Note of Footplate Inspection of Kavach installation in ECR on 12.06.2024 by Lalit K Mansukhani, OSD/CoE(Modern Signalling-Kavach)

******

Inspection through footplate on Kavach fitted Loco Movement was carried out in Up and Down Directions in Section from Anugrah Narayan Road to Deo Road and back. Section and Onboard Kavach and RFID Tag formats - all were latest Draft Ver 4.0 (Unapproved) as on day of Inspection.

Summary of Design related Observations having Safety Implications:

Some Kavach Ver 4.0 design related issues, observed during aforesaid EC Railway inspection, need immediate attention from the point of view of safety and perception of Train Pilots. Logical Arrangement as per principles:

Protection by Signalling/ Interlocking	Lineside Signalling: Movement using	Cab Signalling Mode
Full Protection by Signalling/ Interlocking	Main Signals	Full Supervision
All other Protection by Interlocking (Points lock, LC Closed) except that track section ahead could be occupied by another train (LP to look for it)	• Auto Signal • Semi-Auto Signal with A-Marker Lit • Calling-on Signal	On Sight
Without any Protection by Signal/ Interlocking	Train on Memo etc	Staff Responsible

(A) In Kavach Ver 4.0, the OS MA in yards is being unduly sent to Onboard without ensuring fulfilment of requisite conditions. Indicating On Sight Mode to LP and giving Authority to Onboard Kavach without ensuring Locking of points, Closure of LC Gates etc is similar to taking off Calling-On Signal without Locking of points, Closure of LC Gates, which is not safe. {Item (9) of Enclosure}.

(B) Display of Movement Authority Bar needs to be suppressed during OS Mode since it could be hazardous to indicate so {Item (31) of Enclosure}. Displaying OS MA has been considered hazardous in ETCS.

(C) When Kavach transits to degraded mode, the relaxation in Permitted Speed shall not take place without cognizance by Train Pilot in form of Acknowledgement by Train Pilot. {Item (23) of Enclosure}.

(D) Any lineside signal provides protection and authority beyond its location (not on its approach). However, as per current implementation, those Movement Authority and Permitted Speed, which do not pertain to the Onboard Kavach under subject, are also applied to it. It needs to be discontinued {Item (9) of Encl}.

(E) Display of "Down" as "Up" took place at numerous places due to Software Glitch. RDSO vide recent Amendment dtd 21.06.2024 in Spec Ver 4.0 has reduced the RFID Reader Height by 100mm {Item (15) of Encl}. RDSO may reconsider solution proven in field in 2016.

CoE has communicated these issues earlier, Joint Note of RDSO, CoE, Stakeholders will be helpful. Time-bound action plan, duly addressing above items having safety implications, needs to be followed up scrupulously by Stakeholders so that the approvals related to Kavach Ver 4.0, LP Manual as per Ver 4 are not delayed further.

Important Observation to ensure Safe Practice: In order to test Kavach in field (such as SPAD Prevention Test), the train pilots are required not to exercise braking. For this, a memo is served following JPO to ensure safety. However, it has been observed at few occasions, that the Memo has been served for field test without observing requisite procedure. It is reiterated to follow the JPO the way it is in vogue in SC Railway.

Detailed observations with actionable items are attached herewith.

Encl: Annexure as above, taking cognizance of Compliance, Discussions till 02.07.2024.

ललित मनसुखानी Lalit Mansukhani
OSD/Centre of Excellence (Modern Signalling-Kavach)

==========

IRISET/CoE/Kavach/Misc 03.07.2024

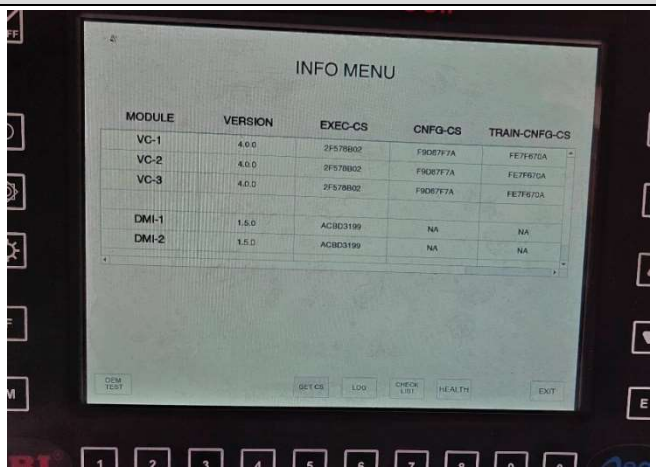
Copy to: DG/IRISET, PED(Coord)/Signal/RB, PED/SM/RB: for kind information please
PED/S&T/RDSO/Lucknow, ED/Tele-II/RDSO, Secunderabad
PCSTEs of Zonal Railways: For item no. (10) in particular and other items as marked

