Pre-Qualify for the Design-Build of Israel Railway's ETCS Track-Side Project

General Technical Description

15.11.2015

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Chapter I- Project Background

Facing a continuously growing demand in passenger and freight traffic, Israel Railways has to cope with an increasing number of trains. In the core network, there is the need to raise capacity significantly. In addition, the existing ATP system is subject to safety shortcomings, which can be mitigated by means of a Full Supervision ATC approach. Both reasons have led to the intention to introduce ETCS Level 2 on the Israeli network. In this chapter, details on the current situation and the motivation are provided.

The current line length of Israel’s Railway Network is about 625 km. The total track length is about 1,175 km. This number includes the tracks of both directions and some station tracks. The signalling system is based on electronic and relay interlocking, using axle counters as well as isolated track circuits as a train detection system. A variant of INDUSI I60R is applied as an automatic train detection system and the signalling scheme is close to German H/V signalling.

Nowadays, Israel’s Railway Network is within a development process. There are several new lines which are already under construction:

- Fast Track to Jerusalem: Tzomet Daniel – Jerusalem Ha’Uma
- Link from Ra’anana to Coastal Line
- Ako-Carmiel Line
- Haifa- Beit Shean Line

There are also some other planned lines that will connect relevant economic areas. Such network extension and the rising volume of traffic (either freight hauling or passenger) have led to some limitations, e.g. the arising of the Ayalon corridor as a bottleneck within the railway network. As a first stage, that troublesome situation has been handled with the implementation of a new block scheme (shortening block length) and the limiting of maximum speed in that segment of the network, both measures working together with the goal of increasing traffic capacity. This way, capacity in the core of the network was raised to ten trains per peak hour and in each direction on the coastal line. There remains pending a second stage, as one of the issues to be resolved within the solution to be offered by winner of the tender, in which the traffic from the New Jerusalem line will have to be assimilated. To serve these services, up to thirteen trains per peak hour and in each direction will have to be operated.
To overcome capacity issues like the aforementioned, several works are being performed to increase the frequency of trains on some lines. Among such works are the following:

1. Rebuilding the track layout of Herzliya station.
2. Rebuilding the track layout of Tel Aviv central, Tel Aviv Hagana station, enabling middle track turn around.
3. Rebuilding the track layout of Lod station.

Alongside the network growth, several actions are being planned and/or performed with the aim of modernising the network and improving efficiency, such as the deployment of a modern railway electrification system (25 kV ac) which will cover 420 km of the network, and the procurement process for new electrified rolling stock compatible with that electrification system.

Given the current and foreseeable outlook of Israel's Railway Network, and within the framework of the development plan, the current automatic train protection system INDUSI seems insufficient in terms of both safety and capacity. Furthermore, INDUSI system is approaching to the end of its life cycle.

With a view to making the overall railway network more efficient, the need to seek an alternative to the INDUSI system is imposed, since it would not, in all the capacity issues, be possible to apply constructional solutions to meet the desired operation requirements (e.g. Ayalon corridor, on absorbing the future traffic of the Jerusalem High speed link), and to overcome the limited scope of that system on safety issues. Such a new automatic train protection system should be able to deal with the present and future shortcomings at a reasonable cost.

**Current and Future Network Layout**

The line length of Israel’s future Network is about 880 km with electronic interlocking, with electrified lines and 1,435 mm of standard gauge. The future total track length is about 1,500 km. This number includes the tracks in both directions and some station tracks. The network is centred on Israel's densely populated coastal plain, from which lines radiate out in many directions.
Figure 1. Outline of existing lines and under construction
Israel's Railway Network is being updated to cope with new necessities such as transport communication between strategic areas, increasing the capacity of existing lines, safety relevant issues, energy or life cycle going to the end of some subsystems.

**Interlockings and Signalling system**

Israel Railways Network is currently divided into two main areas North and South. In the North from Nahariya Station to Shfaim Station, stations are currently operated by Relay Interlocking, that is about to be replaced to Electronic Interlocking ESTW L90 until 2019. In the South from Shfaim to Be’er Sheva stations are operated under ESTW L90 IL electronic interlocking systems.
**Figure 2.** Geographical distribution of Interlocking in the northern part of Israel Railway Network

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Figure 3. Geographical distribution of Interlocking in the southern part of Israel Railway Network
Regarding field elements, there are two main train detection systems installed and coexisting in the Israel Railway Network:

1. 50 Hz Track Circuits
2. Axle Counters

Both systems are used to detect the presence of the trains within defined sections of track.

Also ISR is planning to improve the train detection system by substituting 50 Hz Track Circuits for axle counters.

The three major aspects are “stop” (Hp0/Vr0), “proceed” (Hp1/Vr1) and “proceed at reduced speed” (Hp2/Vr2). In addition there are shunting routes. All signal aspects are shown with a constant light. No flashing aspect exists. There are also double-aspect, e.g. green/yellow to indicate proceed at reduced speed (Hp2). Figure 4 illustrates sample aspects of an entry signal.

