



Institution of Mechanical Engineers

Railway Challenge

Rules

A General Rules

(These rules should be read in conjunction with the Railway Challenge Technical Specification)

A1. Railway Challenge competition objective

The Institution of Mechanical Engineers Railway Challenge competition (hereinafter referred to as “the Competition”) requires teams of university undergraduate and postgraduate students and industry-based apprentices and graduates to conceive, design and manufacture a ‘10¼ inch’ gauge locomotive in order to compete against other teams in a series of track based and presentation challenges.

A1.1 To give teams the maximum design flexibility and the freedom to express their creativity and imagination there are very few restrictions on the overall locomotive design. The challenge to teams is to develop a locomotive that can successfully compete in all the events described in the Challenge Specifications in section B of these rules.

A1.2 Teams may use any manufacturing facilities found in a University workshop or small manufacturing company.

A1.3 Teams may take advice from supervisors or mentors or any other source, but they must make all key design decisions themselves.

A2. Vehicle design objectives

For the purpose of the Competition, teams are to assume that they work for a design consultancy producing a design proposal and a prototype for a small locomotive for a large company. The locomotive is to be designed for operation on a 10¼ inch railway but aspects of wider commercial application and transferability to a commercial railway should be considered.

A2.1 The locomotive should have very high performance in terms of traction, energy storage, acceleration, braking and handling and be sufficiently durable to successfully compete in all the track-based challenges described in the Challenge Specifications (refer to section B) and held at the Competition.

A2.2 The locomotive must be fully controllable via a cable or radio link as described in the Railway Challenge Technical Specification.

A2.3 Additional design factors to be considered include: cost, ergonomics, maintainability, manufacturability, and reliability.

A2.4 In addition to the on-track tests, each team will be required to present their design to the large company that is considering the production of a competition locomotive and tender submissions against other requirements for assessment.

A2.5 Each design and its associated submissions and presentations will be judged and evaluated against other competing designs to determine the best overall locomotive.

A3. Timing

A3.1 The Competition will be held from 25th – 29th June 2020 inclusive (hereinafter referred to as “the Competition Weekend”).

A4. Location

The Competition will provisionally be held at the Stapleford Miniature Railway in Leicestershire. Details of the Stapleford Miniature Railway are available at www.fsmr.org.uk. ****The Stapleford Miniature Railway is a privately owned railway on a private estate and to avoid disturbing the owners all discussions related to the Railway Challenge event and arrangements to visit the railway must be made through the Institution of Mechanical Engineers.****

A5. The Competition

The Competition will consist of a number of ‘challenges’ to assess the various aspects of the design. Full details of the challenges are provided in Section B.

A6. Rules authority

The Railway Challenge Rules are the responsibility of the Railway Challenge Committee and are issued under the authority of the Railway Division of the Institution of Mechanical Engineers.

A6.1 The current Railway Challenge Rules will be posted on the Railway Challenge web site (<https://www.imeche.org/events/challenges/railway-challenge>).

A6.2 Official announcements from the Railway Challenge Committee will be posted on the Railway Challenge web site and shall be considered part of, and shall have the same validity as, these rules.

A6.3 Ambiguities or questions concerning the meaning or intent of these rules will be resolved by the Railway Challenge Committee.

A6.4 Questions about the intent or meaning of a rule may be addressed to the Railway Challenge Committee and, where appropriate, responses will be posted on the Railway Challenge web site.

A7. Rules compliance

By entering the Competition, the team, members of the team as individuals, supervisors, advisors, mentors and other personnel associated with each team agree to comply with, and be bound by, these rules and all rule interpretations or procedures issued or announced by the Railway Challenge Committee.

A8. Right to impound

The Institution of Mechanical Engineers as the Competition organiser reserves the right to impound any onsite registered locomotives or related equipment at any time during the Competition for inspection and examination by the organizers, officials and technical inspectors.

A9. Restriction on use

Teams are cautioned that the locomotives designed in compliance with these Railway Challenge Rules are intended for operation during the Competition only. This clause is not intended to limit the use of locomotives to the Competition, rather to indicate that the organisers do not accept liability of the locomotive if used in any other event.

A10. General authority

The Institution of Mechanical Engineers reserves the right to revise the schedule of the Competition and/or interpret or modify the Railway Challenge Rules at any time and in any manner that is, in their sole judgment, required for the efficient and safe operation of the event.

