Israel Railway Ltd.

Volume 3 - Technical Specifications
FOR EXECUTION OF ELECTRIFICATION WORKS

Table of Contents

APPENDIX C – EXAMPLES OF TYPICAL CROSS-SECTION DESIGNS

APPENDIX D – EXAMPLES OF TYPICAL PLAN AND PROFILE

0.0. Section 00 – Preliminaries

0.1. Section 00 – Preliminaries Overview

This Preliminaries Section includes general and common provisions forming an integral and binding part of the conditions for execution of the Project Works.

The Contractor shall perform the Works in full coordination with ISR, ISR's Project Manager or any party acting on their behalf, and strictly in accordance with the instructions thereof.

All planning, permitting, execution, testing, commissioning and handover activities shall be carried out under the engineering management and supervision of ISR's Project Manager.

0.2. High-level, General Description of the Works

The Works under this Tender include full Design and Build (DB) of the ISR Overhead Contact System for railway electrification pursuant to the terms and conditions set forth herein and in the Tender Documents (hereinafter: the "**OCS System**"). The Works include (without limitation):

1. **Railway Network Execution:** Execution of works on the main lines, stations, and stabling areas (including single, double, or multi-track networks) as defined in the Lines Programme.
2. **Electrification Upgrades** & **Integration:** Implementing additional components, systems, and adjustments to the Initial Electrification Works, and ensuring full integration with the Lines Programme.
3. **Coordination** & **Interface Management:** The services, works and overheads required to facilitate cooperation, manage complex interfaces, and coordinate with other ISR contractors, governmental/municipal authorities, and various professional disciplines.
4. **SCADA Works :**In addition, the Tender Documents include SCADA works specifications. The design and execution of such works, whether in whole or in part is an option, which may be implemented partially or wholly at ISR's discretion.

The scope of the Works includes, without limitation, the following activities:

Design Phase

The Contractor shall be fully responsible for all Design activities (unless instructed otherwise by ISR), which constitute a condition precedent for commencement of any physical Works, including but not limited to:

- Notice to Proceed (Design) - This notice will include a start date to commence the Design phase of the Works as described in this volume (the "**Design Phase**").
- Preparation of updated topographical and control surveys, signed by a licensed surveyor in accordance with ISR standards. The surveyor will be pre-approved by ISR.
- Detection and mapping of existing underground utilities prior to design, including GPR (Ground Penetrating Radar), earth vacuuming, and manual digging as necessary and instructed by ISR.
- Full design of the OCS System in accordance with the Technical Specifications and in accordance with ISR standards.
- Obtaining all design approvals from any competent Authority as required under Law and ISR standards.

- Payments to third parties for supervision, as instructed by ISR.
- Design and approval of Temporary Traffic Arrangements (TTA)
- Design, coordination and execution of the removal and/or relocation of infrastructures interfering with the installation of the OCS, if instructed by ISR.
- Design coordination and collaboration with the design teams of interfacing projects of ISR and any other governmental authority, or anyone acting on their behalf.

ISR may instruct the Contractor, during the Design Phase and prior to issuance of a Notice to Proceed (Execution), to perform preliminary works as defined by ISR from time to time. Such works may be required in parallel with ongoing design, coordination, permitting, or approval activities and shall not constitute a Notice to Proceed (Execution).

Preliminary Works

Works required for advancement of Site readiness and Project execution, including but not limited to temporary traffic arrangements, utility-related works, surveys, enabling works, and works required to support execution phasing and interfaces with other contractors, such as foundations, erection of poles, or similar preparatory activities, all subject to approved design documents, permits, approvals, method statements, and ISR instructions.

Execution Phase

Commencement of the execution phase of the Works shall be strictly conditional, unless otherwise instructed by ISR in writing, upon completion and approval of all pre-execution requirements in connection with preliminary works performed during the Design Phase.

ISR may, at its sole discretion, instruct the Contractor, during the Design Phase and prior to issuance of a Notice to Proceed (Execution), to perform preliminary works, as determined by ISR.

The Contractor shall comply with such instructions and shall perform the required activities in accordance with ISR instructions, applicable Laws, approved method statements, and all relevant safety and operational requirements.

Execution of such preliminary works shall not be construed as issuance of a Notice to Proceed (Execution) for the relevant Work Order or Network Section, and shall not relieve the Contractor from completing all remaining design, approvals, permits, coordination, or other pre-execution obligations required under the Agreement.

Execution Phase shall include the following, among others:

- Notice to Proceed (Execution) - This notice will include a start date to commence the Execution phase as described in this volume (the "**Execution Phase**").
- Obtaining all excavation permits and work permits in accordance with the Planning and Building Law, utility owners' requirements and ISR instructions.
- Local Infrastructures' detection prior to drilling. Infrastructures shall be marked clearly to avoid destruction.
- Execution of Temporary Traffic Arrangements (TTA)
- Foundations for OCS structures (unless instructed otherwise by ISR).
- Erection of OCS poles and structures.
- Installation and tensioning of OCS wiring.

- Completion and integration of the OCS System.
- SCADA cabling works as instructed by ISR.
- Connection to existing OCS or traction substations.
- Post Execution As-Made drawings signed by a licensed surveyor.
- Testing, commissioning and handover to ISR or to the maintenance entity in accordance with ISR requirements and as specified in section 0.9 herein below.

Due to the nature of the Works, activities may be performed adjacent to active and/or energized railway lines. Track possessions (TPs) shall be defined by ISR. The Contractor shall fully adapt its resources, manpower and equipment to the defined track possession windows.

0.3. Nature of the Works and Working Conditions

The Contractor is aware that it shall be required to carry out the Works in different Sites and that aboveground, belowground, geotechnical, geological, hydrological, climatic, environmental and seismic conditions could differ from Site to Site.

It is hereby clarified that for execution of certain parts of the Works, the Contractor may be required to work within areas that have been permanently or temporarily expropriated for the purpose of the Works, strictly in accordance with written instructions issued by ISR (including but not limited to operational railway stations, platforms, and facilities).