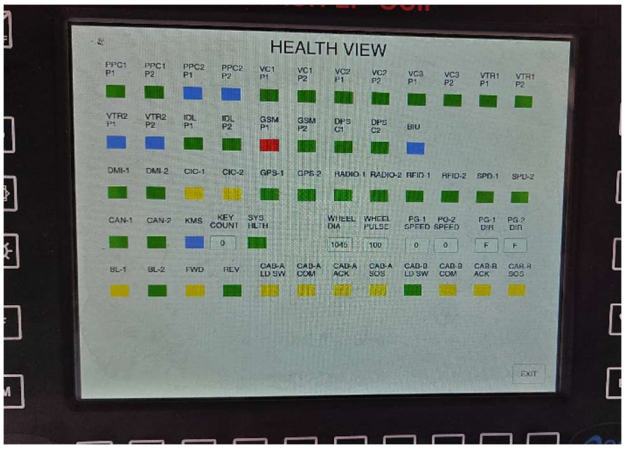
Note of Footplate Inspection of Kavach installation in ECR on 12.06.2024 by Lalit K Mansukhani, OSD/CoE(Modern Signalling-Kavach)

Officers accompanied:

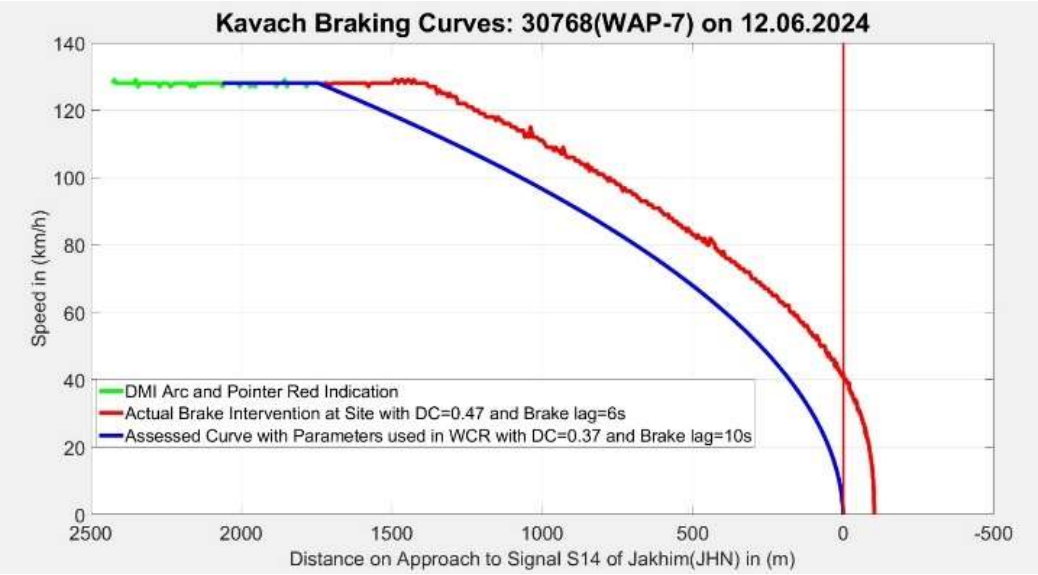
Indian Railway Personnel	Work Executing Agency's Personnel
Shri A.K. Kushwaha (ASTE/W/Hajipur) Shri Shambhu Baitha (ASTE/W/Gaya) Sri S.Z. Haque/CLI/Gaya, Sri Abhimanyu, JE(Signal), Hajipur TI/Gaya	Sri Narendra, DEO/PM/S&T, Ashoka BuildCon Sri Prashanth/ Engineer (Comm)., HBL Sri Praveen, Engineer (Onboard), HBL
Sri N.K. Verma /Gaya, LP Sri Santosh Kumar IV/Gaya, ALP	

