented.

The propulsion system to be used should not cause physical damage to the rails and the equipment in the tunnel. If thrust is provided by contacting the rails (wheels, etc.), the system must be in a structure that will not damage the rails (abrasion, scratching, etc.).

In the case of using structures that will not physically contact the rail, such as a linear motor for propulsion, the system should not cause a temperature rise of more than 30°C on the rails.

Suppose pressurized gas propulsion systems will be used to move the capsules. In that case, it is stated that the design-related elements, the details of the engineering calculations, and the part and material specification list should be reported according to the items specified in the "A.5.2. Technical Design Report" sub-heading. The basic requirements for the compressed gas propulsion system, which must be taken into account during the preparation of this technical report, are explained in the following items.

- Pressurized gas to be used in the propulsion system:
 - It should not be reactive.
 - It should not be toxic.
 - Air should be selected from non-flammable and non-combustible (not combustible with air and/or oxygen at any concentration) gases such as nitrogen (N₂), carbon dioxide (CO₂), and helium (He).
- The appropriate standards (for example, TS EN 13322-1, TS EN 13322-2, Portable Pressure Equipment Regulation, etc.) should be determined and selected by the teams according to the type, temperature, pressure value, and volume of the gas planned to be used for the pressure container (seamed-seamless cylindrical or spherical tube) to be used in the system. Design studies should be carried out regarding the selected standard(s).
- Pressure vessels, of which the teams determine dimensions and technical features according to appropriate standards, can be supplied ready-made from the market. In this case, the type approval of the container must be obtained, and the relevant information must be marked on it by the standards (for example, EN ISO 7225:2007+A1:2012, TS EN ISO 7225/A1, etc.) (position, manufacturer information, container number, etc.).
- Suppose a non-type-approved container is to be supplied or manufactured. In that case, it is necessary to test and report from accredited institutions or organizations that sufficient strength is provided for the container by considering the test standards suitable for the loads in the design conditions, and marking-labeling should be done on this container.
- The valve to be used for filling, discharging and integrating the container into the system and the manometer for instant mechanical pressure measurement must be connected and sealed. Manometer calibration should be documented with a product certificate or documents to be prepared by authorized testing institutions.
- The system must have certified and calibrated electronic pressure gauge(s) and electronic temperature gauge(s). These do not have to be on the pressure container, but they must be on the installation. It should be integrated into the electronic system (with a communication interface such as RS-485, RS-232, or

CAN-Bus) that instantly transmits data from a distance and displays the pressure and temperature values of the gas. The operating temperature ranges of these meters should be selected by the temperature of the gas to be used in the system and should be supported by the product certificate (certificate).

- The system must have an electromagnetic valve(s) with which the user can remotely control the gas flow during the competition. It should also be integrated into the electronic system (with a communication interface such as RS-485, RS-232 or CAN-Bus), as in the electronic pressure and temperature gauge(s). The operating temperature range of these valves should be selected by the temperature of the gas to be used in the system. It should be supported by the product certificate (certificate).
- The TNT equivalent to be found as a result of the energy to be calculated according to the formula below (thermodynamic availability method) for the pressure vessel should be less than 0.5 kg.

$$E = P_2 V \left[\ln \left(\frac{P_2}{P_1} \right) - \left(1 - \frac{P_1}{P_2} \right) \right]$$

where

E : Energy of the compressed gas (kJ) P_1 : Ambient absolute pressure (MPa)

P_2 : Container absolute pressure (MPa) V : Container Volume (L)

1 kg TNT: 4.184 kJ

- In the engineering calculations and design works to be carried out, it should be considered that the pressure inside the tunnel will be at a minimum of 0.1 bar (absolute) and the maximum open-air pressure value and the capsules must be operable within the relevant range.
- All kinds of instruments and/or devices that are planned to be used for measurement and data recording during the storage and transportation of the system must have calibration certificates.

