RailSanya 2027

Problem-Solving Competition

High-Speed Railway Train Rescheduling Problem Under Unexpected Emergency Scenarios

Problem Statement

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The 12th International Conference on Railway Operations Modelling and Analysis (RailSanya2027)

1. Introduction

The RailSanya 2027 Problem-Solving Competition addresses high-speed railway train dispatching under operational disturbances and disruptions, such as initial delays, section or station-track blockages, and temporary speed restrictions. The competition asks participants to construct feasible and high-quality rescheduling plans for a dense railway network, given a baseline timetable, infrastructure data, operational parameters, and disruption scenarios.

Train dispatching, also referred to as railway traffic management, is the real-time process of monitoring train movements, detecting conflicts, and implementing corrective actions. In high-speed railway systems, disruption management is particularly challenging because train services operate at short headways, station dwell times are tightly planned, and rolling stock circulation can propagate delays across multiple train services.

This competition focuses on macroscopic train rescheduling and selected resource recovery decisions. Participants are expected to return a conflict-free rescheduled timetable and, when required by the scenario, a revised rolling stock or rescue action plan. The competition welcomes research into operations, artificial intelligence, simulation-based optimization, hybrid methods, and other reproducible approaches.

Scope and problem context

- A realistic anonymized high-speed railway network with multiple corridors converging at major hub stations.
- Scheduled passenger services with different train categories, priorities, stopping patterns, and passenger-weight proxies.
- Stations with limited platforms, turnback capacity, and overtaking or crossing opportunities.
- Track sections with direction-dependent running times, minimum headways, temporary restrictions, and disruption-dependent availability.
- Optional rolling stock circulation and rescue resources (available locomotives or compatible trainsets for towing or clearing disabled trains) for scenario-specific recovery tasks.

The problem is defined at the macroscopic dispatching level. The released data does not require participants to model detailed station routing or interlocking logic. However, all rescheduled plans must satisfy the minimum headway, platform usage, and resource feasibility rules. Route changes refer to rerouting over permitted network links, distinct from stopping-pattern changes and detailed station routing.

Competition task

For each instance, participants receive an undisrupted timetable and a set of disruption records. An instance is a complete input dataset; its scenario specifies the affected objects, disturbance or disruption effects, and permitted recovery actions. Their task is to submit rescheduling plans covering all records in the instance that specifies train event times, platform assignments, train statuses (defined under Decisions below), and, where applicable, rolling stock assignments and rescue actions. The submitted plan should minimize the weighted combination of passenger arrival delay, timetable instability, and operator costs defined in the objective function while respecting safety and operational constraints.

2. Problem Description

The high-speed railway train dispatching problem considered in this competition is a disruption-response optimization problem. A baseline timetable is first released. The scenario then modifies infrastructure availability, the operating status of train services, or the availability of physical rolling-stock units. Participants must construct a new plan that is feasible under the scenario and as close as possible to the original service plan.

Decisions

1. Train timing: adjust departure times and arrival times relative to the original timetable. Any permission for earlier arrivals or departures will be specified in settings.csv.
2. Platform assignment: assign each stopped train to a feasible station track. Non-stopping trains must also be assigned to a feasible station track for passing-through.
3. Stopping adjustment: keep, cancel, or add stops only when the scenario and settings permit such changes.
4. Train status: mark each service as operated, cancelled, partially operated, short-turned, or rescued as appropriate.
5. Rolling stock assignment: for rolling-stock scenarios, assign each operated service to a compatible electric multiple unit (EMU) while respecting circulation feasibility.
6. Rescue action planning: for disabled-train rescue and clearance scenarios (S2), decide rescue resource dispatch, coupling/towing movement, and clearance timing.

Objective function

The competition uses a scenario-specific weighted objective function. Lower scores are better:

The terms are defined below. Exact coefficients will be specified in settings.csv and may differ across public development instances and private challenge instances.

