

Automatic Block Planning System (ABPS)

Complete User Manual, Terminology Lexicon & Operational Feature Guide

Executive Summary: This manual documents every interface component, acronym, filter option, and mathematical model in the AI-powered Indian Railways Automatic Block Planning System. The system coordinates multi-departmental maintenance requirements across Civil Engineering (TMS), Signal & Telecommunication (SMMS), and Traction Distribution (TDMS) with Control Office Application (COA) train path timetable windows to maximize operational asset availability and minimize train detention.

1. System Architecture & Integrated Data Sources

In Indian Railways, maintenance has historically been planned in departmental silos. ABPS integrates data streams from four core railway information systems into a unified AI scheduling engine:

Source / System	Full Name & Ownership	Data Ingested & Operational Role
TMS	Track Management System (Engineering Dept / Civil)	Track condition parameters, rail flaw detection records (USFD), sleeper renewal, deep ballast screening (BCM), tie tamping (CSM/DUOMATIC), rail weld destressing (LWR/SWR), bridge inspection registers.
SMMS	Signal Maintenance Management System (S&T; Dept)	Interlocking health tests (Electronic Interlocking EI / Route Relay Interlocking RRI), Point Machine overhauls, Axle Counter resets, Track Circuit bonding, KAVACH firmware updates, signal sight checks.
TDMS	Traction Distribution Management System (Electrical Dept / TRD)	25kV AC Over-Head Equipment (OHE) inspection, catenary & contact wire height/stagger tests, Traction Substation (TSS/SS) circuit breakers, section insulators, booster transformer renewal, earthing tests.
COA	Control Office Application (Operating Dept / PCOM)	Real-time train movements, master timetables, sectional line capacity, train density classifications, and availability windows suitable for granting maintenance blocks.
BDMS	Block Demand Management System (Divisional Control)	Unified portal for submitting block requests, reviewing Divisional Operations Manager approvals, and issuing coordinated block execution orders.

2. Official Indian Railways Block Terminology & Slot Patterns

Understanding block terminology is critical for railway safety and coordination between Section Controllers, Station Masters, and field engineers:

- **Traffic Block:** A complete or partial suspension of train movements on a specific track section or running line to allow civil engineering track machines (BCM, CSM, TRR), manual track works, or S&T; overhauls without collision risk.
- **Power Block (25kV OHE):** A planned electrical shutdown where 25kV AC traction supply is disconnected and grounded by the Traction Power Controller (TPC). Requires issuance of a formal **Permit-to-Work (PTW)**. Diesel locomotive traffic may pass if approved, while electric locomotives cannot draw power.
- **Integrated Traffic & Power Block:** The most efficient maintenance mechanism in Indian Railways. Both train movement and 25kV traction power are suspended simultaneously in a corridor window. This allows Engineering (track machines), Electrical (TRD OHE wire renewal), and S&T; (signal points/circuits) teams to work concurrently in the same section, preventing repeated line occupancy.
- **Shadow Block:** A block granted on an adjacent line or crossover that utilizes the window created by a primary block without causing additional detention to through traffic.
- **Emergency Block:** An unscheduled, high-priority block granted immediately by the Section Controller to restore rail fractures, OHE line snaps, or catastrophic signal failures.

Standard Indian Railways Corridor Slot Patterns:

Slot Pattern Name	Hours Window	Duration	Block Classification	Operational Description
Night Mega Corridor Block	00:30 – 04:30	4.0 hrs	Integrated Block	Pre-dawn primary low-density corridor block for joint track machine and OHE maintenance.
Pre-Dawn Joint Block	01:00 – 05:00	4.0 hrs	Integrated Block	Extended heavy overhaul slot for major track renewals and substation feeder testing.
Mid-Day OHE Power Block	11:30 – 13:30	2.0 hrs	Power Block (25kV)	Mid-day low-traffic interval for catenary inspection and contact wire tensioning.
Late Night Rolling Block	23:00 – 02:00	3.0 hrs	Traffic Block	Single-line rolling traffic block for tie tamping (CSM) and rail joint welding.
Early Morning Shadow Block	02:00 – 04:30	2.5 hrs	Shadow Block	Secondary track and loop line maintenance executed in parallel with main-line blocks.