B.2.6. Levitation System

Teams can participate in races in the 208-meter-long competition tunnel using either the electromagnetic levitation system on an aluminum track or the electromagnetic levitation system on a newly installed steel track.

B.2.6.1. Levitation in Aluminum System

As done in previous years, teams can develop electrodynamic levitation systems within the competition tunnel. The relevant levitation systems of the teams will be examined and evaluated during the pre-competition control, and their assessment will be determined based on the points obtained from the progress and technical design report.

In the aluminum system, teams that perform levitation will compete in the racing tunnel with their developed levitation systems after successfully passing pre-race checks.

B.2.6.2. Levitation in Steel System

To support the development of levitation systems with lower power consumption, teams are expected to request levitation improvements in steel systems.

In the steel system, teams that want to work on levitation are required to meet the requirements/conditions stated in the Technical Design Report. Teams developing steel systems will test their developed technologies either in their own infrastructure or in the infrastructure planned to be established at TÜBİTAK campus.

The initial draft plan regarding the planned infrastructure installation is provided in Figure 15. The handbook will be updated with any changes that occur during the production process, and teams will be informed through announcements.

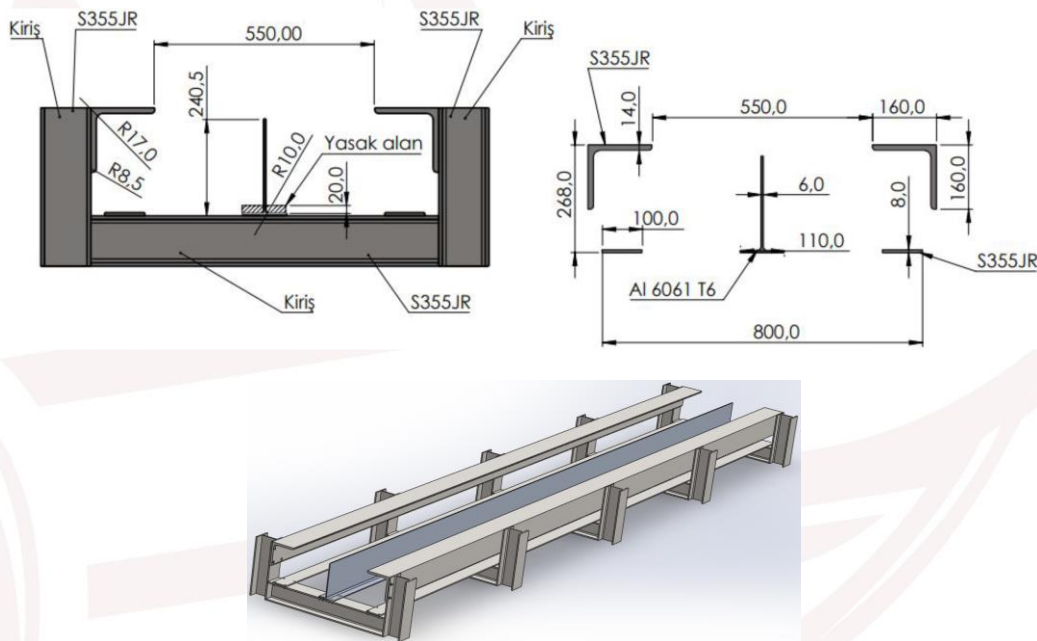


Figure 15. Steel system with levitation draft infrastructure.

The Steel Levitation System Award will be presented separately based on the score in the developed levitation system's technical design report and the performance of its implementation.

B.3. Pre-Competition Controls

In the 2024 leg of the competition, your vehicles must be equipped with a specific ability: they must either be able to move with levitation or generate propulsive force with a linear motor.

This requirement has been established to assess your performance during the competition and the technical capabilities of your vehicle. At least one of your capsules must demonstrate one of these abilities during the competition.

Please note that teams that fail to demonstrate the levitation or linear motor feature during the control stages will lose the right to participate in the speed trials. Being able

to demonstrate at least one of these features in your vehicle will allow you to participate in the speed trials of the competition.