The Contractor shall carry out all actions required to locate existing utilities at the Site by means of electronic detection, trial excavations, GPR, vacuum excavation or any other approved method, and shall clearly and accurately mark such utilities to prevent damage. As part of obtaining excavation permits, the Contractor shall coordinate with representatives of the relevant utility owners and shall comply fully with their instructions.

The Contractor shall be fully responsible for coordinating all design activities, permits, approvals, execution activities, and interfaces related to existing utilities and infrastructure with the relevant utility owners, authorities, third parties, and other stakeholders, as required for execution of the Works.

The executing contractor for utility relocation works shall be determined solely by ISR, following coordination with the relevant utility owner or third party. ISR may determine, on a case-by-case basis, whether such relocation works shall be executed by the Contractor, by the relevant utility owner, or by another third party.

Where ISR instructs that utility relocation works shall be executed by the Contractor, the Contractor shall perform such works without delay and in full coordination with the relevant parties, in accordance with approved design documents, permits, approvals, applicable Laws, and ISR instructions.

Where ISR determines that utility relocation works shall be executed by the relevant utility owner or by another third party, the Contractor shall fully coordinate its design, schedule, interfaces, access requirements, and execution activities with such parties and shall integrate such activities into the Project execution plan.

The Contractor shall not block access roads, agricultural roads, entrances or exits to existing buildings or plots along the alignment. Where required, the Contractor shall plan and obtain all necessary approvals from relevant stakeholders.

Commencement of any Works at the Site shall be subject to the written approval of ISR by issuance of a notice to proceed ("**Notice to Proceed (Execution)**").

It is further clarified that failure to commence Works due to non-fulfilment of the conditions set forth in this Section 0.3 shall not constitute grounds for any claim by the Contractor of any kind. The provisions of this Section shall not derogate in any manner from the Contractor's contractual responsibilities and obligations throughout the Execution Phase.

0.4. SCADA Works – clarification

For the purposes of this document, the term "SCADA Contractor" shall mean the subcontractor responsible for the SCADA works, as designated and appointed by ISR. Such subcontractor may either be a Subcontractor of the OCS Contractor (to the extent ISR exercises the Option pursuant to the provisions of the Agreement) or a third-party contractor appointed by ISR.

Appendix B (Scada System Design-Build Technical Specification) hereto sets forth the technical specifications for the SCADA works to be carried out by the SCADA Contractor.

0.5. Access Roads, Fencing and Site Organization Plan Road

The Contractor shall obtain all required approvals for temporary traffic arrangements and for regulation of all access roads to and adjacent to the Site.

The Contractor undertakes to comply with all safety instructions issued by the relevant Authorities and to implement all requirements thereof, whether provided directly to the Contractor or conveyed through ISR following prior coordination.

It is emphasized that some access roads intersect existing infrastructure such as fuel pipelines, wet utilities and similar facilities.

Without derogating from the provisions of the Agreement, the Contractor shall plan, approve and implement temporary traffic arrangements during the Design Phase as required, and shall obtain any required approval from the competent Authorities, including the authorized traffic authority and the police. The Contractor shall engage an approved traffic consultant for carrying out the foregoing.

Fencing

The Contractor shall fence all site organization and mobilization areas with white corrugated steel fencing with a minimum height of 2.0 meters (or other if instructed by ISR) and shall install suitable access gates in accordance with site constraints. Gates shall remain locked at all times during and off working hours and shall be opened solely for authorized site access, delivery of equipment and materials, and operational needs.

The Contractor shall maintain all fencing throughout the Execution Phase in accordance with ISR requirements and shall relocate fencing as required.

Site Organization Areas

A site organization area is defined as an area located near the Site and required for temporary storage of materials, equipment, tools and temporary offices as necessary for execution of the Works.

To the extent possible and subject to availability, ISR shall specify in the applicable Work Order any site organization area arranged thereby. Should the Contractor require an alternative site or additional site to that arranged by ISR, it shall be responsible for procuring, arranging and maintaining same, including entering into the required agreements with third parties with respect thereto.

Within 20 days from issuance of a Notice to Proceed (Execution) with respect to a specific Work Order, the Contractor shall submit to ISR site organization plans, including approved access arrangements, as approved by the relevant local authority and ISR.

The Contractor shall coordinate and obtain approvals from relevant utility owners regarding the location of the site organization areas.

The Contractor shall ensure continuous and proper maintenance of the site organization areas throughout the Execution Phase and until dismantling.

The site organization plan shall be prepared with an up-to-date topography survey and the general work plan at a scale of 1:100, as required by ISR and any Authority. The plan shall clearly indicate all components required for site organization, including:

- Temporary structures, utility connections, drainage arrangements, equipment parking areas;
- Storage areas, site offices, access routes, entrances and exits, safety fencing;

- Temporary traffic arrangements for vehicles and pedestrians for all execution stages;
- Locations for equipment, cranes and all elements required for execution of the Works.

The Contractor shall be responsible for obtaining, maintaining and renewing any permits related to the site structures, including paying municipal taxes and levies, if applicable.

0.6. Installation of Signage within the Organization Site

The Contractor shall plan, approve and install, in accordance with the instructions of ISR, two project signs for the entire Execution Phase. The signs shall comply with the size requirements instructed by ISR and shall include the project name, the name of the chief designer, ISR's Project Manager, the executing Contractor and the Site Manager, as well as the logos of ISR and the Ministry of Transport.

The content of each sign shall be approved by ISR prior to manufacture. A digital file of the sign shall be submitted for approval following ISR approval and prior to production.

The Contractor shall submit a draft of the sign wording, including an approved visualization, for the approval of ISR.

The exact location, size, background color and lettering shall be determined by ISR.

The signs shall be installed on appropriate steel poles with suitable supports and concrete foundations. Prior to fabrication, the Contractor shall submit detailed structural drawings of the sign, its foundations and installation method, approved by a licensed structural engineer.

