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Kavach 4.0 Expansion — Rs 1,236 Crore for Railway Safety and Fibre Network

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CURATED & WRITTEN BY

Bharat Choudhary

UPSC Educator & Content Creator

in linkedin.com/in/epicbharat

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Kavach 4.0 Expansion — Rs 1,236 Crore for Railway Safety and Fibre Network

> *Indian Railways has approved three major projects worth a combined Rs 1,236 crore to expand the Kavach 4.0 Automatic Train Protection (ATP) system on Southern Railway and to build a redundant fibre optic communication backbone across Central Railway and Western Railway.*

What is Kavach

Kavach (meaning "armour" in Hindi) is India's indigenously developed Automatic Train Protection (ATP) system. It was designed by the Research Designs and Standards Organisation (RDSO) in collaboration with Indian industry partners. The system is certified to **Safety Integrity Level 4 (SIL-4)** — the highest international standard for functional safety in railway signalling, defined under IEC 61508 and CENELEC EN 50126/50128/50129. A SIL-4 certified system must demonstrate a probability of dangerous failure below 10^{-8} per hour, ensuring near-zero risk in mission-critical rail operations.

Kavach received its SIL-4 certification in 2019. Version 4.0 of the Kavach specification was approved by RDSO on 16 July 2024 and introduces several upgrades over earlier versions, including improved location accuracy, better signal aspect information for larger yards, station-to-station interface over Optical Fibre Cable (OFC), and direct interface with existing Electronic Interlocking (EI) systems.

How Kavach Works

Kavach operates on the principle of **continuous supervision of movement authority**. Its core components include:

COMPONENT	FUNCTION
Onboard Equipment	Installed on locomotives; receives movement authority and enforces speed limits
Trackside Equipment	Radio Frequency Identification (RFID) tags and lineside electronic units relay real-time track and signal data
Radio Communication	Uses Ultra High Frequency (UHF) radio network to exchange data between trains and stations
Station Kavach	Interfaces with station interlocking systems and transmits movement authority to approaching trains

Key safety functions:

- **Signal Passed at Danger (SPAD) prevention** — automatically applies brakes if a train approaches a red signal without the Loco Pilot taking action

- **Overspeed protection** — enforces speed restrictions based on track conditions, curves, and temporary limits

- **Collision avoidance** — if two trains are detected on a collision course, both receive automatic brake commands

- **Fog and low-visibility operation** — enables safe train movement by providing electronic movement authority independent of visual signals

- **SoS messaging** — allows Loco Pilots to broadcast emergency alerts to nearby trains and control centres

Project Breakdown — Three Approved Projects

The Rs 1,236 crore approval covers three distinct projects across three Railway zones:

PROJECT	ZONE	SCOPE	COST (RS CRORE)
OPGW + Underground OFC	Central Railway	96-fibre Optical Ground Wire (OPGW) on 2,250.68 RKm of 25 KV traction lines + underground 2x48 fibre OFC on 2,673.21 RKm across Solapur, Nagpur, Pune, Bhusawal, and Mumbai Divisions	**623.63**
Kavach 4.0 + OFC	Southern Railway	Kavach 4.0 deployment on Jolarpettai-Erode section (180 RKm, Salem Division) and Chennai Beach-Tambaram-Chengalpattu section (60 km, Chennai Division) plus new OFC cabling	**310.18**
Underground OFC	Western Railway	2x48 fibre OFC on both sides of the track across Rajkot Division (1,064 km) and Bhavnagar Division (589 km) in Gujarat, totalling 1,653 km	**302.26**
Total			**1,236.07**

What is OPGW? Optical Ground Wire is a composite overhead cable that serves dual purposes — it functions as an earth protection wire for the 25 KV traction system while simultaneously carrying 96 optical fibres for high-speed data communication. Since OPGW runs on existing traction towers, no new civil infrastructure is needed, enabling faster and cheaper deployment.

Why two independent fibre paths? The Central Railway project creates two physically separate fibre routes on every corridor — OPGW running along the overhead traction lines on one side and underground OFC on the other. This dual-path architecture ensures that even if one path is damaged (due to construction, theft, or natural disaster), the communication network remains operational — a critical requirement for Kavach and other safety-critical signalling systems.