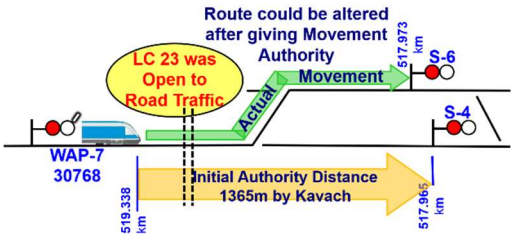
Inspection through footplate on Kavach fitted Loco Movement was carried out in Up and Down Directions in Section from Anugrah Narayan Road to Deo Road and back. Section and Onboard Kavach and RFID Tag formats - all were latest Draft Ver 4.0 (Unapproved) as on day of Inspection.

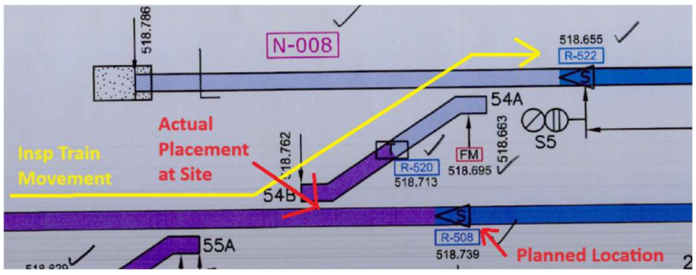
SN	Actionable Item	Action By
1	The Checksum information of Onboard Kavach Firmware (software) through DMI on the day of inspection was as shown here. It was confirmed by the HBL Engineer that it was latest checksum on that day of Inspection. However, he couldn't explain traceability of changes/ Version Control/Date.  (a) Procedure needs to be setup to verify through Version Controlled Checksum whether the Software used during inspection is latest or not. Such discipline was enforced even during Core R&D for development of SIL-4 multi-vendor interoperable product through field trials from 2013-end to 2015. On adding Passenger Carrying/ Coaching trains in field trials from Feb-2016 onwards, all changes were notified through a Group to keep track of changes with compilation of each use case in monthly Report. It is high time to restore good old practice to have smooth development and clearance from Independent Safety Assessor (ISA). (b) It is advised to make the display more informative by adding Loco Number, Version and Date with Checksum, Parameters undergoing updates during Shed Visit such as Wheel Dia etc, Timestamp of Previous Shed Visit, Timestamp of Previous functioning of Onboard Kavach in Kavach territory.	RDSO CoE Medha HBL Kernex GG Tronics QFTL

SN	Actionable Item	Action By
2	In order to have secure radio communication, there is provision of acquiring Authentication Key Sets by Stationary-Kavach and Onboard Kavach for 120 days initially from Centralized "Key Management Server (KMS) and to top up whenever it goes below 60 days. It is acquired through SIM card (Commercial Mobile Network) irrespective of whether the Onboard Kavach is in Kavach territory or not. The functioning of Onboard Kavach cannot start without any Authentication Key. All officials (OSD/CoE, ASTEs from ECR and OEM HBL Personnel) and Kavach equipped Locomotive reached well before time at Anugrah Narayan Road Station but Onboard Kavach didn't possess any Authentication Keys, which caused some delay in commencing the inspection. On insertion of SIM cards by HBL personnel in Vital Gateway Card, the Onboard Kavach acquired Authentication Keys and got ready for Kavach functioning. (a) Further, even after acquisition of Authentication Key Sets, the DMI display continued to show "Nil" Authentication keys due to software glitch. The software was modified post-inspection to reflect it correctly.  (b) To avoid delays and to utilize path, it is prudent to check availability of Authentication keys well before bringing Onboard Kavach Locomotive in section for field trials. Post-inspection, a Video Conference was convened by CoE on 14.06.2024 with relevant Stakeholders (CoE, RDSO, ECR, Railway Board, 03 OEMs) to address the related issues. MoM of VC have been issued separately.	OEM HBL
3	Due to mismatch in Tag Data and their placement location, RFID tags 442 and 444 appeared as missing on DMI. It may be rectified on priority at site and the whole section to be checked for any such discrepancy. 	OEM HBL ECR