The design, foundation and installation of the signage shall be executed by the Contractor, under its sole responsibility, and in accordance with applicable Laws.

The Contractor shall take into account that relocation of the signage may be required during the execution of the Works.

0.7. Site Offices for Project Management Team

The site organization area, including the Project Management Team offices, shall be fenced with white corrugated steel fencing with a height of 2.0 meters and shall include a locked access gate.

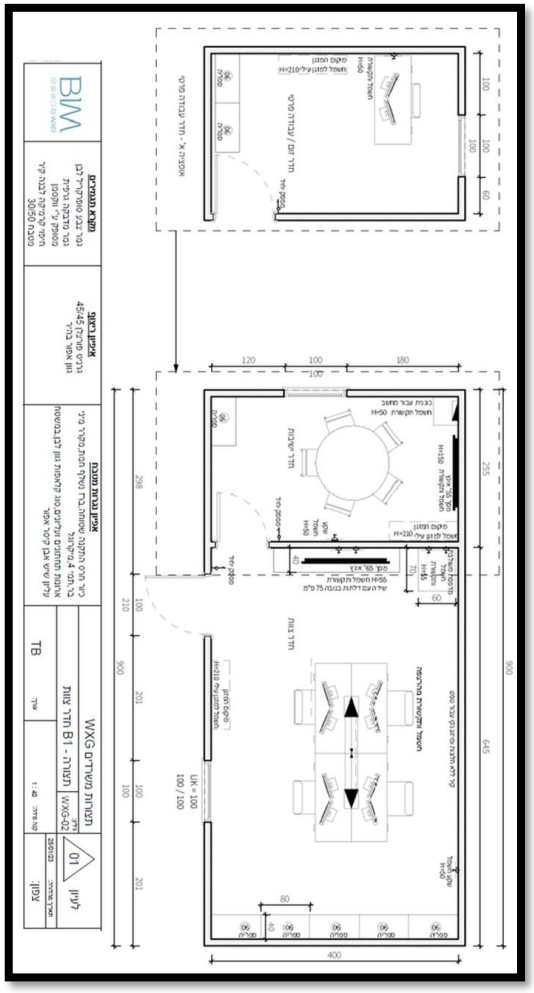
If required, the Contractor shall establish field offices for ISR and the PMC representatives, in accordance with this Section and the attached office layout plans.

The structures shall be established for use by ISR and its staff and shall be suitable for office work.

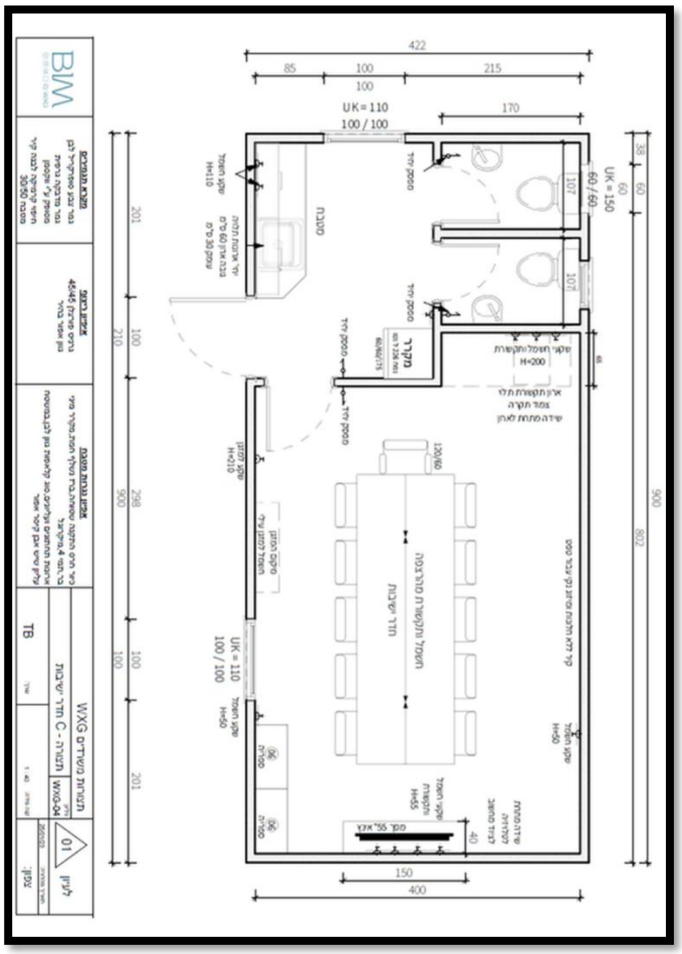
The offices shall include furniture and equipment as stated in the table below.

A total of two structures shall be provided as specified. The offices and all equipment shall remain on Site until inspection and approval of the final Payment Request, and removal shall be subject to approval by ISR.

Site offices layout A:



Site offices layout B:



Office furniture Table:

Item No.	Description	Quantity	Specifications	Example picture
01	Work Desk	6	Dimensions: 160x80 cm Color: White Equivalent to IKEA model: BEKANT desk 160x80 cm	
02	Mobile Drawer Unit	6	Dimensions: Width 40 / Depth 45 / Height 65 cm Color: White Equivalent to IKEA model: TROTTEN 3-drawer unit with wheels	
03	Office Chair	7	Color: Grey / Black Equivalent to IKEA model: FLINTAN office chair with armrests	
04	Meeting Chair	10	Color: White with chrome-plated legs Equivalent to IKEA model: LIDÅS chair, white / chrome	
05	Large Meeting Table	8	Dimensions: 125x100 cm Color: White Two units to be connected to form one table of 2.5 m length Equivalent to IKEA model: LAGKAPTEN / ADILS	
06	Small Meeting Table	1	Diameter: 103 cm Color: White Equivalent to IKEA model: DOCKSTA table	
07	Bookcase	7	Bookcase dimensions: 80x40x192 cm, White Shelves dimensions: 76x38 cm, White	

08	Office Cabinet – 4 Hinged Doors	4	Dimensions: Width 160 / Depth 40 / Height 90 cm Color: White	
09	Espresso Machine (Capsules / Grinder + Milk Frother)	1		
10	Top-Freezer Refrigerator 200 L	1		
11	Microwave Oven	1		
12	Hot / Cold Fresh Water Dispenser	2		
13	Whiteboard 80x120 cm	4		

The Contractor shall provide all required infrastructure for the establishment and continuous operation of site offices at the mobilization and site organization areas. The offices shall be fully functional and suitable for project management, administrative activities throughout the Project duration, including fire extinguishers and first aid kit.