A11. Team size

Teams must comprise no more than 15 team members.

A12. Individual eligibility

Eligibility is limited to individuals who at the time of the Competition are either:

- a registered student on (or a graduate of no more than two years from) a taught engineering course at a UK university or recognised overseas university;
- a current member of an MPDS scheme and have been registered for no more than two years;
- a registered apprentice (or individual having completed an apprenticeship within the last two years).

A12.1 Institution of Mechanical Engineers membership

All team members must be affiliate or associate members of the Institution of Mechanical Engineers, or the equivalent membership grades of another Engineering Council affiliated professional body (or international equivalent) in the calendar year in which the Competition takes place.

A12.2 Age

All team members must be at least eighteen years of age at the time of the Competition.

A12.3 Returning team members

No team may have more than 40% of its team members who have been members of a previous Railway Challenge team.

A13. Insurance

A13.1 Teams are required to confirm that adequate insurance is in place, including but not limited to public liability insurance (minimum £15m) for the team. Declaration that cover is in place for the team's participation at the Competition Weekend must be made via the liability waiver (refer to A14) which must be completed upon registering on site. Teams will not be permitted to participate without this confirmation.

A13.2 Teams from outside of the EU or Switzerland are required to present evidence of medical insurance covering participation at the Competition Weekend. This must be provided with the liability waiver (refer to A14) upon registering on site. Teams will not be permitted to participate without evidence of cover.

A14. Liability waiver

All on-site participants, including team members and supporters, will be required to sign a liability waiver upon registering on-site.

A15. Registration

All team members and supporters who intend to attend the Competition weekend must complete the formal Railway Challenge Competition registration. Details will be available on the Railway Challenge web site at the relevant time.

A16. Team Supervisor

Each team is expected to have a supervisor appointed by the university or company. During the Competition the Team Supervisor is expected to accompany the team to the Competition and will be considered by the Competition officials to be the official representative of the university or company for the duration of the event.

A16.1 Role of the Team Supervisor

The Team Supervisor may advise their teams on general engineering and engineering project management theory but may not design any part of the locomotive nor directly participate in the development of any documentation or presentation. Team Supervisors may not fabricate nor assemble any components nor assist in the preparation, maintenance, testing or operation of the locomotive. During the Competition the Team Supervisors may not assist teams.

A17. Professional assistance

The team may take advice from professional engineers, specialists and other information sources but the information supplied must be given in general terms and not as a solution to the specific challenges. Professional advisors may not make design decisions or drawings. It is the responsibility of the team to explain this limitation to any advisor and the Team Supervisor may be required to sign a statement of compliance with this restriction.

A18. Access to locomotives during the Competition

Only registered team members will be able to work on a locomotive once it has been put on track and only registered team members will be allowed in the designated technical areas.

A19. Safety

A19.1 The safety of team members, representatives of the Institution of Mechanical Engineers or Stapleford Miniature Railway and other persons present during the Competition Weekend is of paramount importance. Teams competing have a duty to ensure that all activities which their members perform during the Competition Weekend are undertaken with the safety of themselves and others in mind.

A19.2 All team members must attend a safety briefing at the start of the Competition Weekend and must comply with any safety requirements or guidance issued by the IMechE.

A19.3 Team Safety Supervisor

Each team must appoint one of its members to be their nominated Safety Supervisor, who will be responsible for ensuring that all activities undertaken by their team during the Competition Weekend are performed in a safe manner, seeking to avoid the risk of endangering themselves or others.

Team Safety Supervisors will be responsible for guiding other members of their team on safety matters, including the highlighting of safety risks and providing instructions (to stop and reassess, for example).

A19.4 Activities with specific safety risks

The following activities during the Competition Weekend have been identified as having potential to compromise safety:

- The unloading of locomotives from, and reloading onto, vehicles used for road transportation;
- Work undertaken on locomotives during the Competition Weekend, and all locomotive movements – particularly those not part of allocated test or Competition runs;
- The Maintainability Challenge (refer to B7), including the jacking and lifting of locomotives.

Teams are required to produce method statements, including risk assessments, for each of the above activities which implement controls to ensure safe methods of working (refer to section A21 for submission requirements).