Teams must pass the following checks before entering the tunnel. Only the team captain and 2 team members will be allowed to enter the technical control area, and advisors are not allowed in the technical control area. All kinds of communication, objections, and answering technical questions must be carried out by the team captain or the team members to be assigned by him/her.

Teams can upload a "5 min., 30 mb" long video to the area to be shared with the teams, in which the general capsule presentation, the explanation of the sub-components, and the security systems are specified before the competition.

1.Capsule Security Check

- Check whether there are anchor points and whether balanced lifting can be ensured.
- Check whether the capsule is lifted and balanced after installing the eyebolts.
- The capsule and the control computer are disconnected, and the capsule's emergency braking system is checked for activation.
- Checking the location and robustness of the drawbar that allows the capsule to be retracted in case it remains in the tunnel
- Check whether there are any safety precautions for fire, etc.
- Safety control of elements such as regulators and relief valves of pressure vessels
- Safety inspection of battery equipment, IMS, and materials used in battery packaging

2.Measurement Control

- Capsule weight control
- Capsule length control
- Capsule cross-section check (taking into account pipe diameter, prohibited areas, and equipment area)

3.Movement and Braking Control

- Checking that the capsule can be moved by physically pushing it when it is not working
- Checking capsule stability
- Communicated brake control
- Communicated emergency brake control

4.Levitation System Control

- Levitation/did the capsule levitate (for rotary disk)
- Was team able to demonstrate the levitation adequately by calculation/analysis?

5.Propulsion System Control

- Was the Propulsion/Capsule able to move?
- Was team able to show the Propulsion System with calculation/analysis?

6.Navigation System Control

- Were the 6 reflector strips in the 6-meter tunnel read?
- Has the location and speed been determined using the read reflector strip information?

7.Communication System Control

- Is the mounting location of the NAM on the capsule mechanically suitable?
- Is appropriate cabling used in the chassis grounding of the NAM?
- Is there any metallic obstruction that disturbs the LOS (Line of Sight) of the NAM in EM terms / is a suitable extension antenna used?
- Is the cabling used for NAM and IPCAM a CAT6E or higher shielded product?
- Are static IP assignments made for the remote control computer, capsule control computer, and IP-cam if used?
- Can remote control computer IP change be done parametrically?
- Are the mandatory parameters displayed appropriately on the remote control computer interface?
- Can capsule acceleration data be recorded?
- Has the mandatory STOP command been added to the remote control computer interface?
- Is the communication between the capsule control computer and the remote control computer smooth?
- Is an IP camera available?

B.4. Carrying the Capsule, Tunnel Entry and Exit Rules

The details of how the capsules of the teams that have passed all technical controls will be taken to the competition are given below. Teams are expected to come prepared for these procedures.

- 1.**The capsule will be taken into the tunnel via a hydraulic platform, 4 meters long and 1 meter wide, with a maximum lifting capacity of 500 kg.
- 2.**Capsule weight can be up to 250 kg.
- 3.**Capsules weighing 80 kg or less can be placed and lowered manually on the hydraulic platform. In this case, the maximum weight lifting limit allowed per person will be 20 kg. A maximum of 5 people should take part in the lowering and lifting of the capsule, and the rules specified in the Occupational Health and Safety regulations must be followed. There should be clearly marked lifting points for each person on these capsules.