SN	Actionable Item	Action By
4	For Signal ahead at Danger, the permitted Speed started diminishing with overspeed Amber (Yellow) colour warning from 2.5km itself followed by the Speed Pointer and part of Circular Arc turning Red from time 11:13:13 (HH:MM:SS). The Brake Application Icon on DMI appeared ~15 Seconds later at 11:13:28. The turning of Speed Pointer, Circular Arc Portion to Red and appearance of Brake Application Symbol shall occur simultaneously, not with gap of 15 seconds. This design software related anomaly has been already advised and OEM has agreed vide Joint Note dated 18.01.2024 between CoE and OEM HBL, however, the corrective action is yet to be taken.	OEM HBL
5	Kavach entered into Trip Mode even before crossing the Signal / RFID tags installed at the foot of the Signal as shown in the photo. This design related discrepancy needs to be resolved by OEM at the earliest. 	OEM HBL

SN	Actionable Item	Action By
6	Although the Locomotive was moving in Down only, the direction on DMI suddenly changed from "Down" wrongly to "Up" when it entered in Trip Mode. OEM HBL assured that this software design related logic will be rectified soon.	OEM HBL
7	Once overshooting of End of Authority (EoA) / SPAD is detected, Emergency Brake would be applied by Kavach. It appears from the DMI indications that the Brake Command by Kavach was withdrawn as the speed fell below 5 kmph. It is desirable not to withdraw the Emergency Brake Command until train comes completely to stop in such case. This aspect may be verified at falling gradient by Dir-I/T&RS/CoE/Kavach. It occurred later at other occasions also during the inspection.	OEM HBL CoE RDSO
8	Locomotive stopped at km 519.338 i.e 111m after crossing the Signal (shown below in Red Curve). HBL had used DC=0.47 kg/sq.cm, Brake Lag=06 Sec as approved by RDSO. Had DC and Brake Lag been 0.37 kg/sq.cm and 10 Sec (As cleared by CoE in WCR field trials), it would have stopped before Signal at Danger, as shown below in Blue Curve.  	OEM HBL CoE RDSO

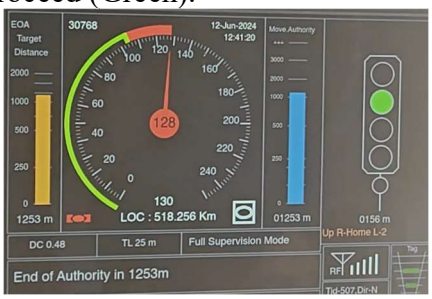
SN	Actionable Item	Action By
9	On invoking Override at km 519.338, the Onboard Kavach immediately entered in On Sight (OS) Mode with display of On Sight Movement Authority. Further, the Authority (1,365 m) displayed was corresponding to Mainline (S6 at km 517.973). 519.338km – 517.973km = 1,365m The train was actually routed to Loopline. On investigation through conventional signalling datalogger, it was learnt that the route was not locked while giving Movement Authority, therefore it could be altered by Station Master to Common Loopline (S4 at 517.965km) after giving Movement Authority.  The Authority Distance is subsequently adjusted in non-radio based ETCS L-1 through Repositioning Balise. The Aspect of the signal at divergence (such as Calling-On Signal) is not able to distinguish between locked routes in ETCS Level-1. Therefore, the relevance of Repositioning Balise in radio-based ETCS L-2 is not same as in ETCS L-1. Same applies to radio-based Kavach. It was learnt on investigation through Signalling Datalogger that the route was not locked and the LC Gate also was open initially. On seeing approaching Locomotive, Gateman lowered the booms. Kavach unduly provided Movement Authority without ensuring locking of route, closure of LC Gate to Road Traffic i.e without actually having authority. This needs design modification. CoE has advised RDSO for not giving Movement Authority without protection by route (latest reiteration vide letter 19.01.2024). This is in line with the fact that any lineside signals provide protection and authority beyond its location (not on its approach). Moreover, Kavach displayed Movement Authority distance to Train Pilot in On Sight Mode as newly introduced “feature” in Kavach Ver 4 Spec.	RDSO All OEMs