The site offices shall be connected to permanent or temporary water supply and sanitary sewer systems, including toilets, washbasins and drainage, in accordance with applicable regulations. Where permanent connections are not available, approved temporary solutions shall be provided, maintained and serviced by the Contractor.

The Contractor shall provide a reliable electric power supply to the site offices, including lighting, sockets, air conditioning and backup arrangements as required. All electrical installations shall comply with applicable standards and safety regulations.

The Contractor shall ensure continuous internet and communication services, including broadband internet access, data connections and telephone services, sufficient to support project management systems, document control, coordination meetings and remote communication with ISR and other stakeholders.

The Contractor shall provide and maintain all office and IT equipment required for the proper functioning of the Project Team, including printers, scanners and copying facilities, in quantities sufficient for the needs of the Project.

The Contractor shall provide a minimum of five (5) and no more than ten (10) laptop computers, Lenovo Yoga 7 or an approved equivalent (Intel i7 or AMD Ryzen 7 processor, 1 TB SSD storage, at least 16 GB RAM, Windows 10 or Windows 11 license, and a touch screen), with a screen size of 14 or 15.6 inches.

In addition, the Contractor shall provide a minimum of five (5) and no more than ten (10) desktop monitors (21-inch LG or approved equivalent), mouse and keyboard kits, and docking stations, all fully compatible with the provided laptops.

All computers shall be supplied with, and capable of operating, all software required for the execution of the Works, including, without limitation, operating systems, office applications, scheduling software (MS Project or equivalent), and design software (AutoCAD or equivalent), all with valid licenses.

The Contractor shall be responsible for the maintenance, repair, and replacement of all computers and related equipment throughout the duration of the Project, including replacement in the event of malfunction, and shall replace the computers at least once every two (2) years.

The Contractor shall provide two (2) Drones, DJI Air 3S Combo Kit or an approved equivalent, for project use.

The Drones shall be supplied brand new and in full working order, including without limitation, all standard accessories required for their operation (3 batteries per drone, controllers, chargers and carrying cases)

The Drones shall be replaced upon loss of airworthiness, significant malfunction, or damage affecting safe operation, and in any case no later than three (3) years from the date of supply.

All infrastructure systems and office equipment shall be installed, operated and maintained by the Contractor, and shall remain fully operational for the entire duration of the Works, at no additional cost to ISR.

The Contractor shall be responsible for the constant supply of office equipment and consumables, including but not limited to printing paper compatible with the printers in use, stationery, writing instruments, rulers, pins, magnets, and similar items.

The Contractor shall be responsible for the supply of toiletry and hygiene items, including but not limited to toilet paper, soap, paper towels, dish sponges, cleaning materials, and shall also be responsible for the daily cleaning of the offices.

The Contractor shall be responsible for the continuous supply of kitchenette and coffee station products throughout the entire duration of the Works, including but not limited to milk, sugar, black coffee, instant coffee, coffee capsules and/or coffee beans, cutlery, and similar items.

The Contractor shall be responsible for daily cleaning of the offices.

0.8. Protection Against Climate Damage, Groundwater and Temporary Drainage

The Contractor shall take all measures necessary to protect all executed Works, structures, materials, tools and equipment from damage caused by natural elements throughout the Execution Phase and until the end of the Warranty Period.

In particular, the Contractor shall implement all measures required by ISR to protect the Site against flooding from rainfall or any other water source.

The Contractor shall also provide and maintain temporary drainage arrangements as required.

0.9. Contractor's Staff and responsibilities

The Contractor shall submit and obtain ISR's approval for the Core Management Team and Key Personnel as detailed in the table in Section 0.40 below.

The Core Management Team and Key Personnel constitute minimum requirements, and the Contractor will be required to engage, maintain and deploy professionals, experts, consultants, advisors and other service providers and subcontractors as necessary and required to ensure that the Works are carried out fully, appropriately and properly in accordance with the Agreement, each Work Order and applicable Law.

A licensed Surveyor shall be appointed for surveys, measurements, preparation of as-made drawings, submission of payment quantities and site marking. The surveyor shall be available within 24 hours from receipt of ISR's request.

To the extent instructed by ISR, an environmental quality officer shall be appointed, holding an academic background in relevant fields such as environmental engineering, landscape architecture or ecology, and with at least three years' experience in supervision of railway or road infrastructure projects.

The environmental quality officer shall liaise with the environmental consultant appointed by the competent authority and shall ensure compliance with all environmental requirements. Approval of environmental conditions by the competent Authority shall constitute a condition precedent to commencement of any Works.

The environmental quality officer shall report to ISR's Project Manager any deviation from defined threshold values or mandatory work instructions. All deviations shall be recorded in an "Exceptional Events Log", including details of the nature of the deviation, date, responsible party, corrective instructions and completion date.

5.

0.10. Emergency Availability

The Contractor shall maintain 24/7 availability for emergency communications throughout the duration of the contract. The Contractor shall designate a dedicated emergency contact telephone number, which shall be continuously monitored and accessible at all times, including nights, weekends, and public holidays. This number shall connect to a qualified representative authorized to receive and respond to emergency notifications and to initiate immediate coordination and response actions as required. The emergency contact details shall be provided to ISR and relevant operational representatives prior to the commencement of Works and shall be kept valid and updated for the entire Term of the Agreemnt.

0.11. Safety at Work

The Contractor shall perform all Works in accordance with all Laws, ISR's procedures and all relevant occupational safety standards.