Term	Meaning	Example components
Z_time	Passenger-weighted timetable deviation.	Weighted absolute arrival/departure delay; terminal arrival delay; maximum delay soft penalty.
Z_operation	Operational changes from the original plan.	Platform reassignment, station track change, overtaking/order change, additional waiting.
Z_service	Passenger service degradation.	Cancelled train penalty, skipped stop penalty, short-turn penalty, missed connection penalty.
Z_resource	Rolling stock recovery cost.	EMU reassignment, spare EMU activation, deadhead movement, insufficient turnaround penalty if treated as soft in a trial setting.
Z_rescue	Emergency rescue cost.	Rescue train activation, rescue travel time, disabled train clearance delay, blocking duration.

Each instance will have a scenario-specific objective function composed of the relevant components listed above. All instances include timetable recovery performance, while additional components are activated when required by the scenario, such as rescue-related penalties or rolling-stock recovery penalties. The instance-specific components and coefficients will be specified.

For the final leaderboard, performance will be evaluated across the full set of official instances. The aggregation method, including the treatment of instances for which no valid feasible solution is produced, will be specified in the competition rules.

Feasibility constraints

ID	Constraint	Definition
C1	Event consistency	For each operated train, event times must be temporally ordered along its path. Arrival must not occur after departure at the same station, and departures must respect minimum dwell times.
C2	Running time	For each operated train and each traversed section, the applicable standard running time must be determined according to whether the train stops or passes at the two adjacent stations, including the corresponding acceleration and deceleration time supplements. The realized section running time must not be shorter than the applicable standard running time and may be extended up to 1.5 times that standard running time.

C3	Headway and section conflicts	Trains using the same directed track section must satisfy the released minimum headway rules. For bidirectional or single-track sections, opposing movements must not occupy the section simultaneously unless explicitly allowed.
C4	Platform and station-track capacity	A platform or station track may serve at most one train at a time. Successive trains assigned to the same station track must satisfy the specified minimum reoccupation interval. In particular, the arrival time of a following train at a station track must be no earlier than the departure time of the preceding train from the same station track plus the required minimum clearance interval.
C5	Route continuity and network availability	Each operated train must follow one continuous valid path from its actual origin to its actual destination on the scenario-available network. Blocked links, unavailable platforms, or temporarily closed stations cannot be used during their unavailable intervals.
C6	Stopping pattern and dwell rules	Minimum dwell times and maximum dwell or holding limits must be respected. All stops contained in the original timetable must be preserved for the operated portion of a train unless the train is fully cancelled or the corresponding segment is removed by an explicitly permitted partial-cancellation or short-turn action. The realized dwell time at a served station may be increased or reduced relative to the original timetable, but must not be shorter than the specified minimum dwell time.
C7	Single-schedule uniqueness	Each operated train must have exactly one reported path and one consistent set of timetable events. Splitting a train into multiple unrelated services is not allowed unless represented as a permitted partial-operation or short-turn action.
C8	Unchanged-plan preservation	Trains unaffected by the scenario should remain unchanged unless a change is necessary to resolve conflicts or improve feasibility. Deviations of unaffected trains are permitted only when justified by the recovered global plan and penalized in the objective.
C9	Rolling stock circulation	When rolling stock recovery is active, each operated train must be assigned to one compatible EMU unit. When rolling stock recovery is active, the rolling stock assigned to each operated train must contain at least as many cars as specified in the original plan for that train. A larger composition is permitted, provided that all applicable rolling stock compatibility, platform-length, station-track, and infrastructure constraints are satisfied.
C10	Rescue operation feasibility	When rescue actions are active, rescue trains must start from available depots or stations, travel over feasible paths, respect track conflicts, couple/tow only after the disabled train is reachable, and clear the blocked section before normal operation resumes.
C11	Output completeness	All required output records must be present, well-typed, internally consistent, and aligned with the released input identifiers. Unknown train, station, platform, EMU, or link identifiers are invalid.
C12	Segment blockade	For each released segment blockade, no train may enter the affected segment during the specified blockade interval. A train whose segment-entry event occurs before the blockade becomes effective is not considered to violate the blockade solely because part of its traversal extends into the blockade interval, unless the scenario explicitly specifies a stricter occupancy prohibition. Segment-entry events that have already occurred are exempt from retrospective blockade validation.
C13	Temporary speed restriction	When a temporary speed restriction is active on a segment or specified infrastructure range, a train traversal is considered affected if any portion of that traversal within the restricted range occurs during the effective restriction interval. For an affected traversal, the restricted running-time standard must be applied to the entire corresponding section traversal. The traversal must not be divided into a normal-speed portion and a restricted-speed portion for running-time calculation. Traversals completed before the restriction becomes effective or starting after the restriction has expired use the normal running-time standard.
C14	Occurred-event fixation and validation exemption	Timetable events explicitly marked as already occurred are treated as fixed historical observations. Their reported times and realized infrastructure usage must not be modified by the recovery optimization, and they are exempt from retrospective constraint validation even if they appear to violate running-time, dwell-time, headway, platform, blockade, or other feasibility rules because of dispatching-state inconsistencies or data-acquisition errors. Occurred events may nevertheless serve as fixed boundary conditions when evaluating constraints involving subsequent not-yet-occurred events.