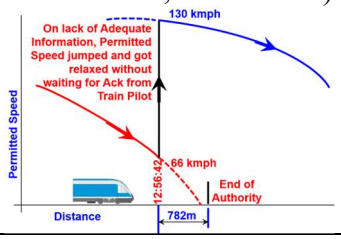
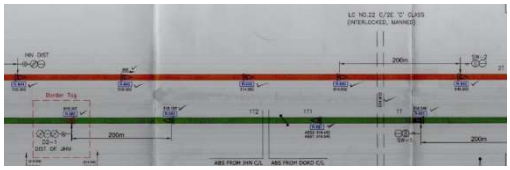
SN	Actionable Item	Action By
10	Alteration of route in SN (9) above after SPAD Prevention Test revealed that the procedure to ensure safety during SPAD Prevention Test was not followed. As per JPO of 2014, the SPAD Prevention Test is to be carried out with Route set for Mainline. CoE has reiterated the same last year also vide letter 24.07.2023 to Zonal Railways. All Zonal Railways are requested to observe utmost care i.e the conditions for signal to be taken off for mainline are fulfilled before the Private Number for Advance Memo to approach signal at Red for Kavach SPAD Prevention Test is taken up.	All Zonal Railways. DRM/DDU
11	RFID Tag 508 at Jakhim Station was planned on Mainline but placed at common Crossover.  Such improper placement caused this mainline RFID tag to get unduly read even for Loopline Movement with point 54 Reverse. This unexpected tag reading was considered as wrong routing of train and brakes were applied. This needs to be set right at site on priority. 	OEM HBL ECR
12	When Locomotive was still on berthing track at Location km 518.719 only, the On Sight Movement Authority by Kavach suddenly increased ~400m beyond both (Mainline and Downline) starter signals at 11:18:49. It again got restored at 11:18:53 when the Movement Authority Distance fell by ~400m. 	OEM HBL

SN	Actionable Item	Action By
13	On crossing the tag 584, the Movement Authorities were suddenly withdrawn at Time 11:41:01 Hrs resulting into sudden Emergency Brake Application from speed of 86kmph. After analysis, a glitch was found in the Ver 4.0 software by OEM HBL software logic while handling of Adjustment Tag. The modification in software had to be carried out by OEM HBL to set right the glitch. Corrected Software will be loaded with altered Checksum by OEM in EC Railway and elsewhere.	OEM HBL
14	Once overshooting of End of Authority (EoA) / SPAD is detected, Emergency Brake would be applied by Kavach. It appears from the DMI indications that the Brake Command by Kavach was withdrawn as the speed fell below 5 kmph. It is desirable not to withdraw the Emergency Brake Command until train comes completely to stop in such case. This aspect may be verified at falling gradient by Dir-I/T&RS/CoE/Kavach. Onboard Kavach was brought to Post Trip at time 11:41:50 Hrs. 	OEM HBL CoE RDSO

SN	Actionable Item	Action By
15	On selecting Override at 11:41:52, Onboard Kavach immediately turned to On Sight Mode at Time 11:41:53, Location km 516.186 with Display of On Sight Movement Authority as 3393m, with Direction exhibited wrongly as "Up". After 02 Sec, at 11:41:56 Hrs, the "Proceed (G)" Signal Aspect was displayed on DMI with Permitted Speed as 130kmph. It will be difficult for Train Pilot to be "On Sight" for any obstruction ahead in form of train ahead at 130 / 160 kmph; arrangement needs review. Although the train was moving in Down Direction, display of "Up" continued until 11:41:54 as shown above. Such incorrect display occurred multiple times during the inspection, at times for prolonged duration. Direction determination (Nominal/Reverse) is SIL-4 functionality. Off-late, determination of direction through multiple tags of same tag set has been introduced in Ver 4.0. CoE had raised apprehensions vide letters 22.09.2022 and in recommendations in CoE Letter 04.01.2023. Such determination of direction is not solicited in view of CoE Letter 19.01.2024. However, RDSO vide recent alteration dtd 21.06.2024 in the Spec, has changed nominal height of RFID Reader from 450mm to 350mm vide Kavach Ver 4.0 SRS Annexure-F Amdt-1. The solution worked out during field trials on passenger carrying trains in 265km section of SC Railway in 2016 by taking considered decision on 14.07.2016 vide Part(1) of NP-23 of concerned Vol.9 of Signal Dte file of RDSO was implemented in Ver 3.2 in field and Control Tables but has been withdrawn in Ver 4.0. Same may be reviewed to avoid undue SoS{CoE lr 25.07.2023, 28.12.2023}.	OEMs RDSO
16	The Down Advanced Starter Signal No. SW-2 of Dev Road was put back when the train was on approach of its Inner Distant Signal. The commensurate drop in Movement Authority distance was reflected at 11:43:25 i.e 08 seconds after reflection in Signal Aspect at 11:42:57 Hrs. Both information (Signal Aspect as well as Movement Authority) are transferred from Ground Kavach equipment to Onboard Kavach Equipment through radio communication. On analysis of log, it was found that the delay of 08 Seconds in processing is on S-Kavach equipment side since despite sending Signal Aspect as Red in11:42:57, it continued Movement Authority upto same (2766 m) spot till 11:43:05. This enormous delay of 08 seconds in processing is on higher side. As can be seen, Movement Authority, Permitted Speed, EoA dropped and Emergency Brake was applied immediately following that. As expected, the train stopped after crossing Advanced Starter, which is in order, since the Signal was put back in face of train approaching at higher speed (near MPS). However, the permitted speed in On Sight Mode remained well above 15 kmph.	OEM HBL RDSO