4. Lifting equipment will be used to lift and lower capsules weighing more than 80 kg to the hydraulic platform. These capsules should contain details suitable for attachment to lifting equipment.
5. The lifting equipment to be used for putting the capsules on and off the platform will be provided by TÜBİTAK.
6. The teams are responsible for bringing their capsules from their tents to the competition area.
7. A maximum of 4 people will be allowed to work while pushing and pulling the capsules into the tunnel.
8. Capsules may enter and exit the tunnel from the same place, or the other end of the tunnel may be used for exit.
9. Capsules must be able to move in both directions on the rail. For capsules that cannot move in the reverse direction, there must be no structure to prevent the capsule from being pulled out of the tunnel. (For example, the brake must be able to be opened at the end of the competition, and the capsule must be able to move. It should not damage the rail during capsule pull. Suppose there is a possibility of damaging the rail. In that case, the magnetic rise must be active to avoid contact with the rail, or the desired energy, pressure, etc. source must be provided to the capsule to activate it later.)
10. After the level alignments of the guide rail on the lifting platform and the rail in the tunnel are made, the capsule will be taken into the tunnel and placed on the start line.
11. The tunnel hatch will be closed.
12. When requested by the team, the vacuum process will be started in the vacuum tunnel.
13. The capsule will start the competition when the contestants are allowed to exit.
14. At the end of the competition, the capsule will advance at a low speed behind the competition start line and wait. (The capsule that cannot come will be pulled after the tunnel cover is opened.)
15. After the pressure equalization is achieved, it will be notified that the cover is ready to be opened.
16. The authorized staff will open the cover.
17. Capsules that cannot come to the starting position will be pulled and brought to the starting position.
18. Alignment of the lifting platform rail and the tunnel rail will be done.
19. The capsule will be removed from the tunnel and placed on the platform.
20. The capsule will be safely removed from the platform.

There may be changes in the specified procedure due to the design of the tunnel and compressor systems, in which case the competing teams will be informed in advance.

Figure 16 shows a visual of the platform designed for the capsules to enter the tunnel.

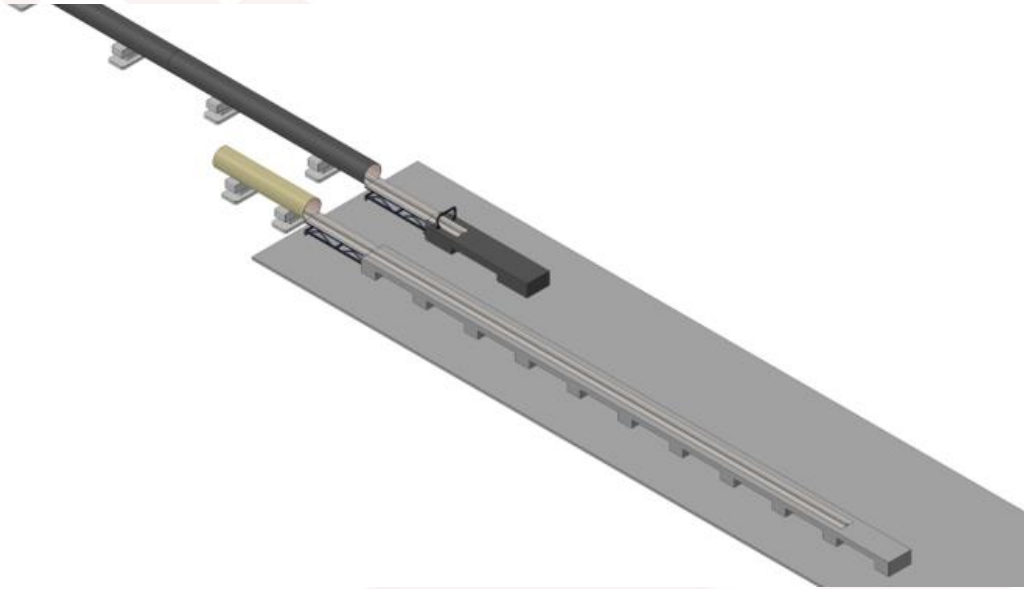


Figure 16. Tunnel entry platform.



Figure 17. Competition area top view.

B.5. Tunnel Area and Features

The infrastructure where university students can test their design capsules has been established at TÜBİTAK Gebze campus. The tunnel infrastructure and technical features are designed so that the capsules can compete in international equivalent competitions.

The sections where the competing teams will complete their preparations, the audience areas and the control areas, as well as the areas where the dynamic and

safety pre-tests of the capsules will be made and the Hyperloop tunnel line where the competition will be held, are given below. The sketch of the competition area is shown in Figure 18.