Scenario types

The competition uses three complementary scenario families. They are intentionally designed to test different dimensions of high-speed railway recovery.

Scenario	Name	Core difficulty	Main required output
S1	Multi-disturbance and disruption timetable recovery	Several bounded disturbances (initial delays) and/or disruptions (temporary infrastructure restrictions) occur at the same time, producing severe delay propagation and train-ordering conflicts.	Rescheduled timetable, path/platform assignments, train statuses.
S2	Disabled-train rescue and clearance	A train failure blocks or restricts part of the network. A rescue unit must be dispatched to clear or tow the disabled train while other services are rescheduled.	Rescheduled timetable plus rescue action plan.
S3	EMU circulation disruption and service recovery	The original EMU circulation is broken. Some trains can run only if a feasible unit is reassigned, a spare unit is activated. Therefore, trains might be delayed, or some services are cancelled/short-turned.	Rescheduled timetable plus EMU assignment and service-adjustment plan.

S1: Multi-disturbance and disruption timetable recovery

- Each disturbance or disruption has a known event time or start and end times, as applicable, and affected elements (e.g., train events, segments, or station-tracks). The corresponding record specifies its operational effect, such as an initial delay, blockage, or temporary speed restriction.
- Primary challenge: Multiple disturbances and/or disruptions will happen within the planning horizon.

S2: Disabled-train rescue and clearance

- Examples: a high-speed train stops on a section and blocks one direction; a rescue EMU or locomotive must be dispatched from a depot or nearby station.
- The submitted plan should include the rescue unit, dispatch time, route, coupling time, towing or clearing movement, and clearance time.
- Primary challenge: jointly scheduling emergency resource movement and normal passenger services.

S3: EMU circulation disruption and service recovery

- Examples: a late inbound service cannot provide the planned EMU for its next outbound service; a unit is unavailable due to inspection, maintenance, or failure; only a limited number of spare EMUs are available at hub stations.
- Permitted actions may include waiting for the original unit, reassigning another compatible unit, activating a spare unit, cancelling a service, or short-turning a service.
- Primary challenge: deciding who operates the next train service, not only when the train departs.

3. Input Data Format

The competition dataset will be released as CSV files with consistent identifiers. The table below proposes a clarified file structure.

The input timetable represents a real-time dispatching snapshot and **is not assumed to be feasible with respect to all constraints**. Temporary constraint violations may exist because dispatchers are still modifying the plan or because of measurement and data-acquisition errors. Feasibility requirements are therefore imposed on the recovered timetable for events that have not yet occurred. Events marked as already occurred are treated as fixed

historical observations and are exempt from retrospective feasibility checks. However, occurred events may still be used as boundary conditions when evaluating the feasibility of subsequent, not-yet-occurred events.

File structure

File	Required?	Purpose
stations.csv	Yes	Station-level data: station type, platforms, turnback capability, hub/depot flags.
links.csv	Yes	Directed or undirected track-section data: endpoints, length, running time, track count, directionality, availability.
timetable.csv	Yes	Baseline train-event timetable.
train_info.csv	Yes	Train category, priority, passenger-weight proxy, origin, destination, stopping pattern, cancellation settings.
rolling_stock.csv	Required for S3	EMU unit availability, initial location, compatibility, spare-unit flag.
circulation.csv	Required for S3	Planned train-to-EMU assignment and planned service chaining.
rescue_resources.csv	Required for S2	Rescue units, starting depots, availability, speed, coupling/towing parameters.
scenario.csv	Yes	Scenario records describing disruptions/disturbances, rescue tasks, or rolling stock disruptions.
settings.csv	Yes	Global and scenario-specific parameters, penalties, headways, dwell rules, and validation thresholds.