Kavach Deployment Timeline

Kavach deployment has accelerated significantly since 2024:

MILESTONE	DATE	DETAILS
SIL-4 certification	2019	Kavach certified to highest safety standard
Version 4.0 approved	16 July 2024	RDSO approves Kavach 4.0 specification
Record single-month commissioning	January 2026	472.3 RKm commissioned in a single month
Prayagraj-Kanpur section	22 March 2026	190 RKm on Delhi-Howrah corridor commissioned
Delhi-Mumbai and Delhi-Howrah corridors	As of March 2026	1,452 RKm commissioned across both corridors
Total deployment (all corridors)	As of March 2026	Over 2,200 RKm commissioned nationwide
Infrastructure laid	As of February 2026	8,570 km OFC laid, 1,100 telecom towers, 6,776 RKm trackside equipment, 767 station data centres, 4,154 locomotives equipped
National target	By 2032	Full Kavach coverage across 44,000 km in six years

Railway Safety in India — The Numbers

Kavach deployment is part of a broader safety transformation on Indian Railways:

METRIC	2014-15	2024-25	2025-26 (UP TO FEB)	CHANGE
Consequential train accidents	135	31	14	**90% reduction** from 2014-15
Accidents per million train-km	0.11	0.03	—	**73% improvement**
Deaths in train accidents	—	18	16	—
Injuries in train accidents	—	92	28	—

Safety spending has tripled: From Rs 62,367 crore in 2014-15 to Rs 1,41,022 crore in 2024-25 — with Rs 1,16,470 crore allocated in the 2025-26 Budget. The proposed outlay for FY2026-27 could exceed Rs 1.3 lakh crore.

The **Rashtriya Rail Sanraksha Kosh (RRSK)** — a dedicated railway safety fund created in 2017-18 — received Rs 1,05,378 crore in Gross Budgetary Support during its first five-year term (2018-23) and was extended for a second five-year term with Rs 45,000 crore allocated for renewal, replacement, and upgradation of critical safety assets.

Fibre Optic Backbone — Why It Matters

The fibre optic expansion is not just about Kavach connectivity. It serves multiple strategic purposes:

- **Kavach backbone** — Kavach 4.0 requires reliable station-to-station OFC links for real-time movement authority transmission

- **Automatic Block Signalling (ABS)** — fibre enables higher-capacity signalling systems that allow more trains on the same track safely

- **Centralised Traffic Control (CTC)** — fibre connects remote stations to central control rooms for unified train management

- **Passenger services** — Wi-Fi at railway stations (already live at 6,108+ stations through RailTel), real-time train tracking, and digital passenger information systems

- **Revenue monetisation** — dark fibre can be leased to telecom operators, generating non-fare revenue for Railways

- **Redundancy** — dual-path fibre architecture (OPGW + underground) ensures no single point of failure

RailTel Corporation of India, a Navratna PSU (status granted 30 August 2024), already operates over 61,000 route-km of optical fibre on Railway right-of-way. These new projects will add thousands of kilometres to this existing backbone and fill critical connectivity gaps in Central, Southern, and Western Railway zones.

Global Comparison — ATP Systems Worldwide

SYSTEM	COUNTRY/REGION	COVERAGE	COST PER RKM	SIL LEVEL	KEY FEATURE
Kavach 4.0	India	2,200+ RKm (target: 44,000 km)	~Rs 50 lakh (~$59,000)	SIL-4	Indigenous, UHF radio-based, cheapest ATP globally
ETCS (Level 2)	European Union	~11,000 track-km across EU; target: all TEN-T core corridors by 2030	~Rs 2 crore (~$240,000)	SIL-4	Cross-border interoperability, GSM-R based
PTC	United States	57,536 route miles (~92,600 km)	Varies by railroad	—	GPS-based, mandated after 2008 Rail Safety Act

Why Kavach is significantly cheaper: Kavach costs approximately Rs 50 lakh per route-km compared to around Rs 2 crore for ETCS — making it nearly **four to five times cheaper**. This cost advantage stems from Kavach using UHF radio (rather than the GSM-R required by ETCS), its distributed architecture that permits piece-meal deployment, and the absence of cross-border interoperability requirements that make ETCS costlier. The Rs 70 lakh cost for equipping one locomotive is also substantially lower than ETCS onboard unit costs.

However, industry observers have noted that Kavach does not yet meet all global interoperability standards — unlike ETCS, which is designed for seamless cross-border train operations across the European Union.