3. Complete Guide to Every Website Page, Option & Button

3.1 Top Header & Global Controls

- **Title & Subtitle:** Displays system branding and active integration status with Indian Railways BDMS network.
- **Weekly Plan Tab:** Sets the AI scheduling horizon to 7 days for tactical, immediate block allocations.
- **Monthly Plan Tab:** Sets the AI scheduling horizon to 30 days for strategic, monthly rolling corridor block planning.
- **■ Generate Block Plan Button:** Executes the backend constraint-satisfaction optimization algorithm to match pending maintenance tasks against available COA corridor windows.
- **■ Export JSON Button:** Downloads the active block plan as a formatted JSON document for archival or COA/BDMS system ingestion.

3.2 Sidebar Navigation

- **IR Emblem & Wheel:** Authentic Indian Railways wheel emblem with active rotational animation representing 24/7 network continuity.
- **BDMS Online Badge:** Live status indicator showing continuous connectivity to the Block Demand Management System.
- **Operations Dashboard ('#nav-dashboard'):** High-level managerial view containing KPIs, departmental distribution, ingestion statistics, and corridor utilization.
- **Block Plan (AI) ('#nav-schedule'):** Primary AI scheduling workspace displaying Gantt visualization and detailed block allocation tables.
- **Maintenance Register ('#nav-tasks'):** Database of all ingested maintenance tasks from TMS, SMMS, and TDMS with search and filter controls.
- **Block Corridors (COA) ('#nav-corridors'):** View of timetable availability windows derived from the Control Office Application (COA).
- **System Information ('#nav-about'):** Technical reference detailing system algorithms, formulas, and department mapping rules.
- **Live System Clock:** Real-time 24-hour clock synchronized with Indian Standard Time (IST).

3.3 Operations Dashboard Section

- **Asset Availability (%) KPI Card:** Measures the percentage of total track-hours available for revenue train operation. High availability (>95%) indicates optimal scheduling without wasteful downtime.
- **Critical Tasks KPI Card:** Count of high-severity maintenance tasks (e.g. rail fractures, interlocking faults) requiring immediate blocks.
- **Overdue Tasks KPI Card:** Tasks that have exceeded their target maintenance due date, receiving dynamic urgency penalties.
- **Total Tasks KPI Card:** Aggregate count of all pending tasks ingested across TMS, SMMS, and TDMS databases.

- **Blocks This Week / Month KPI Cards:** Total number of AI-scheduled maintenance blocks planned within the selected horizon.
- **Department Breakdown (Donut Chart):** Visual proportion of maintenance workload between Engineering (Blue), Traction (Saffron), and S&T; (Green).
- **Data Source Integration (Bar Chart):** Distribution of tasks ingested by source system (TMS vs SMMS vs TDMS).
- **Availability Meter & Side Stats:** Large-format circular gauge showing monthly asset uptime, total blocks, and average block duration (3.2 hrs).
- **Corridor Utilization Progress Bars:** Percentage of pending maintenance tasks covered by scheduled blocks per railway corridor section.

3.4 Maintenance Register (TMS / SMMS / TDMS Section)

Allows maintenance engineers to inspect and query pending work items:

- **Search Input Bar ('#filter-search'):** Full-text search filtering by Task ID, description keywords, or corridor section.
- **Department Dropdown ('#filter-dept'):** Filter tasks by Engineering, Traction, or S&T; departments.
- **Criticality Dropdown ('#filter-crit'):** Filter tasks by Critical, High, or Normal urgency ratings.
- **Tasks Table Columns:** Task ID, Description, Department, Criticality, Corridor Section, Overdue Days (+Xd), and Priority Score.
- **Task Detail Modal:** Clicking any task opens a comprehensive modal revealing the source system (TMS/SMMS/TDMS), estimated duration in hours, due date, and calculated priority score.