<table>
<thead>
<tr>
<th>Entry signal sign with possible signalling facilities on the pole</th>
<th>Lights</th>
<th>Appearance of lights</th>
<th>Meaning of lights and train driver operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed signal, Entry signal, Warning signal, Advanced signal for start, Speed signal, Light signal pole</td>
<td>Red – normal state</td>
<td><img src="image" alt="Red Light" /></td>
<td>Danger – do not enter the station – driver must stop before the light signal.</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td><img src="image" alt="Yellow Light" /></td>
<td>Drive at limited speed – driver may enter the station at a speed of up to 60 km/h or as stated on the light signal/speed sign, if any.</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td><img src="image" alt="Green Light" /></td>
<td>Drive – driver may enter the station at the maximum permissible speed</td>
</tr>
<tr>
<td></td>
<td>Dark</td>
<td><img src="image" alt="Dark Light" /></td>
<td>Danger – do not enter the station – driver must stop before the light signal.</td>
</tr>
</tbody>
</table>

*Figure 4 Sample aspects of entry signal*
All signals, except block signals, always show their most restrictive aspect in their basic aspect. The most restrictive aspect of a signal (for main and shunting signals red, distance signal yellow/yellow) does not have to be set by a command from the system and will remain lit even in cases of systems failure.

**Automatic Train Protection**

Israel Railways makes use of INDUSI (“Induktive Zugsicherung”, “inductive train protection”), which belongs to the class of ATP systems. Its application areas besides Israel are Germany, Austria, Romania, Slovenia and Canada. INDUSI facilitates inductive coupling and consists of two components, namely a track-borne and a train-borne magnet.

The train protection system uses the frequencies 1,000 Hz at the pre-signal, 500 Hz before the main signal and 2,000 Hz at the main signal. In Israel, the 500 Hz magnet is mandatory and always located 370 m before the main signal.

Figure 5 illustrates the supervised speeds as a function of the three train types.

![Figure 5](image-url)  
**Figure 5**  
160R supervision curves in Israel
Fixed Telecommunications Network

ISR owns a SDH network based on fibre optics. Israel Railways established and operates an independent transmission system, for the purpose of communication signals, voice, data and security.

The transmission system based on fiber optical cable lies in the ground along the railway lines from Nahariya to Dimona.

The optical cable feeds the SDH network consisting of 90 sites.

The SDH network's topology is rings (STM-4 & STM16), in order to enable protection in case of failure.

Mobile Telecommunications

There are two main mobile communication systems in operation in ISR:

- "VHF radio communication system". It is ISR own system based on about 20 based stations with full coverage of the net. ISR is planning to keep this system as a "stand-by" system for DRP cases.

- "MIRS- cellular communication system". It is a public system that is close to be after End of Life. ISR is planning to replace MIRS by GSMR.

Network Traffic Control Centre

The Network Management and Traffic Control Centre (NTC) is currently located in Haifa Hof Ha’Carmel station. The system consist from two main subsystems: ARAMIS and COMMAND 900. This is the system in charge of collecting information related to the operating status of all wayside track elements, such as switch operation, track section occupation, identification of the train that occupies each track section.

Power supply systems

All current lines in the Israel Railway Network are not electrified but ISR is contemplating the modernization of the current network and, actually, the future lines which are under construction will be 1x25 kV electrified.

Currently the power supply source to the signalling buildings is provided by a 3x380Vac connection provided by Israel Electric Corporation (IECO). This will be the only external power source for future technical buildings.

As a backup energy system, there are batteries providing at least 8 hours of uninterruptible power service.
Chapter II - Description of the project

The ERTMS/ETCS L2 system shall be progressively implemented across the entire Israel Network (see Figure 1). The whole Israel Railway Network includes existing and planned projects and contains about 1,500 KM track, 8 operational IXL's, 1 reserve IXL.

The ERTMS/ETCS L2 system shall be implemented in three main stages:

1. **Stage 1** (see Figure 7, Figure 9), includes the section Herzliya- Jerusalem Binyanei Hauma- Modi’in -Lod (excluded). Stage 1 includes operation of two (2) RBC's (according to numbers of IXL areas, the number of RBC's can be changes with accordance to the "Detail Design"), 213 KM of track, and one (1) reserve RBC for the whole network.

2. **Stage 2** (see Figure 2), includes the sections Naharia- Karmiel- Beit Shean-Kfar Saba- Herzeliya ,three (3) RBC's (according to numbers of IXL areas, the number of RBC's can be changes with accordance to the "Detail Design") 440 KM of track.

3. **Stage 3** (see Figure 3) includes the track sections -Lod- Rosh haain-Ashkelon-K.Gat- B.Sheva- Zefa - Zin, three (3) RBC's (according to numbers of IXL areas, the number of RBC's can be changes with accordance to the "Detail Design") 780 km track.