4. Solution Output Format

Participants must submit solution outputs in the file format and template specified for each competition stage. During the online competition phase, submissions will follow the format required by the competition platform.

The output must be sufficient for the validator to reconstruct each operated train movement, platform occupation, rolling stock assignment, and rescue action. Detailed file templates, field definitions, and validation requirements will be provided with the competition data and evaluation package.

Final submission package

Each team must submit the following materials by the final submission deadline:

- Final solution files for all required public competition instances;
- A technical report describing the methodology, modelling and algorithmic approach, treatment of different scenarios, main parameter settings, computational environment, and computational results; and
- A runnable implementation, source code, model and parameter files, and execution instructions for confidential evaluation by the organizers (public code release is not required), plus any additional materials specified in the final submission instructions. The code will be kept private, used only for this check, destroyed afterwar the competition is ended, and is remaining in the intellectual property of the authors.
- Each team must submit a technical report in English in PDF format, using A4 page size. The main text must not exceed 10 pages. There is no minimum page requirement.
- The report must describe the problem formulation, methodology, algorithmic approach, treatment of the different scenarios, main parameter settings, computational environment, and computational results. It must

also include the required solution-quality trajectories and discuss the strengths and limitations of the proposed approach.
- Detailed formatting requirements will be provided in the report template.

5. Evaluation Criteria

Evaluation proceeds in three stages: format validation, feasibility validation, and score calculation. A validator and scoring notebook (https://www.kaggle.com/code/peiranhan/metric-template-2-1) will be released together with the public competition instances. For each submitted solution file, the validator will:

- Verify consistency with the official input data and the required output schema;
- Check compliance with all feasibility constraints; and
- Calculate the objective value of a feasible solution.

Feasibility validation

- Schema check: required fields exist, identifiers are valid, data types are correct, and JSON is parseable.
- Timetable consistency check: train events are temporally ordered and dwell rules are satisfied.
- Infrastructure check: link, station, platform, and disruption-availability constraints are satisfied.
- Conflict check: headway, section occupancy, and platform occupancy conflicts are absent.
- Service-rule check: cancellation, short-turn, skip-stop, and added-stop actions follow the scenario permissions.
- Resource check: rolling stock and rescue resource feasibility is verified when active.
- Completeness check: all planned trains are accounted for by either an operated plan or an explicit non-operated status.

Quality metrics

Metric	Definition	Comment
Passenger-weighted delay	Sum of weighted arrival/departure deviations across relevant train events.	Primary service-quality term.
Terminal delay	Delay at final destination for operated trains.	Useful for passenger arrival reliability.
Maximum delay	Largest delay among operated trains.	Optional fairness/stability term.
Operational change penalty	Platform changes, route changes, added stops, skipped stops, and overtaking/order changes if counted.	Controls excessive plan deviation.
Cancellation/short-turn penalty	Penalty for cancelled or partially operated services.	The cancellation and short-turn penalty coefficients are large enough to discourage avoidable cancellations.
Rolling stock penalty	EMU reassignment, spare activation, deadhead movements, or circulation deviations.	Active in S3.
Rescue penalty	Rescue activation, clearance delay, and emergency movement cost.	Active in S2.

Computational budget and reporting

Official solution-quality scores will be determined by the organizers running frozen submissions on previously unseen test instances using the same hardware and the prescribed computational budget. Code, models and parameter settings must be fixed at the final submission deadline; instance-dependent adaptation is allowed only within the frozen code. Team-reported wall-clock times are for reference only.

- The computational budget will specify:
  1) a maximum wall-clock time for each instance;
  2) a memory limit; and
  3) a limit on the number of concurrent processes or threads.

- The common execution environment and detailed computational limits will be specified in the competition rules.
- The technical report must state the computational environment and report the wall-clock time for each public competition instance.
- The report must include a solution-quality trajectory showing the best feasible objective value obtained over time for each public competition instance. Where a valid lower bound is available, teams should additionally report the corresponding optimality-gap trajectory.