Team Safety Supervisors must ensure that the procedures and controls detailed in their method statements are followed whenever the above activities are undertaken during the Competition Weekend.

Failure to provide method statements for the above activities may mean that teams are prevented from participating in the Competition Weekend, including the unloading of their locomotives from the road vehicles they arrive on.

The provision of and working to method statements does not necessarily mean that safety risks are adequately mitigated. Therefore, teams shall follow any instructions given to them by Railway Challenge officials regarding safety.

It is advised that Team Safety Supervisors monitor the activities listed above but do not undertake any practical work such that they are better able to supervise their safe execution. This is mandatory during the Maintainability Challenge (refer to B7).

No more than ten team members may undertake work on their locomotive at the same time during the Competition Weekend. However, team's method statements may impose a maximum lower than ten shall be imposed for some or all activities on their locomotive.

A19.5 The Judges reserve the right to impose points penalties on teams for any practice or behaviour during the Competition Weekend which imports a safety risk (refer to section B for further details of penalties).

A20. Drugs and alcohol policy

In line with Industry standards and rules regarding Drugs and Alcohol, no person is permitted to be within the railway environment after consuming any substances – legal or otherwise. This is a zero-tolerance policy. If team members are planning on working on their locomotive at any point, they need to keep this in mind and conduct themselves appropriately.

Anybody suspected to be under the influence of any Drugs or Alcohol within the railway environment will be removed from the railway environment and may be required to leave the site entirely for the remainder of the Competition Weekend.

A21. Document and media submission

Teams are required to submit documentation and other material in accordance with the following table. The methods for submission will be briefed to teams nearer the submission deadlines.

Document	Submission deadline	Relevant section
Outline project plan	Within one month of entry being confirmed	B8.4
Design report (and appendices including a compliance matrix)	Four weeks prior to the Competition Weekend	B8.5
Technical poster	On arrival at the Competition Weekend	B10.3
Innovation article/paper	Four weeks prior to the Competition Weekend	B11.3
Method statements and risk assessments for activities with specific safety risks	Two weeks prior to the Competition Weekend	A19.4
Video showing that a team's locomotive has been tested and running prior to the Competition Weekend	Two weeks prior to the Competition Weekend	Technical Specification 3.4

Failure to provide the required documentation by the defined deadlines may incur penalties. Failure to provide the required documentation altogether may prevent a team from participating in one or more of the Competition challenges.

B The Challenge Specifications

The Competition will consist of a number of 'challenges' to assess the various aspects of the design. Details of these challenges are given below.

Prior to entry in any of the track based challenges a scrutineering process will take place. Any locomotive which fails scrutineering will not be permitted to participate in the track based challenges unless the head of scrutineering decides that the vehicle is safe to run (possibly under limited conditions). In this case the head judge will be informed and may wish to apply a points penalty.

The maximum points available to teams in each challenge will be as follows:

Track Based challenges:

Auto-Stop Challenge	150
Ride Comfort Challenge	150
Energy Storage Challenge	300
Traction Challenge	150
Noise Challenge	150
Reliability Challenge	150
Maintainability Challenge	150

Presentation challenges:

Design Challenge	150
Business Case Challenge	150
Technical Poster Challenge	150
Innovation Challenge	150

Scoring

For the track-based challenges below, one third of the points will be awarded to teams making reasonable endeavours to compete in the challenge. The remaining two thirds of the points will be awarded as follows:

Energy Storage Challenge, Traction Challenge and Ride Comfort Challenge:

The team with the best performance (in accordance with the scoring method described for that challenge) will receive the maximum of the remaining points available. Other teams will receive points (from the remaining two thirds) allocated in proportion to the team with the best performance based on their own performance. Direct proportionality will be used for those challenges where a greater result is better (Energy Storage) while inverse proportionality will be used for those challenges where a lesser result is better (Traction and Ride Comfort).