3.5 Block Corridors (COA Section)

- **Corridor Search Bar ('#corridor-search'):** Search corridors by section name, date, or slot pattern name.
- **Block Type Filter ('#filter-block-type'):** Filter windows by Integrated Traffic & Power Block, Power Block (25kV OHE), Traffic Block, or Shadow Traffic Block.
- **Train Density Filter ('#filter-density'):** Filter windows by Low, Medium, or High train operational density.
- **Corridors Table Columns:** Corridor Section, Date, Window (COA Slot), Block Pattern / Type (with color-coded badge), Available Hours, and Train Density indicator.

3.6 Block Planner (AI Schedule & Gantt View)

- **Summary Strip:** Real-time summary showing Asset Availability %, Total Blocks, Tasks Scheduled, Unscheduled Tasks, and Generation Timestamp.
- **Interactive Gantt Matrix:** Two-dimensional matrix plotting Corridor Sections against Calendar Dates. Cell numbers indicate blocks scheduled. Cells are color-coded: Blue (Single-dept Traffic Block), Purple (Multi-dept Integrated Block), Saffron (Power Block), and Red (Critical Urgency).
- **Scheduled Blocks Table Columns:** Block ID, Corridor Section, Date, Time Window, Block Classification, 25kV OHE Cut status (Required PTW vs Energized), Department(s), Tasks Covered count, and Status (Planned).
- **Block Detail Modal:** Clicking any block or Gantt cell opens a detailed modal displaying the Corridor, Date, Window, Slot Pattern name, 25kV OHE isolation requirement, and the full list of co-scheduled tasks covered within the window.

4. Mathematical Formulation & AI Scheduling Algorithm

The block planning engine utilizes a **priority-weighted constraint-satisfaction algorithm** designed to maximize infrastructure reliability while minimizing line downtime.

Dynamic Task Priority Score Formula:

$$\text{Priority Score} = \text{Base Criticality Score} \times [1 + (\text{Overdue Days} / 7)]$$

- **Critical Base:** 100 points | **High Base:** 60 points | **Normal Base:** 30 points
- **Urgency Multiplier:** Every 7 days overdue doubles the effective priority weight of the task.

- **Step 1 – Task Scoring & Sorting:** All pending tasks from TMS, SMMS, and TDMS are scored using the dynamic priority formula and sorted descending (highest urgency first).
- **Step 2 – Corridor Window Matching:** For each task, the engine searches chronologically for available COA corridor windows that match the task's corridor section and have remaining duration capacity.

- **Step 3 – Multi-Departmental Co-Scheduling:** When a window is selected for a task, subsequent tasks on the same corridor (even from other departments) are fitted into the remaining window capacity. If tasks from Traction and Engineering/S&T; share the window, the block is classified as an **Integrated Traffic & Power Block**.
- **Step 4 – Asset Availability Computation:** The engine calculates total operational capacity vs utilized block hours to output the final network asset availability percentage.

5. Practical Operational Workflows (Use Cases)

- **Use Case 1: Daily Divisional Control Review (Sr. DOM / CPTM):** Open the Operations Dashboard to check Asset Availability % and identify any spikes in Critical Tasks. Review Corridor Utilization bars to spot under-maintained sections.
- **Use Case 2: Generating Weekly Coordinated Block Plans:** Select the 'Weekly Plan' tab on top and click '■ Generate Block Plan'. Review the generated Gantt matrix for multi-departmental Purple blocks, and click any block row to inspect co-scheduled tasks before exporting the JSON file for COA transmission.
- **Use Case 3: Traction Power Controller (TPC) Isolation Review:** Navigate to 'Block Corridors (COA)' and filter by 'Power Block (25kV OHE)'. Verify slots requiring 25kV power cut (PTW) and cross-reference with scheduled blocks table to ensure Permit-to-Work issuance procedures are prepared.
- **Use Case 4: Auditing Overdue Critical Track & S&T; Defects:** Navigate to 'Maintenance Register', filter by Criticality = 'Critical' and sort by overdue days to ensure high-priority USFD flaw detections or Point Machine overhauls are scheduled immediately.

Document Information: Indian Railways Automatic Block Planning System • Version 1.0 • Ministry of Railways, Govt. of India • CRIS & BDMS Standard Compliance.