Additional Functionality

Operation of trains under different operation levels will be possible, without further restrictions than those needed to guarantee the protection of the different trains.

A security operation level has been also developed to cover the degraded situation of malfunction of the RBC when a train, running in ERTMS Level 2 FS, is given a MA that allows it to pass a signal showing red aspect, posing a hazardous situation if the train can reach the danger point or pass the overlap where applicable. The proposed solution contemplates the installation of some ERTMS/ETCS Level 1 equipment, such as switchable Eurobalises and Lineside Electronic Unit (LEUs).

In order to cover the degraded situation when the train is running in Level 2 and the RBC has been hacked due to a security breakdown, the way to protect the train from overpassing a signal at danger shall be accomplished by implementing Level 1 functionality in the locations planned and taking into account the information from
balises. This implies installing switchable balises in every BG group associated with lineside signals of Network sections defined by ISR.

**Step1: Stopping the train at a red signal**
1) Transition to Level 1
2) Train trip
3) Termination of Communication Session

**Step2: Continue Operation**
4) Manual transition to Level STM

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**Figure 6.1 Overview of the proposed steps 1)-4) to be accomplished to cover the Level 2 degraded safety situation after security breach in communications**

In order to cause the minimum effects to the nominal operations due to a security breach in communications, the RBCs should send MAs with the EoA at the lineside signals when in red. Therefore, in the event of a failure of a lineside signal, the EoA will be placed at the failure signal and the driver would be able to perform an override of the signal following the corresponding procedure.
Figure 6.2 Overview of the proposed steps 1)-4) to be taken plus the TSR mitigation option

Train runs under Braking Curve derived from a TSR

Next Signal in opposite direction

ETCS L1 AREA
Description of Stage 1:

**RBC distribution layout**

For the first ETCS L2 implementation stage in the Herzliya – Jerusalem Binyanei Hauma line, the installation of 2 RBC linked with MEM 3 and MEM 4 in Rosh Ha’Ayin South and Tel Aviv South respectively is foreseen, and 1 additional RBC in Lod, which could replace any of the active RBC in case of failure.

The next figure shows the RBC distribution layout in the *Herzliya – Jerusalem* line.

*Figure 7. RBC distribution layout.*
The following figures present general implementation stages and main time schedule for the first stage:

**ERTMS Project Stage 1, Project scope:**
- ETCS L2 on - 213 km single track (89 km line)
- 17 trains at peak hour on Ayalon corridor
- 3 Trains at peak hour on A1 Jerusalem – Tel Aviv
- Infrastructure changes in Herzliya, Tel Aviv center and Tel Aviv Hahagana
- Installation of 3 RBC (2 + 1 reserve)

**Line Capacity:**
14 Trains at Ayalon corridor
2 of them from A1 line

**Figure 8.1**

**ERTMS Project Stage 1, 07/2018:**
Passenger trains in operation at Ben Gurion Airport – Modi'in Section:
Vehicles which have not been retrofitted will be operated on INDUSI mode
RBC-4 in operation (Tel Aviv south)

**Figure 8.2**
ERTMS Project Stage 1, 10/2018:

Operation passenger trains at Tel Aviv South - Modi'in Section:
Retrofitted vehicles will operate in ETCS/STM MODE
Vehicles which have not been retrofitted will operate in INDUSI
Modifications of MEM3 Interlocking
RBC-3 in operation (Rosh Haayin)

Line Capacity:
14 Trains at Ayalon corridor by INDUSI
2 of them from A1 line

ERTMS Project Stage 1: 04/2019:

Passenger trains in operation at all Stage 1 sections.
Retrofitted vehicles will operate in ETCS/STM MODE
Vehicles which have not been retrofitted will operate in INDUSI
Modifications in MEM3 Interlocking.
RBC-R in operation (Spare in Lod)

Line Capacity:
14 Trains at Ayalon by INDUSI/ETCS/STM
2 of them from A1 line
Full operation of ERTMS Project
Stage 1, 04/2019:
17 trains Scheduled
17 trains at Ayalon corridor (3 of them in A1 line)

The following figure describes the track layout for the first stage:

Figure 8.5

Figure 9
Description of stages 2

Stage 2 (see Figure 2), includes the sections Naharia- Karmiel- Beit Shean- Kfar Saba- Herzeliya.

Three (3) IXL’s will be in operation:

- Naaman
- Hof Ha-Carmel
- Natanya

440 KM of track

On the RFP stage the needed information will be provided by ISR.

Description of stages 3

Stage 3 (see Figure 3) includes the track sections -Lod- Rosh haain- Ashkelon-K.Gat- B.Sheva- Zefa – Zin

Three (3) IXL’s will be in operation:

- LOD
- Kiryat Gat
- Beer-Sheva

780 km track.

On the RFP stage the needed information will be provided by ISR.