Noise Challenge:

Teams will score points (from the remaining two thirds) based on the ratio for perceived loudness of their locomotive relative to that of the team with the best performance. This will therefore be calculated using the following formula:

$$P \times 2^{\frac{L_{min} - L_x}{10}}$$

where: P is the maximum points available for the respective part of the challenge

L_{min} is the sound level of the team with the best performance (in dB(A)); and

L_x is the sound level of the team for whose score is being calculated (in dB(A))

Auto-Stop Challenge:

Teams will score points (from the remaining two thirds) based on a normal distribution (bell curve) around the target stopping point (point B) with a standard deviation of 1 applied, a locomotive stopping exactly at point B receiving the full allocation of points. Locomotives overrunning point B by more than 0.1 m will have their points reduced by 20%.

Maintainability Challenge:

The team with the best performance (in accordance with the scoring method described for the challenge in B7) will additionally receive the remaining two thirds of the points available. Other teams will additionally receive points (from the remaining two thirds) allocated in proportion to the team with the best performance based on their own performance. Inverse proportionality will be used.

For the other challenges, teams will be awarded points as follows:

Reliability Challenge:

Teams will be scored in accordance with the rules for that challenge.

Design Challenge, Business Case Challenge, Technical Poster Challenge and Innovation Challenge:

The team with the best mark (in accordance with the mark scheme described for each challenge) will receive the maximum of the points available. Other teams will receive points allocated in proportion to the team with the best performance based on their own mark. Direct proportionality will be used for these challenges.

Penalties

The judges may apply penalties as they feel appropriate for:

- any violation of rules or technical specification identified;
- operational practice or behaviour which impacts on safety or is otherwise considered unacceptable.

The following table provides an indication of penalties which may be applied. The list is not exhaustive. However, penalties will be at the complete discretion of the judges and may differ from those detailed below (for persistent behaviour or dependent on the severity of the incursion, for example). The head judge will provide an explanation to each team leader of any penalties awarded prior to the final scores being announced.

Area	Reason	Penalty applied
Technical Specification Compliance	Affecting operational safety integrity or fairness	50
	Other	15
Gauging	Gauge infringement leading to a structural foul or derailment	50
	Other gauge infringement	15
Operational	Failure to sound horn before locomotive movement	5
	SPAD	50
	Out of control locomotive movement (e.g. no tether or unsolicited move)	100
Maintainability challenge	Safety issue whilst working	20
	Failure to drive in and out under own power	15
	Insecure component, incorrectly torqued fastener, other incorrect arrangement on reassembly (e.g. missing fastener)	25
	Locomotive not in full operational condition at outset or completion of challenge (excluding ability to drive in/out under own power)	25
Rules and Logistics	Affecting operational safety integrity or fairness	50

Awards

The team scoring the most points, taking into account any applicable penalties, will be declared the overall winner of the Railway Challenge. Awards will also be given to the winner of each individual challenge. To receive an award for an individual challenge, teams must be present at the Challenge Weekend.

Logistics

Prior to the Competition, a logistics plan will be provided to teams detailing arrangements for the Competition including how the challenges will be run. This document will supplement these rules and teams will comply with its requirements, particularly where this relates to assessment of the challenges.

Compliance

Within each of the challenges detailed in the Challenge Specifications (refer to section B of these rules), compliance is required to be demonstrated in the compliance matrix (refer to clause 11.2.1 of the Technical Specification). Clauses within the rules for which such compliance is required to be demonstrated are indicated through their underlining.

B1. The Auto-Stop Challenge

Overview

B1.1 This challenge tests the ability of the designed locomotive to automatically stop a hauled load in a controlled manner. Teams will need to consider all aspects of braking system control.

Procedure

B1.2 A lineside distance marker, provided by the team (refer to clause 5.5 of the Technical Specification), will be positioned by the team adjacent to the track at point A.

B1.3 The test locomotive, complete with load vehicles and the auto-stop function enabled, must be driven towards point A to pass it at a speed of not less than 10 km/h.

B1.4 On passing point A, the test locomotive must detect the lineside distance marker and automatically apply the automatic braking mode (refer to clause 5.5 of the Technical Specification).

B1.5 The test locomotive should automatically stop with its front as close to point B as possible. Point B will be positioned 25 m along the track beyond point A. Teams should note that a downward gradient exists from point A to point B.

B1.6 Once the judges have confirmed that the locomotive has stopped, the driver should apply the parking brake.

B1.7 If the locomotive reaches point C, which will be positioned 5 m further along the track beyond point B, the driver must manually apply the brakes to bring the train to a stop.

B1.8 The team shall remove its lineside distance marker from the track at point A on completion of the challenge.