Execution of Works shall commence only after receipt of approval from ISR's safety manager and from the Contractor's safety officer.

0.12. Equipment Required for Execution of the Works

Importation and Availability of Equipment

In accordance with the distribution of the work sites and for the purpose of ensuring appropriate quality, all equipment, materials and tools required for execution of the Works shall be present in Israel at least thirty (30) calendar days prior to the planned work commencement date.

All materials and equipment shall be stored in accordance with the relevant standards, manufacturer instructions and applicable PHST manufacturer guidelines, as relevant.

Transfer of Equipment to the Site Organization Area

Transportation of materials to the site organization area shall be carried out in accordance with the manufacturer's instructions and applicable standards and shall be the sole responsibility of the Contractor.

The Contractor shall not commence any Works unless all equipment required for the execution of the specific activity is present on Site, in the quantity and quality required, to the satisfaction of ISR and in accordance with the drawings, relevant standards, nature of the Works and manufacturer instructions.

All required equipment shall be delivered to the site organization area in proximity to the commencement of the Works and shall be present on Site at least one (1) hour prior to receipt of track possession, for the purpose of inspection of all required equipment.

0.13. Verification and Design Review of ISR Drawings, Data and Interface Information (DB)

Review of Drawings and Data Received from ISR

Upon receipt of any drawings, data or information provided by ISR (the "**Data**") or by other parties acting on its behalf, including but not limited to reference drawings, surveys, existing infrastructure information, interface drawings, specifications, bills of quantities (if any) and dimensional data, the Contractor shall perform a professional, coordinated and timely review thereof.

The Contractor shall examine the Data in advance of execution and, within fourteen (14) working days from receipt, notify ISR in writing of any error, omission, contradiction or inconsistency identified within the Data, between the Data and actual site conditions, or between the Data and applicable Laws or standards, which could reasonably be identified by an experienced Design–Build contractor.

This obligation shall include, *inter alia*, verification and measurement of existing elements to which the Works are connected, and notification of any on-site conditions inconsistent with the ISR Data.

Nature of the Data Received from ISR

The Contractor acknowledges that the Data is provided for information and interface purposes only. Certain dimensions shown therein may be approximate and execution details may be indicative only, and subject to adjustment in accordance with actual site conditions. The Contractor shall be responsible for coordinating and executing the Works in accordance with accurate, verified and correct dimensions.

Scope of Review

The Contractor's review obligation under this clause shall be limited to identifying reasonably detectable discrepancies and inconsistencies in the Data and shall not constitute a detailed design verification, independent calculations, or a review of the Contractor's own design solutions.

Nothing in this clause shall be construed as relieving the Contractor for its full and exclusive responsibility for the design of the Works, nor as transferring any design liability to ISR.

Consequences of Failure to Notify

Failure by the Contractor to notify ISR within the timeframe stated above of discrepancies that could reasonably have been identified shall result in such discrepancies being deemed included within the Contractor's design responsibility. Any corrections, including demolition and reconstruction if required, shall be carried out by the Contractor without any obligations to ISR.

ISR Instructions

Upon notification, ISR shall issue written instructions or clarifications within a reasonable time. The Contractor shall not proceed with execution of the affected Works until such instructions are received, unless otherwise directed by ISR in writing.

Safety

Notwithstanding the above, the Contractor shall immediately notify ISR upon discovery of any issue affecting safety, regardless of when such issue is identified.

0.14. Quality Control Laboratory

The Contractor shall engage and maintain an approved and certified laboratory for purpose of performing the required tests, all in accordance with ISR's Quality Control Specification attached in **Appendix A (ISR Procedures)** to the Technical Specification and forming an integral part thereof.

The laboratory testing shall include, inter alia:

- Preliminary tests for the assurance of material quality.
- Ongoing tests for execution quality.
- Tests for workmanship quality.
- Various on-site tests, as required by ISR.

Documentation and Test Records

The Contractor shall maintain full and detailed documentation of all tests performed at the work sites and/or at manufacturers or suppliers' facilities. Documentation shall also include products bearing a standards certification mark.

The Contractor shall prepare consolidated summaries of test documentation and submit them to ISR in accordance with its requirements and the provisions of the Agreement.

The laboratory shall operate in accordance with the Contractor's Quality Control Plan and under the supervision of its Project Manager and in compliance with the requirements of the quality assurance company maintained thereby.

0.15. Preliminary Tests for Civil Engineering Works

Preliminary tests to determine the quality and composition of materials, and their compliance with all applicable standards, specifications and Agreement requirements, shall be performed by the approved and certified laboratory as part of the Quality Control Plan implemented by the Contractor, all in accordance with ISR's Quality Control Specifications attached in **Appendix A (ISR Procedures)** hereto and forming an integral part of the Technical Specification.

Payment for such tests, including sampling and transportation, shall be borne by the Contractor.

Preliminary tests shall include, inter alia, determination of the quality of aggregates, base layers, imported fill materials, excavation material (where used as fill), materials intended for concrete, and, if required by ISR, additional preliminary tests for any item or material supplied by the Contractor.

The scope of preliminary testing shall be determined in accordance with applicable standards and shall be approved by ISR, based on the Quality Control Plan, the type of Works, their scope and results. Test results shall be submitted for the approval of the quality control entity and ISR sufficiently in advance of material supply.

0.16. Materials, Equipment and Tools – OCS System

Source of Materials

The Contractor is obligated to procure materials in accordance with the requirements of the relevant Standards, the Technical Specifications, quality assurance instructions and the requirements of ISR.

Materials and equipment shall be procured from approved factories that comply with ISR's standards and quality requirements, certified for railway use, and in accordance with the Technical Specifications. Factories shall be approved in advance in accordance with quality assurance instructions.

Failure to comply with the applicable standards or with quality assurance requirements may result in rejection of materials.