Scoring rubric

Feasibility is a mandatory eligibility requirement rather than a scored criterion. Only solutions that pass the official validator will be considered for the competition ranking and finalist selection.

Criterion	Weight	Description
Solution quality	50%	Composite score after feasibility validation. Lower objective value is better.
Methodology	20%	Technical soundness, originality, suitability of the proposed approach for the problem, and the quality of its algorithmic and modelling design.
Final online presentation and Q&A	20%	Clarity and technical depth of the finalist presentation (5 points); the team's ability to explain its approach, justify key design choices, and answer questions from the judging panel (15 points).
Report quality	10%	Clarity, completeness, organization, and insightfulness of the final report, including sufficient information for readers to understand the methodology, implementation, and reported results.

Finalist Selection and Final Ranking

Eligible submissions will first be assessed on solution quality, methodology, and report quality, accounting for 50, 20, and 10 points, respectively. Based on this preliminary assessment, up to three teams will be selected as finalists. The finalist announcement will identify the selected teams without disclosing their preliminary ranking. Where there are ten or more submissions, reviews may be divided among the judges. Each reviewer may nominate finalist candidates or none. All unconflicted judges will review the nominated submissions before the consensus meeting to select up to three finalists.

Each finalist team must participate in an online presentation and question-and-answer session with the judging committee. This session will allow the judges to assess the team's understanding of its approach, clarify methodological and implementation details, and discuss the reported results. All finalist teams will be allocated the same presentation and question-and-answer time.

The online presentation and question-and-answer session will account for the remaining 20 points. The final ranking will be determined after these sessions by combining all four assessment components according to the published scoring rubric.

The final ranking will be announced at RailSanya 2027. Presentations at the conference will provide an opportunity to share the finalists' work with the railway research community and will not contribute additional points to the competition score.

6. Timeline

Deadline Time Zone

- Unless explicitly stated otherwise, all registration and submission deadlines expire at 23:59:59 Anywhere on Earth (AoE, UTC−12) on the stated date.
- Online meeting times and conference activities will be scheduled separately, with the applicable time zone explicitly stated.

Detailed Schedule

- October 20, 2026 — Competition announcement registration opening
- October 30, 2026 — Competition instances released
- December 1, 2026 — Registration deadline
- November 1, 2026 to February 26, 2027 — Q&A period (The Q&A will be published on Kaggle https://www.kaggle.com/competitions/rail-sanya-2027-problem-solving-competition)
- February 26, 2027 — Solution & Report submission deadline
- March 13, 2027 — Finalists announced
- March 17–19, 2027 — Finalist video meeting with the Judges
- April 7, 2027 — Conference presentation materials due
- April 12–15, 2027 — Finalists' presentations and announcement of the winner at RailSanya 2027

Assessment Schedule

- The final solution files and technical report must be submitted by February 26, 2027. Finalists will be announced on March 6, 2027, and the finalist online presentations and question-and-answer sessions will take place between March 10 and March 15, 2027.
- Finalists will receive their session schedule, presentation requirements, and the deadline for submitting online presentation materials with their finalist notification.
- Materials for the presentations at RailSanya 2027 must be submitted by April 7, 2027. These materials are separate from those required for the finalist online assessment.

7. Participation and Registration

The competition will be hosted on Kaggle. Competition updates, clarifications, and the leaderboard will be posted on the Kaggle competition page. Questions of general interest and their official answers will also be published there.
Kaggle page: https://www.kaggle.com/competitions/rail-sanya-2027-problem-solving-competition

All teams must complete the official registration form by the registration deadline. Each team should submit one registration form through a designated team representative. The representative is responsible for ensuring that the submitted team information is accurate and complete.
Registration link: https://forms.cloud.microsoft/r/TX2Mvyi5vn?lang=en-US

Participation is open to students, researchers and industry practitioners. Teams may consist of up to 5 members in total, including the team leader. The registered team name should be consistent with the team name used on Kaggle and in the final submission. Team composition may be updated before the registration deadline. No changes to team membership or team name will be permitted after the registration deadline.

Questions regarding the competition should be directed to: railsanyapsc@outlook.com.