Figure 18. Competition area map.

The layout of the competition includes the following parts:

- 1.** Audience Section
- 2.** Team Tents Section
- 3.** Technical Control Area
- 4.** Capsule Vacuum Test Area
- 5.** Vacuum System Area-1
- 6.** Hyperloop Tunnel

One phase 220 V AC, 50 Hz mains voltage line will be in the competition area. Capsules must be supplied with their own charger/converter. The teams are responsible for protecting the capsules and the team's equipment and parts against all weather and environmental conditions in the tents provided for the teams to work in the competition area and during the competition process.

Hyperloop has an infrastructure - available in Figure 4 and Figure 5- that allows the application of the principle of magnetic bearing and propulsion of the capsule along the sectional aluminum rail inside the tunnel. The 208-meter-long tunnel, formed by joining tubes, is on steel-reinforced concrete cradles. The upper area of the tubes is used as an equipment area for the placement of materials required for electrical and mechanical systems.

Figure 19 and Figure 20 show a visual of the tunnel's inside. Teams will be informed about the changes that can be made to the infrastructure.



Figure 19. Inside the tunnel-I.



Figure 20. Inside the tunnel-II.

C. INNOVATION CATEGORY

This year, in addition to the Hyperloop development competition category, it is planned to award Innovation Awards in specific categories to support the development of promising technological concepts.

Innovation Awards aim to innovate, improve, change, and create more efficient processes, products, or services in the field of hyperloop systems. Teams applying to the innovation categories will not be required to provide a fully functional hyperloop vehicle that passes technical control successfully.

Teams who want to apply for innovation awards can apply to the following five categories, which are independent of each other:

- 1.** Electromagnetic Levitation System Development
- 2.** Propulsion System Development
- 3.** Infrastructure Development
- 4.** Communication System Development
- 5.** Mechanical System Development

During the competition week, teams that have applied in these categories are expected to showcase and present their work throughout the year. Only the team captain or team members can participate in the exhibition and presentation.

The innovation categories are not included in the training programs provided to teams. More detailed information regarding the innovation category will be included in future specification versions. The current updates are made to define the boundaries of the current situation.

C.1. Electromagnetic Levitation System Development

Teams should describe their designs under this heading if they want to design a different levitation system outside the scope of the competition. The following information is expected, at least regarding the different levitation systems:

- Selected suspension method
- Differences between the selected suspension method and other levitation systems
- Calculation of loads to be applied to the system (total weight calculation that needs to be suspended, dynamic loads, etc.)
- Sizing of the suspension system (total lifting force, lifting height, operational air gap, etc.)
- Design, calculations, and analysis (electromagnetic analysis)
- Evaluation of analysis results (examining whether the values obtained in the analysis results meet the requirements)
- Levitation system: Amount of heat generation and analysis on rails

- How to ensure the levitation system's control software and the capsule's stability?
- Safety measures to be taken in the levitation system (magnets coming loose, vehicle sticking to the track, high temperature, etc.)
- Feasibility of applying levitation system to hyperloop capsules
- Levitation system's energy consumption under predicted operating conditions

The levitation system that has been designed should be presented during the competition week by teams in the form of a test environment or video presentation, along with the analysis outputs.

C.2. Propulsion System Development

Only linear induction motors are allowed to implement propulsion systems such as the competition tunnel levitation system. Teams wishing to develop a propulsion system other than Linear Induction Motors must describe their propulsion system under this heading. The following information about a different propulsion system is expected, at least under this heading:

- The propulsion technology being worked on and its type (capsule-based LSM, launch-oriented LRM, compressor fan, etc.)
- Hyperloop prototype motor requirements (force, speed, voltage, etc.)
- If there are any limits, such as size, volume, weight, etc., they will be specified.
- Analytical calculations
- Electrical and electromagnetic design and analyses will be explained if you have a propulsion system.
- Motor thermal analyses and cooling methods will be explained.
- The mechanics analyses of the system will be explained.
- If there are aerodynamic analyses, compression ratio
- Feasibility of Hyperloop systems
- The energy consumed by the propulsion system under the specified operating conditions.
- Production method
- Security measures to be taken

The designed propulsion system should be demonstrated by teams during the competition week in either a self-prepared test environment or through a video presentation, along with analysis outputs.