0.17. Design documentation under the Responsibility of the Contractor

Design documentation under the responsibility of the Contractor shall include, inter alia, and without derogating from any other provisions of the Tender Documents:

- Design of the site organization area, obtaining all approvals for its establishment, operation and maintenance.
- Design of temporary supports for structural elements or ground, including for excavations adjacent to railway tracks, structures, roads, pipelines and above- or below-ground systems.
- Design of formwork for all concrete works and auxiliary facilities.
- Preparation of reinforcement schedules for reinforced concrete elements;

- Design of temporary access roads and working platforms;
- Design of auxiliary and temporary drainage;
- Design, coordination and approval of all project work stages and temporary traffic arrangements;
- Design of integration and execution of modifications to existing systems.
- Preparation of shop drawings for various elements, including horizontal drilling under railway tracks or roads, as detailed in the various specifications, including all requirements for obtaining approval of ISR.
- Preparation of as made drawings.

All design work shall be carried out by the Contractor, who shall engage licensed and experienced designers subject to approval by ISR.

0.18. Site Meetings

During the Execution Phase, regular coordination meetings shall be held for the purpose of coordinating the Works, at a frequency of at least once per week, with the participation of the Contractor's Project Manager, design teams, ISR's Project Manager and any other consultant or representative on behalf of ISR.

The Contractor shall invite to such meetings, as instructed by ISR, subcontractors and suppliers whose participation is required for coordination of production, supply and execution activities.

The Contractor, its subcontractors and all authorized personnel performing technical and administrative management roles shall be obliged to attend coordination meetings at the times and for the duration required by ISR.

Quality Control meetings shall be held separately from execution coordination meetings, with the participation of ISR's Project Manager, Contractor's Quality Control Manager, discipline-specific quality managers as required, Quality Assurance manager, design teams as required, and representatives of the ISR and/or its consultants where necessary.

0.19. Approval of Subcontractors and Suppliers

Within fourteen (14) calendar days from issuance of a Notice to Proceed (Design), the Contractor shall submit for the approval of ISR a list of all subcontractors and suppliers employed or intended to be employed in execution of the Works under the applicable Work Order.

For each proposed subcontractor and supplier, the Contractor shall submit a list of similar works in nature and scope performed within the past five (5) years, at least three (3) projects of which were executed in Israel.

Each subcontractor shall be a registered contractor holding the appropriate classification.

Subcontractors in disciplines requiring completion of design and preparation of shop drawings by the Contractor shall be evaluated also on the basis of their design capabilities.

Subcontractors intended to perform infrastructure works to be delivered to third parties (such as utilities, Israel Electric Company (IEC), telecommunications companies, etc.) shall be approved by the relevant utility owner.

ISR may reject the engagement of any subcontractor by the Contractor for performance of any Works if deemed unsuitable for any reason, including failure to meet the above conditions, without being required to provide justification.

0.20. Other Contractors

The Contractor is aware that other contractors may work concurrently at the Site, performing various works on behalf of ISR and/or that ISR may engage other contractors to perform works on the Project.

The Contractor shall be obligated to coordinate the activities of such contractors with its own Works, including integration of their works into the Project schedule, and to interface with such contractors in accordance with Interface Management and Coordination Requirements detailed in section 2 of this document.

0.21. Information and Document Management Systems

The Contractor shall implement and operate an approved Document and Information Management System (DMS/EDMS) for all Project-related correspondence, drawings, documents, RFIs, approvals, records and deliverables.

The system shall be subject to the prior written approval of ISR and may include, for reference only, systems such as Siteam, or any other approved equivalent platform. No document, drawing, instruction or approval shall be deemed valid unless issued and recorded through the approved system.

0.22. Quality Control System

The Contractor shall establish and maintain a comprehensive Quality Control (QC) system in accordance with ISR Quality Assurance Specifications (attached in **Appendix A (ISR Procedures)** to the Technical Specifications).

The system shall be subject to the prior written approval of ISR and may include, for reference only, systems such as Siteam, or any other approved equivalent platform.

The QC system shall include, *inter alia*:

- Design Quality Control and independent checks
- Procurement and supplier Quality Control
- Construction Quality Control
- Inspections, audits and traceability
- NCR issuance, closure and corrective/preventive actions.
- Day – to – day correspondence between all parties (Contractor, Design Team, ISR, PMC etc.)

The Contractor shall engage an external quality control company, the identity of which shall be subject to the approval of ISR.

ISR or QA review, audits or acceptance shall not constitute a waiver of the Contractor's full responsibility for quality.

0.23. Request for Information (RFI) Procedure

All RFIs shall be submitted, tracked and closed exclusively through the approved DMS and as instructed by ISR.

0.24. Schedule

Within fourteen (14) calendar days from the issuance of a Notice to Proceed (Design), the Contractor shall submit to ISR, for its approval, a detailed Project Schedule covering all design timelines for the Works.

The Schedule shall also include indicative milestone dates for the Execution Phase, including procurement, construction, testing, commissioning, and handover.

Within fourteen (14) calendar days from the issuance of a Notice to Proceed (Execution), the Contractor shall submit for ISR approval a fully detailed Project Schedule covering all execution timelines for the Works.

The Project Schedule shall be prepared using recognized scheduling software (e.g., a combination of Primavera and TILOS, or equivalent), shall clearly identify critical path activities, milestones, and interfaces with third parties, and shall be fully aligned with the approved phasing and access constraints. The Contractor shall update and maintain the Project Schedule on a weekly basis to reflect actual progress, approved changes, and mitigation measures for delays. The software will be pre-approved with ISR beforehand.

0.24.1. Software and General Requirements

The Project Schedule shall be prepared and managed utilizing recognized, professional scheduling software, specifically a combination of Primavera (P6) and Trimble TILOS (or an approved equivalent linear scheduling software).

Pre-Approval: The specific software platforms and versions selected by the Contractor must be submitted to and pre-approved by ISR beforehand.

Core Functionality: The software integration must clearly identify critical path activities, project milestones, and logical interfaces with third parties. Primavera P6 shall be utilized for resource loading (including wiring trains, key OCS personnel, and crane configurations) and critical path analysis, while TILOS shall be used to map execution progress against the specific railway chainage (kilometrage) and track possession windows.