8. Awards and Conference Registration

- Up to three finalist teams will be invited to present their work at RailSanya 2027.
- Conference registration arrangements for finalist representatives are as follows.
- All registered members of each finalist team, up to five members including the team leader, will receive a waiver of the RailSanya 2027 conference registration fee. Each member attending the conference must nevertheless complete the conference registration procedure.
- Cash prizes of EUR 1,500, EUR 1,000, and EUR 500 will be awarded to the first-, second-, and third-place teams, respectively. Each amount is the total prize for the team, not an award to each individual member. The prizes will be paid by the RailSanya 2027 Organizing Committee or the conference sponsors.
- Award-winning teams will also receive medals and certificates.
- The judging committee reserves the right to make fewer awards, or no awards, if the quality of submissions is deemed insufficient under the published evaluation criteria.
- Unless separate support is explicitly confirmed in writing, participants are responsible for their own travel, accommodation, visa, and other expenses associated with attending the conference.

9. Conference Presentation

Each finalist team is expected to nominate at least one representative to present its work in person at RailSanya 2027. A dedicated session for the Problem-Solving Competition will allow finalist teams to present their methods, results, and findings to the conference participants.

If in-person attendance is prevented by visa difficulties, health reasons, or other exceptional travel circumstances, the team may request permission to present remotely. Such requests must be submitted to the organizers as early as possible and are subject to approval.

Approved remote participation will satisfy the conference presentation requirement and will not affect the team's assessed score, final ranking, or eligibility for an award.

The format of any approved remote presentation, including whether a prerecorded presentation and live question-and-answer session are required, will be agreed with the organizers in advance.

10. Provided Files and Tools

- Input data files for each instance and scenario.
- A sample solution_result.json and its schema illustrating the required output structure.
- validator.py for schema and feasibility validation for single solution.
- score.ipynb or metric notebook for objective calculation after validation.
- visualizer.py for time-space diagrams and selected station platform occupation charts.
- baseline heuristic solution for the development instance, if available.
- README.md with installation, execution, and submission instructions.

11. Data Provenance and Limitation Disclaimer

The competition datasets are expected to be based on an anonymized and simplified high-speed railway network. Station names, train identifiers, track identifiers, and resource identifiers should be anonymized to protect operational confidentiality. Network topology, capacity parameters, timetable patterns, and disruption records may be adapted for research and educational purposes.

The datasets should not be interpreted as a complete representation of actual railway operations. Participants may publish research results based on the competition data only with appropriate acknowledgment of the competition and in accordance with the data-use rules released by the organizers.

12. Disclosure of AI Use

Teams must include a declaration in their technical report describing any use of generative AI tools in preparing the submission. The declaration must identify the tools used and explain their purposes and the extent of their use, including assistance with writing, coding, debugging, analysis, or the development of the proposed approach.

Teams remain fully responsible for the accuracy, originality, and integrity of their report, code, and results. All AI-assisted content and outputs must be reviewed and verified by the team. The use of AI tools does not reduce the requirement to explain and justify the submitted work during the assessment.

Where AI forms part of the solution methodology itself, its role must also be described in the methodology section.

Teams that have not used generative AI tools must state this explicitly.

13. Competition Organization and Judging Committee

Chair of the Judging Committee: Prof. Dr. Francesco Corman, ETH Zurich.

Problem Owner: Dr. Zhengwen Liao, Beijing Jiaotong University.

Competition Assistant: Peiran Han, Beijing Jiaotong University.

The full membership of the judging committee will be announced at RailSanya 2027, together with the final competition ranking.

The judging committee’s decisions on the merits of submissions and the final ranking are final.

Requests to correct an administrative or calculation error may be submitted through the official competition contact within 10 calendar days of the relevant notification. Such requests must identify a specific error and do not constitute an opportunity to revise the submission or seek a reassessment of academic judgment.

14. Impartiality and Conflicts of Interest

Members of the organizing committee and judging committee must not provide team-specific advice, coaching, or other assistance in developing a competition submission. This restriction does not prevent the organizers from providing general guidance or clarifications that are made equally available to all participants through the official competition channels.

Committee members must disclose any actual or potential conflict of interest, including supervisory, collaborative, institutional, or personal relationships with participating teams. A member with a conflict of interest must not assess the relevant submission or participate in decisions concerning that team.

Non-public competition information must not be disclosed to participants.