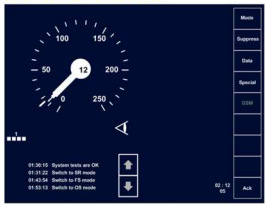
SN	Actionable Item	Action By
17	System Failure occurred at 11:46 with application of Emergency Brake from 107 kmph, in the zone of RFID Tags 704, 706 etc. System transited from System Failure Mode to Standby Mode on its own on run at 11:47:00 and Emergency Brake continued. This event occurred while leaving Deo Road Station in Down Direction. On 01.07.2024, OEM HBL confirmed the irregularity and assured of rectifying the problem. It was observed regarding RFID tags of same tag set that there were mismatches in sequences of Physical Installation at site along the direction of travel Direction and their reporting to Vital Computer. Recent modification dtd 21.06.2024 in Specs needs testing at higher speeds, rework in Locos already fitted with Kavach	OEM HBL RDSO
18	The system prompted for Selection of Train Configuration etc on run. It may be reviewed. Locomotive stopped near to OHE Mast 511/20. 	OEM HBL RDSO
19	Adjustment Tag No. 581 was read by the Onboard Kavach. However, it was declared as missing tag by Onboard Kavach. Distances / Location/ Tag Data etc may be checked up. 	OEM HBL ECR

SN	Actionable Item	Action By
20	The Physical Lineside Signal on Approach exhibited Proceed (Green) aspect whereas it shows Attention Aspect (YY) on DMI (12:40:18). It may cause confusion to Train Pilots.	OEM HBL
21	The Movement Authority sent by S-Kavach was inadequate and around 1.1 km only beyond Signal at Proceed (Green).  It resulted into Emergency Brake Application at 12:41 when Signal was actually exhibiting Green (Proceed) Aspect. It was set right after passing RFID Tag no. 509 at foot of Home Signal (wrongly labelled at Routing Home on DMI).	OEM HBL RDSO
22	Brake Application Icon (Symbol) appeared for long. Even the duration with Speed Pointer as “White (No brakes, No Overspeed Warning)” itself persisted for 09 Seconds from 12:44:49 Hrs to 12:44:58 Hrs.	OEM HBL RDSO