0.24.2. Design Phase Schedule Submission

Within fourteen (14) calendar days from the issuance of a Notice to Proceed (Design), the Contractor shall submit to ISR, for its approval, a detailed Project Schedule covering all design timelines for the Works. Such schedule must delineate all permits, engineering submittal packages, review periods, and interface coordination stages. It shall also incorporate indicative, high-level milestone dates for the subsequent Execution Phase, including long-lead material procurement, construction, testing, commissioning, and final handover.

0.24.3. Execution Phase Schedule Submission

Within fourteen (14) calendar days from the issuance of a Notice to Proceed (Execution), the Contractor shall submit to ISR, for its approval, a fully detailed Project Schedule covering all execution timelines for the Works. Such schedule must feature a comprehensive Work Breakdown Structure (WBS) broken down by geographical sections, track alignments (Greenfield/Greyfield), and engineering disciplines:

Granularity of Activities: To ensure accurate monitoring, the duration of any single field activity within the Execution Phase shall be limited to a maximum of fourteen (14) calendar days (excluding curing periods, such as concrete hardening for foundations, or long-lead material transit times).

Logical Dependencies: All activities must be tied with realistic predecessors and successors, eliminating unconstrained tasks ("open ends") within the schedule logic network.

0.24.4. Engineering Requirements for Schedule Development

Work Breakdown Structure (WBS): The schedule shall be logically structured and divided by execution sections, technical disciplines (Masts & Foundations, Wiring & BWA, SCADA), and project phases (Mobilization, Design, Procurement, Construction, and Testing & Commissioning).

Activity Duration: The duration of any single activity during the Execution Phase shall not exceed fourteen (14) calendar working days (excluding long-lead procurement items or mandatory engineering curing periods, such as concrete hardening).

Milestones: The schedule shall incorporate all binding contractual milestones, including conditional milestones dependent on the handover of areas or prior works by ISR or third parties (such as the handover of civil earthworks sections).

Interfaces and Possessions: The schedule must accurately reflect real-world site constraints, including defined working shifts and the coordination of track possessions within an active network

0.24.5. Weekly Updates, Maintenance, and Progress Reporting

The Contractor shall update, maintain and submit the Project Schedule on a weekly basis to accurately reflect actual progress, approved variations, and delay mitigation measures. Each weekly schedule update package must be accompanied by a concise Progress Narrative Report, which shall explicitly include:

Actual physical progress percentages versus planned percentages (Planned vs. Actual).

Identification of any shifts or variances in the Critical Path.

A detailed look-ahead for the upcoming two (2) weeks, highlighting required track possessions, resource deployments, and critical interfaces.

0. 24.6. Recovery and Mitigation Measures

In full alignment with the weekly maintenance requirements, if any weekly update indicates a cumulative delay or slippage that threatens a contractual milestone or the final handover date, the Contractor shall immediately incorporate proactive mitigation measures. ISR reserves the right to demand a formal Recovery Schedule within seven (7) days of such a variance. Such recovery plan must demonstrate how the Contractor will deploy additional resources (e.g., adding working shifts, utilizing additional installation crews, or accelerating procurement) to fully absorb the delay within the approved execution timelines, at no additional cost to ISR.

0. 24.7. Alignment with Phasing and Access Constraints (Infrastructure Exclusions)

The Project Schedule must be fully aligned with the approved project phasing and all access constraints. The Contractor shall proactively incorporate site risks and required interface verifications into its weekly planning.

The Contractor is fully responsible for scheduling preliminary surveys and structural verifications well in advance of planned installation dates, ensuring any minor rectifications are fully absorbed within the schedule network without impacting execution milestones.

0.25. Design Approval

All designs shall be submitted through the approved DMS and will be subject to review and revisions according to ISR standards and regulations.

0.26. Material Approval Workflow

The Contractor shall establish and implement a material approval workflow, including submission of technical datasheets, certificates, samples and approvals by ISR and the QA company.

No materials shall be manufactured, shipped, delivered or installed without prior written approval from ISR and/or QA.

Approval of materials will not relieve the Contractor of responsibility for performance, compliance, durability or fitness for purpose.

0.27. Management Routines and Site Administration

During the Execution Phase, regular coordination meetings shall be held for the purpose of coordinating the Works, at a frequency of at least once per week, with the participation of the design teams, ISR's Project Manager and any representatives or consultants required by ISR.

The Contractor shall invite to such meetings, as instructed by ISR, subcontractors and suppliers whose participation is required for coordination of production, supply and execution activities.

The Contractor, its subcontractors and all relevant personnel performing technical and administrative management roles shall be obligated to attend coordination meetings at the times and for the duration required by ISR.

The Contractor will attend all meetings necessary for the progression of the Works. The following table lists the mandatory meetings, to which additional meetings may be added as required by ISR:

	Frequency	Contractor Participants	Agenda
PMC	weekly	Project Manager, OCS manager	Updates on Project status from each party, ISR's feedback and concerns, action items and responsibilities, future planning and next steps
Construction	weekly	OCS Construction Manager, Work Order Manager, PMO	Next week lookahead, review of previous meeting minutes, current construction progress updates, challenges and issues encountered, action items from previous meeting, next steps and responsibilities, schedule for next Meeting
Safety	weekly	Work Order Manager, Head Safety Manager	Review of previous meeting minutes, current safety performance metrics, safety training updates, safety protocols and compliance, hazards' identification and mitigation, safety concerns, action items and responsibilities, next steps and future safety initiatives
Workplan	weekly	Work Order Manager, PMO	Monthly schedule forecast, identifying risks and issues, adjusting resources table for upcoming week, next steps and responsibilities
Design	weekly	Design Manager, Interface Manager	Overview of current design status, review of design documents, feedback and required adjustments, action items from previous meeting, future design milestones