Scoring

B1.9 The distance from point B to the front of the locomotive will each be measured by the judges and used to calculate the score for this challenge.

B1.10 If the driver manually applies any control of the locomotive between points A and C (excluding the audible warning device) the team will not register a score for this challenge.

B2. The Ride Comfort Challenge

Overview

B2.1 This challenge will test the effectiveness of the suspension of the locomotive to isolate the locomotive body from track irregularities and other sources of vibration.

Procedure

B2.2 The test locomotive will need to include a nominated acceleration measurement location as specified in the Railway Challenge Technical Specification. This mounting point must be directly on the body structure of the locomotive and must not be dynamically isolated any further.

B2.3 A tri-axial accelerometer will be mounted at the measurement location and a cable secured leading back to the vibration meter to be operated by the judge in the leading load vehicle.

B2.4 The test locomotive, complete with load vehicles, will be moved to point D.

B2.5 The locomotive must be driven, starting from point D and continuing to stop at point E.

B2.6 The maximum time allowed for the locomotive to be driven from point D to point E will be 6 minutes, requiring an average speed of 10 km/h.

Scoring

B2.7 The accelerations in each of the x, y and z directions will be measured. This value will be used by the judges to calculate the score for this challenge.

B2.8 The accelerations will be measured between 0 and 100Hz and processed in accordance with EN 12299:2009 'Railway applications – Ride comfort for passengers – Measurement and evaluation' (section 6.7.2 – Mean Comfort Standard Method) although the full duration of the run from point D to point E will be used instead of the 5 minute period defined in EN 12299:2009.

B3. The Energy Storage Challenge

Overview

B3.1 This challenge aims to assess how well the locomotive can recover and reuse energy as, for example, when stopping at and restarting from a station.

B3.2 Teams will need to clearly demonstrate to the satisfaction of the judges that only the energy extracted from the braking phase is used in this challenge and describe in the Design Challenge Report how this is to be achieved.

Procedure

B3.3 The test locomotive, complete with load vehicles, will be moved to point E, which will be marked by the judges at a suitable location on the track.

B3.4 The status of the energy recovery system on commencement of the challenge will be confirmed to the judges.

B3.5 Following a signal from the judges, the locomotive must be started and driven towards point F. At a location before point F to be chosen by the driver and indicated to the judges, the primary power source of the locomotive must be disengaged from the drive wheels and from that point energy recovered through braking may be stored in the energy recovery system.

B3.6 No energy other than that gained from braking the locomotive and the coupled load will be recovered to the energy recovery system during the challenge.

B3.7 The locomotive must stop before point F. In addition to being retarded using the energy recovery system, the locomotive's service brake may be applied to stop before point F.

B3.8 The locomotive must remain at a stop before point F for a minimum of one minute and up to a maximum of three minutes. On a signal from the judges, the locomotive may then proceed again in the same direction and should run as far as possible using only the energy recovered to the energy recovery system whilst braking to stop before point F.

B3.9 The locomotive brakes must be applied when it has come to a stop having run as far as possible using stored energy. The locomotive must not restart until the judges' signal has been given.

B3.10 No mass must be lost from the locomotive during the run and the energy stored in the energy recovery system on completion of the challenge will not be less than that confirmed to the judges on commencement of the challenge.

B3.11 No application of sand or other adhesion modifiers to the rails will be permitted.

B3.12 The speed of the locomotive must not exceed 15km/h at any time during this challenge.

Scoring

B3.13 The distance travelled using recovered energy will be measured by the judges and used to calculate the score for this challenge. For locomotives stopping after point F, the distance after point F at which the locomotive initially stopped will be deducted from the distance travelled using recovered energy. The minimum distance achievable for locomotives stopped after point F shall be zero.

B4. The Traction Challenge

Overview

- B4.1 This challenge tests the ability of the designed locomotive to pull a load from a standing start. Teams will need to consider all aspects of traction including motive power, transmission and adhesion. This challenge will be run in combination with the Noise Challenge (refer to B5).

Procedure

- B4.2 The test locomotive, complete with load vehicles, will be moved to point H.
- B4.3 On a signal from the judges the locomotive must accelerate from a standing start and travel to pass points I and J.
- B4.4 The speed of the locomotive must not exceed 15km/h at any time during this challenge.