C.3. Infrastructure Development

To successfully implement Hyperloop systems in the future, it is crucial to develop appropriate infrastructure. The safety and efficiency of capsules operating at high speeds depend on the correct design of the infrastructure. Under this topic, teams are

expected to conduct research on how the infrastructure of future Hyperloop systems will be.

- Under the Infrastructure heading:
- Infrastructure structure (Materials used in tunnels, geometries, etc.)
- Infrastructure cost comparisons
- Low-pressure environment control, Vacuum pumps
- Station Central and related infrastructure
- Infrastructure maintenance, repair, and monitoring
- Emergency and Security Scenarios
- The effects of infrastructure on environmental conditions
- Hyperloop route determination considering the geographical structure, demographic characteristics, and transportation demands of our country

Similar studies can be conducted on topics like these. In studies aimed at supporting the integration of Turkey's future transportation technologies, attention should be paid to these topics. In addition to the headings mentioned above, the following headings, in particular, are requested to be addressed.

- A hyperloop tunnel proposal with a length of 2 km (including diameter, required infrastructure for levitation and communication, sizing, etc.).
- To reach sound speeds and test all sub-system components, an infrastructure planning study of at least 30 kilometers in length is required.

C.4. Communication System Development

Hyperloop tunnels exhibit the characteristics of a Faraday cage due to being largely made of steel. As a result, conventional wireless communication equipment used in open space cannot be efficiently utilized. Under this heading, for the communication system inside the tunnel:

- Capsules transfer information such as speed and location
- Communication system architecture
- The communication method used with tunnels

Similar studies can be conducted on these topics.

C.5. Mechanical System Development

In order to ensure the sustainability and safety of future Hyperloop vehicles, the development of mechanical systems is necessary. Specifically, the identification of the most suitable mechanical solutions for issues such as vibrations caused by vehicle movement at high speeds in a vacuum environment, resolving pressure differentials originating from the vacuum environment, and enabling the vehicle to move at high speeds is expected.

Under the title of mechanical system development:

- Reliable and controllable brake hardware
- Despite the possible elevation difference between the rails, the capsule can stay balanced between the rails.
- The safe transportation of the capsule, including in non-functioning condition, from the rails.
- Development of systems that dampen vibrations caused by levitation or high speeds of the capsule.
- Capsule's stability systems guide it on the rails, allowing it to move without deviating from the track.
- Even in emergency braking situations, ensuring the vehicle's safety and preventing the vehicle from disintegrating requires a well-designed chassis and selecting appropriate materials.
- The parts of the capsule that will come into contact with the rails should have a design that does not damage the rails.
- Battery pack assembly onto the capsule safely
- In the tunnel, it is crucial to ensure that no loosely secured parts could detach from the vehicle and cause an accident. Regular inspections should be conducted to identify any such parts.

Similar studies can be conducted on topics related to this article. The visual designs and explanations of mechanical systems should be detailed in accordance with engineering principles.

D. GENERAL RULES

To access the General Rules booklet applicable to the competition, [click here](#).

E. ETHICS

To access the Ethics booklet applicable to the competition, [click here](#).

Declaration of Responsibility

T3 Foundation and TEKNOFEST are not responsible in any way for any product delivered by the competitors or any injury or damage caused by the competitor.

T3 Foundation and organization officials are not responsible for the damages caused to third parties by competitors. T3 Foundation and TEKNOFEST are not responsible for ensuring that teams prepare and implement their own systems within the framework of the laws of the Republic of Türkiye.

Hereby, the Turkish Technology Team Foundation reserves the right to make any changes to this specification.

F. CONTACT

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