UPSC Angle

This topic is relevant for both Prelims and Mains:

- **Prelims:** SIL-4 certification, RDSO role, ETCS vs Kavach, RRSK fund, RailTel, OPGW technology

- **Mains GS-3 (Infrastructure):** Railway safety investment as a public good; cost-benefit analysis of indigenous technology development; Kavach as a model for Atmanirbhar Bharat in critical infrastructure

- **Mains GS-3 (Science and Technology):** Indigenous technology development cycle — from RDSO research to SIL-4 certification to nationwide deployment; comparison with global ATP standards

- **Mains GS-2 (Governance):** Role of RDSO as a standard-setting body; public sector innovation through RailTel; institutional reforms enabling faster project approval and execution

UPSC RELEVANCE

Kavach 4.0, SIL-4, RDSO, OPGW, RRSK, RailTel, ETCS, PTC — all frequently tested in factual MCQs.

MAINS GS-3:

Railway safety infrastructure, indigenous technology development under Atmanirbhar Bharat, fibre optic backbone for Digital India.

📌 FACTS CORNER — KNOWLEDGEPEDIA

KAVACH 4.0 — CORE DATA:

Full form: Kavach = Armour (Hindi); ATP = Automatic Train Protection

Developer: Research Designs and Standards Organisation (RDSO), Lucknow

Safety certification: SIL-4 (highest level under IEC 61508), received in 2019

Version 4.0 approved: 16 July 2024

Cost per route-km: ~Rs 50 lakh (~$59,000)

Cost per locomotive: ~Rs 70 lakh (~$83,000)

Communication: Ultra High Frequency (UHF) radio network

Total deployed: Over 2,200 route-km (as of March 2026)

Delhi-Mumbai + Delhi-Howrah corridors: 1,452 RKm commissioned

Target: 44,000 km coverage in six years (by 2032)

Record commissioning: 472.3 RKm in January 2026 (single month)

Locomotives equipped: 4,154 (as of February 2026)

Station data centres: 767 set up

RS 1,236 CRORE PROJECT BREAKDOWN:

Central Railway (OPGW + underground OFC): Rs 623.63 crore — 2,250.68 RKm OPGW + 2,673.21 RKm underground OFC

Southern Railway (Kavach 4.0 + OFC): Rs 310.18 crore — Jolarpettai-Erode (180 RKm) + Chennai Beach-Chengalpattu (60 km)

Western Railway (underground OFC): Rs 302.26 crore — Rajkot (1,064 km) + Bhavnagar (589 km) = 1,653 km

RAILWAY SAFETY STATISTICS:

Consequential train accidents: 135 (2014-15) → 31 (2024-25) → 14 (2025-26, up to February) — 90% reduction

Accidents per million train-km: 0.11 (2014-15) → 0.03 (2024-25)

Safety spending: Rs 62,367 crore (2014-15) → Rs 1,41,022 crore (2024-25) — more than doubled

Rashtriya Rail Sanraksha Kosh (RRSK): Created 2017-18; Rs 1,05,378 crore spent in first term (2018-23); Rs 45,000 crore for second term

RAILTEL CORPORATION:

Formed: September 2000

Status: Navratna PSU (since 30 August 2024)

OFC network: Over 61,000 route-km

Railway stations with Wi-Fi: 6,108+

Bandwidth capacity: Up to 800G at 60 locations

GLOBAL ATP COMPARISON:

Kavach (India): ~Rs 50 lakh/km, SIL-4, UHF radio, 2,200+ RKm deployed

ETCS Level 2 (EU): ~Rs 2 crore/km, SIL-4, GSM-R, ~11,000 track-km across EU

PTC (USA): GPS-based, 57,536 route miles (92,600+ km) mandated coverage

Belgium: First EU nation (after Luxembourg) to equip entire main railway network with ERTMS (December 2025)

OTHER RELEVANT FACTS:

RDSO headquarters: Lucknow, Uttar Pradesh

RDSO is the sole R&D and standards organisation of Indian Railways

OPGW = Optical Ground Wire — dual-purpose cable (earth wire + 96 optical fibres) on 25 KV traction towers

IEC 61508: International standard for functional safety of electrical/electronic systems

CENELEC EN 50126/50128/50129: European railway safety standards

Rail Safety Improvement Act of 2008 (USA) mandated PTC on all major freight and passenger lines by December 2020

EU target: ETCS on all TEN-T core corridors by 2030; full network by 2050

Indian Railways network: ~68,000 route-km (one of the largest in the world)

FY2026-27 proposed safety outlay: Over Rs 1.3 lakh crore

Sources: PIB , ANI News , DD News , Business Standard , Swarajya

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