Scoring

- B4.5 The time taken to travel between points I and J will be measured by the judges and used to calculate the score for this challenge.

B5. The Noise Challenge

Overview

B5.1 This challenge will test the noise emitted by the locomotive. An assessment will be made for pass-by noise with the locomotive travelling at maximum speed. This challenge will be run combined with the Traction Challenge (refer to B4).

Procedure

B5.2 A microphone for measuring pass-by noise will be set up at point J. The microphone will be at a distance of 0.5 m from the track centre and at a height of 0.5 m from the top of the rails. The microphone will be located on a side of the track to be selected by the organisers on the day of the challenge.

B5.3 The challenge will proceed as per the Traction Challenge (refer to Rules B4.2 to B4.4). For the purposes of the noise challenge, the locomotive must be travelling under maximum possible power throughout the challenge, except to prevent it exceeding a speed of 15 km/h where a near constant speed shall be maintained.

B5.4 The test locomotive must be in its normal operating configuration for this challenge. This requires the prime mover to be at maximum power output (provided Rule B5.3 is not infringed). For the purposes of this challenge, the prime mover is defined as that which is refuelled (or recharged) from an external source.

B5.5 Persons on the load vehicles and nearby spectators must remain silent for the duration of the challenge.

B5.6 The test may be repeated if significant background noise which may affect the outcome is apparent during the test run. However, results from the same test run shall be used for the purposes of both the Traction Challenge (refer to B4) and this challenge.

Scoring

B5.7 The measurement time interval will commence when the front of the locomotive passes a point 3 metres before the measurement position (at point J) and end when the rear of the locomotive passes a point 3 metres after the measurement position. The A-weighted equivalent continuous sound pressure level, L_{Aeq} , for the measurement interval will be determined in dB(A) and normalised to a speed of 15km/h using the following formula where v is the actual pass-by speed:

$$L_{Aeq(15km/h)} = L_{Aeq(v)} - 30 \times \log (v/15km/h)$$

B6. The Reliability Challenge

Overview

- B6.1 This challenge aims to assess how reliable the locomotive is at meeting scheduled times and not incurring any undue delay or requiring external assistance.
- B6.2 This challenge will run throughout the Competition Weekend in combination with all scheduled running on each day of the Competition Weekend.
- B6.3 Teams will need to demonstrate fault free running to the satisfaction of the judges.

Procedure

- B6.4 If a team is subject to a delay in service caused by the team or a technical failure of its locomotive, it shall have up to 15 minutes to resume in service after which the judges shall reserve the right to request external assistance. This will reduce to 10 minutes during the run on the Sunday of the Competition Weekend. In the case of rescue, the team will lose opportunity for further testing or completion of challenges in that scheduled run.
- B6.5 Teams should consider their ability to access tools and spare parts in order to meet the requirements of rule B6.4.

Scoring

- B6.6 Teams participating in the event will start out with 150 points. The minimum score attainable at the end of this challenge is 0.
- B6.7 Teams not having provided a video showing that a team's locomotive has been tested and running prior to the Competition Weekend or unable to demonstrate reliability testing verified by a Chartered Engineer (in accordance with Section 3.4 of the Technical Specification) on arrival at the Competition Weekend will have 50 points deducted from their score.
- B6.8 The Competition Weekend will include provision for three locomotive runs per team (one each day of the Competition Weekend and comprising a scrutineering, practice and final run). Teams will have 50 points deducted from their score for each run not undertaken.

B6.9 For each run undertaken, teams will be deducted points as follows:

- 10 points for each scheduled departure time from or arrival time at the station missed where caused by the team or a technical failure of their locomotive;
- 10 points for any other delay in service caused by the team or a technical failure of their locomotive;
- 20 points wherever external assistance is required to recover the locomotive to an operational state.

Deductions in accordance with this clause will be at the complete discretion of the judges.

B7. The Maintainability Challenge

Overview

B7.1 This challenge will test the ease with which major components can be safely removed from the locomotive and then replaced to test the ease with which maintenance can be carried out.

Procedure

B7.2 A method statement and risk assessment must be prepared (refer to A19.4). This must include torque values for any fasteners which are to be removed and refitted during the challenge. The Technical Specification contains additional requirements which must be met with respect to jacking and lifting. The method statement must also comply with the team member limitations specified in rule B7.4.