SN	Actionable Item	Action By
23	Kavach was righteously supervising the train speed with Permitted Speed 66 kmph at ~780m from Up Home Signal on approach at Danger when it suddenly started permitting 130kmph without any acknowledgement form Train Pilot while transiting to such degraded mode at Time 12:56:42. This relaxation in Permitted Speed shall have taken place only after cognizance by Train Pilot in form of pressing of Acknowledgement Button (CoE Ltr 25.03.2024, 09.04.2024) 	All OEMs RDSO
24	The LC Gate 22 (at km 514.412) is actually not Interlocked but has been shown as interlocked (Typo Error) in Kavach RFID Tag TIN Layout. OEM HBL and Ashoka BuildCon assured to take care in future while drafting. Mismatch among drawings may lead to serious implications as mentioned in Item(15) of Note of Inspection of MTJ-PWL Section of NCR by OSD/CoE on 15.08.2023. Utmost care needs to be exercised while checking. 	OEM HBL ECR
25	The Gradients have been made part of Kavach Control Table by taking inputs from Track authorities, however, reference / details of all controlled source documents such as Gradient chart / documents, PSR details, OHE Mast Details used as input to Kavach Control Table were not available in the Kavach Control Tables. Mention of same may be ensured.	OEM HBL ECR
26	Undue Speed controls were observed in field in Utran - Kosamba Section of WR as per Nov-2023 Kavach Control Tables of the section, which was addressed through revised Control Tables of Dec-2023. Similar issue didn't crop up in Mathura-Palwal Kavach Control Tables since the spacing of Auto Signals was relatively more in Mathura-Palwal. EC Railway Section also has works for Auto Signals. In order to avoid undue speed control by Kavach affecting operations which are otherwise permitted, the improvements in the Kavach control table were reiterated by CoE vide letter dated 05.02.204. RDSO is requested to address the same as part of Spec so as to have uniformity across Zonal Railways/Units.	All OEMs RDSO
27	On-site brief training was imparted to field officials by OSD/CoE at Anugrah Narayan Road Station. ECR officials were asked to ensure that adequate OFC in chambers have been kept in Block Sections at the future Kavach RIU locations in line with location planning for forthcoming Auto Signalling works.	ECR
28	The Kavach NMS has not been installed in EC Railway. It needs to be expedited.	OEM HBL, ECR
29	Supervision of Temporary Speed Restrictions (TSR) through Kavach TSR Module at Divisional Control Office has been incorporated as new feature in the Kavach Spec Ver 4.0. However, no preparation or no survey has been carried out at site so far. Survey needs to be expedited.	OEM HBL ECR

<table>
<tr><th>SN</th><th>Actionable Item</th><th>Action By</th></tr>
<tr><td>30</td><td>The Radio Communication on Existing Communication Backbone (not LTE) was found to be quite good in field, missing of single packet/ frame alone was reported only at 04 places, meaning good endurance to inclement conditions, not to affect operations even with further substantial deterioration.</td><td>OEMs
RDSO</td></tr>
<tr><td>31</td><td>A new item of display of On Sight MA Distance Bar has been introduced in Kavach Spec Ver 4.0. It is confirmed through observations during inspection in EC Railway that such display of OS MA Bar in Ver 4.0 is invariably available in field also.

The comparison of expected responses from perspective of Train Pilot with ECTS L-2 and Kavach Ver 4.0 in following common situation on Indian Railways is depicted hereunder:

<table>
<tr><th rowspan="2">Technology</th><th rowspan="2">Permitted Speed Restricted?</th><th colspan="2">On Sight MA Distance</th></tr>
<tr><th>Used in Logic?</th><th>Displayed to Train Pilot?</th></tr>
<tr><td>Kavach Ver 4.0</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>European ETCS L-2</td><td>Yes</td><td>Yes</td><td>No</td></tr>
</table>

Unlike Kavach Ver 4.0, ECTS L-2 doesn't display OS MA Distance Bar despite knowing distance (Screenshot), considering the fact that it could be hazardous with train ahead to indicate location of Signal, which beyond the train ahead, to Train Pilot. Display of Movement Authority Bar needs to be suppressed during OS Mode.</td><td>RDSO
OEMs
CoE</td></tr>
</table>

The only Ver 3.2 installation in Kolkata-Delhi-Mumbai Section is Mathura-Palwal. Rest all installation in progress are either "Draft Ver 4.0" or "Non-commissionable Hybrid (mix of 3.2 and 4.0 with RFID Tag Spacing, other installation predominantly in line with Ver 4.0)"- {Please see Category (b) of RDSO-CoE Joint Note 11.09.2023}.

Therefore, in order to progress and enable commissioning of Kavach in Kolkata-Delhi-Mumbai priority Section, finalization of Ver 4.0 is to be ensured on priority. Time-bound action plan, duly addressing items having safety implications, needs to be prepared, shared and followed up scrupulously so that the approvals of Kavach Spec Ver 4.0, products as per Kavach Spec Ver 4.0 and other related approvals, are not delayed further.

LALIT KUMAR MANSUKHANI
ललित मनसुखानी
Digitally signed by LALIT KUMAR MANSUKHANI
Date: 2024.07.03 08:36:48 +05'30'
Lalit Mansukhani
OSD/Centre of Excellence (Modern Signalling-Kavach)