B7.3 The judges will only permit a team to complete the maintainability challenge if they are satisfied that the method statement and risk assessment demonstrate that the challenge can be undertaken safely.

B7.4 The challenge shall be undertaken by no more than four team members. The safety supervisor, as specified in rule A19.3, must not be one of those team members but must monitor progress for the purpose of complying with the method statement and indicating safety risks to the team members involved (providing instructions as necessary), in accordance with rule A19.4.

B7.5 The locomotive must be moved to a position on the track agreed by the judges. The judges may check that fasteners to be removed and refitted during the challenge are correctly torque tightened and that no additional items are mounted on the locomotive to specifically assist with this challenge.

B7.6 All powered systems on the locomotive must be deactivated and the locomotive must be in a complete and operational state.

B7.7 Team members participating in the challenge must move to the safe distance zone identified by the judges.

B7.8 On a signal from the judges the team members must prepare the locomotive for lifting or jacking to enable the safe removal of one driven wheelset and then return to the safe distance zone.

B7.9 The judges will satisfy themselves that the locomotive condition is safe for lifting or jacking.

B7.10 On a signal from the judges the team members will jack or lift the locomotive, remove one driven wheelset and move it to the location specified by the judges. The team members must then return to the safe distance zone.

B7.11 Once the judges are satisfied that the wheelset has been completely removed, the team members must commence refitting the same wheelset.

B7.12 Prior to lowering the locomotive, the team must satisfy the judges that it is safe to lower.

B7.13 Once the judges are satisfied that the locomotive is safe to lower, the team members must continue refitting the removed wheelset and return to the safe distance zone on completion.

B7.14 Once the wheelset has been refitted and the judge is happy that locomotive is safe to run the team must start the locomotive and move it under its own power to a point specified by the judges, in both directions.

Scoring

B7.15 The time taken for the wheelset to be removed and refitted will be measured and the team with the shortest time will be the winner of this challenge. Times when the team is in the safe distance zone will not be included in the time taken.

B7.16 Successful operation of the locomotive following refitting must be demonstrated for the time to be valid.

B7.17 The judges may check that fasteners which have been removed and refitted during the challenge are correctly torque tightened.

B8. The Design Challenge

Overview

B8.1 The design challenge will take the form of a written report that is submitted to the judges four weeks prior to the Competition Weekend.

B8.2 During the Competition Weekend questions may be raised from the report by the judges during the business case presentation (refer to B9).

B8.3 The report may also be used to raise questions as part of the scrutineering process.

Procedure

B8.4 An outline project plan must be prepared (refer to section A21 for submission requirements). This should be top level only to show the main milestones and the expected completion dates for each. Typical milestones might be: Concept Design; Design Approval; Bench/Laboratory Testing; Track Testing; and the Competition Weekend itself. The plan itself will not be scored, but it will be reflected on in the Design Challenge Report (refer to B8.6).

B8.5 A 'Design Report', including appendices and accompanied by a compliance matrix, must be prepared as set out in the Railway Challenge Technical Specification (refer to section A21 for submission requirements).

B8.6 The design report should include sections on:

- costing;
- maintenance;
- how progress was made against the outline project plan.

Scoring

B8.7 The judges will assess the reports on the following basis:

- How the locomotive design meets the specified requirements;
- The engineering effort that went into the design of the locomotive;
- The understanding of key engineering concepts demonstrated in the report;
- How well the costing has been carried out;
- How well the locomotive has been designed for maintainability;
- General presentation and readability.

B9. The Business Case Challenge

Overview

- B9.1 The Railway Challenge teams are to consider themselves as representatives of a manufacturer that has produced a prototype locomotive which they wish to tender for a locomotive procurement competition.
- B9.2 The Railway Challenge judges have formed a large company, IMERC Limited and wish to procure a number of 10¼ inch gauge locomotives for lease to commercial attraction operators, school/college engineering courses or other application. The locomotive manufacturer shall identify and justify the intended application(s).
- B9.3 The locomotives to be procured shall comply with the Railway Challenge Technical Specification. The locomotive design, particularly innovative features shall be outlined to the IMERC representatives.
- B9.4 IMERC invites interested parties to present a business case for their locomotive with a view to winning an order to supply a fleet of fifty (50) locomotives. The business case presentations shall be made to the executives of IMERC (i.e. the Railway Challenge judges).
- B9.5 Each manufacturer will be evaluated on their ability to convince the executives of IMERC that its locomotive best meets the demands of the proposed end user leasing the fleet, and that the design can be profitably manufactured, sold to IMERC and leased to the end user for economic operation.
- B9.6 Teams should assume that the executives represent different areas of IMERC, including engineering, production, marketing and finance, and thus may not all be engineers.
- B9.7 Whilst IMERC wishes to procure 10¼ inch gauge locomotives, any aspects of a team's locomotive with potential wider commercial application and transferability to the national (standard gauge) railway should be highlighted where appropriate.
- B9.8 Teams should highlight areas where they believe the design of their prototype locomotive could/should be improved for a production fleet.

B9.9 Teams are required to provide a price for the scope of supply, including a breakdown of the associated costs. Teams shall provide a copy of this and any other information to the Railway Challenge judges (playing the role of IMERC executives) at the presentation (refer to B9.12).

B9.10 Teams are specifically required to comment on the environmental aspects of their design and to identify any issues around emissions.

B9.11 For teams that have received a Railway Challenge award, an explanation of how that award has been used should also be given.

Procedure

B9.12 Teams must make a 10 minute presentation to the Railway Challenge judges (playing the role of IMERC executives). Teams may use visual aids of their choosing such as the Technical Poster (refer to section B10). Teams may not use live presentation software (e.g. PowerPoint, Prezi), to support their presentation.

B9.13 Not all team members need to participate in the presentation. However, the participation of multiple team members is encouraged and will form part of the assessment criteria for this challenge.

B9.14 Five minutes of questioning by the judges will follow each team's presentation.

Scoring

B9.15 Presentations will be evaluated in line with the rules detailed above. Additional marks will be awarded for teams' organisation, use of visual aids, presentation delivery and response to questions.

B10. The Technical Poster Challenge

Overview

B10.1 The Poster Challenge requires teams to create a technical poster which informs readers of the design of their locomotive. The posters will be presented at the Competition Weekend for all attending, including spectators, judges and other challenge officials, to gain an understanding of the design concepts adopted in the locomotive design.

B10.2 During the Competition Weekend questions may be asked by the judges about the poster when they are assessing it.

Procedure

B10.3 A technical poster must be prepared following the guidelines contained in the Railway Challenge Technical Specification (refer to section A21 for submission requirements).

Scoring

B10.4 The judges will assess the poster according to the following criteria, each having an equal weighting:

- Visual impact (colour, use of diagrams, etc.);
- Presentation quality (layout, size of lettering, etc.);
- Technical content.

Four judges will assess the poster according to these criteria with the scores individually awarded by the judges then moderated and agreed.

B11. The Innovation Challenge

Overview

B11.1 The Innovation Challenge will take the form of a written submission in the format of an academic journal article or conference style research paper which will describe a novel and innovative aspect incorporated into the locomotive.

B11.2 During the Competition Weekend questions may be asked by the judges about the novel and innovative features of the design when they are assessing the locomotive.

Procedure

B11.3 A short journal article or conference style paper must be prepared following the guidelines contained in the Railway Challenge Technical Specification (refer to section A21 for submission requirements).

Scoring

B11.4 The judges will assess the article or paper on the following basis:

- How the innovation can contribute to the industry's Railway Technical Strategy, specifically one or more of the four Cs (increasing customer satisfaction and capacity, reducing carbon and cost);
- The potential of the innovation to introduce significant change in the industry;
- The novelty which is described within the paper;
- The presentation and structure of the paper.

Appendix 1. Revisions

This is the second issue of the Railway Challenge 2020 Rules.

Clause	Change
A6.1	Website address for the Railway Challenge updated.
B	Order of challenges in list of maximum points revised to be consistent with the order presented in the remainder of section B (which, for track-based challenges, is consistent with the order in which they occur).
B Penalties	Suggested penalty to be applied for the rules and logistics item changed to be consistent with the first item for which the reason is the same,
B6.5	Cross-reference corrected.
B6.6 to B6.9	Points values halved to be consistent with the total points for this challenge in this year's event.