	Frequency	Contractor Participants	Agenda
QA-QC	Weekly	Quality Control Manager, Work Order Manager	Review of previous meeting minutes, QA-QC status reports, quality issues, compliance updates, action items and responsibilities, review of Non-Conformance Reports (NCRs), resolution follow-ups, action items from previous meeting, next steps for NCRs
Schedule	Every Other Week	PMO, Work Order Manager	Review of Gantt chart updates, performance review against schedule, identifying delays and mitigation plans
Billing	Monthly	PMO, Work Order Manager, Procurement Officer	Review of previous meeting minutes, current billing status, outstanding invoices, future billing projections, action items and responsibilities
Risk management	Monthly	PMO, Work Order Manager	Review of previous meeting minutes, current risk register updates, identification of new risks, assessment of existing risks, likelihood and impact analysis, mitigation strategies for high-risk items, action items and responsibilities, monitoring and reporting procedures, risk concerns

0.28. Design Schedule and Design Milestones

The Contractor shall submit a detailed design schedule, defining minimum and maximum durations for each design stage, including tolerances, within 20 working days from issuance of Notice to Proceed (Design).

Design milestones are contractual and binding and shall be fully integrated with execution milestones.

ISR reserves the right to change any or all the time periods specified in the table below at its sole discretion.

For the purposes of this Tender:

Greenfield Area - As described in Section 0.34.

Greyfield Area - As described in Section 0. 34.

Clarification: The timelines described in the Design Milestone table refer to calendar days.

Accumulated length shall not include execution phasing of the same continuous section.

Design Milestone	Greenfield Area- up to 5 KM Accumulated days from NTP (Design) [days]	Greenfield Area - over 5 KM Accumulated days from NTP (Design) [days]	Greyfield Area - up to 5 KM Accumulated days from NTP (Design) [days]	Greyfield Area - over 5 KM Accumulated days from NTP (Design) [days]
Preparation of updated topographical and control surveys, signed by a licensed surveyor according to ISR standards. The surveyor will be pre-approved by ISR (if not provided by ISR).	15	20	15	20
Detection and mapping of existing underground utilities prior to design, including GPR (Ground Penetrating Radar), earth vacuuming, and manual digging as necessary and demanded by ISR (if not provided by ISR).	20	30	20	30
Completion of preliminary design of the OCS System and SCADA system (if requested) in accordance with the Technical Specifications and ISR's approval.	30	40	30	40
Completion of detailed design of the OCS System and SCADA system (if requested) in accordance with the Technical Specifications and ISR's approval.	40	60	40	60
Obtaining all design approvals from the competent and relevant authorities and in compliance with all Laws and Standards and according to ISR standards, Completion and approval of execution phasing plan.	85	100	96	100
Design, approval and execution of temporary traffic arrangements as required.	100	120	130	130

Without derogating from the Contractor's design obligations, ISR may, during the Design Phase, instruct the Contractor to commence execution of preliminary works.

0.29. Regulatory Approvals and Authorities

Other than in respect of the ISR Obtained Permits as specified in the Agreement, the Contractor shall bear full and exclusive responsibility for obtaining, maintaining and complying with all statutory and regulatory approvals required for the Project, including approvals from VATAL, RRA and any other competent Authority.

Delays or requirements imposed by Authorities shall not constitute grounds for claims or extensions of time, unless expressly stated otherwise in the Agreement.

0.30. OEM and Manufacturer Requirements

All materials, components and systems shall be supplied by Original Equipment Manufacturers (OEMs) approved by ISR.

Substitutions shall not be permitted without prior written approval by ISR.

The Contractor shall ensure full manufacturer traceability, approvals and compliance with installation requirements.

0.31. Warranty, Maintenance and Spare Parts

During the Warranty Period, the Contractor shall be fully responsible for the following (without derogating from the provisions of the Agreement pertaining to the Warranty Period):

- Corrective maintenance
- Preventive maintenance
- Breakdown repairs

The Contractor shall supply spare parts in a minimum quantity equal to 5% of all installed components. Such quantity shall be maintained throughout the Warranty Period. The Contractor shall prepare and submit for ISR approval a detailed list of the spare parts intended for handover and Final Acceptance. Upon completion of the Warranty Period, the Contractor shall provide ISR with the full required quantity of approved spare parts, irrespective of any use during the Warranty Period.

0.32. Procurement, Storage and Inventory Management

With respect to each Work Order, the Contractor shall establish procedures for procurement planning, purchasing, inventory management and long-lead items.

The Contractor shall ensure quality control inspections prior to shipment from the manufacturing facility, including factory acceptance tests to the extent required.

If required, the Contractor will assist ISR with audits in any factories or manufacturing plant where Works are being executed.

Local Procurement & Storage Center

The Contractor shall establish, operate, and maintain a Local Procurement & Storage Center (LPSC) to serve as the primary logistics hub for the Project. The LPSC shall be located within the central region of the State of Israel, in an area with convenient access to major transportation routes, enabling efficient distribution to all Work Sites. The LPSC shall not be located in areas beyond the Green Line (including Judea and Samaria).

The LPSC shall function as the Contractor's main warehouse and procurement center, to which all materials, equipment, components, and systems intended for the Works shall be delivered, inspected, stored, managed, and dispatched to the various Work Sites. The Contractor shall ensure that the LPSC is adequately designed, organized, and operated to support continuous and efficient supply chain operations throughout the Project duration.

The LPSC shall include, as a minimum, covered storage areas, secured open-air storage areas, designated inspection and acceptance zones, handling and loading/unloading facilities, inventory management systems, and appropriate security, safety, and environmental protection measures. ISR and/or its representatives shall have full access to the LPSC at all times, including the right to conduct inspections, audits, and unannounced (spot) inspections, for the purpose of verifying compliance with the Agreement, quality requirements, storage conditions, traceability, and inventory control. The minimum total area of the LPSC shall not be less than 5,000 m^2, unless otherwise approved by ISR.

0.33. OCS Equipment, Tools and Vehicles

RRV: Road -Rail Vehicles/Dual Vehicle

All RRVs' and Dual vehicles shall be Israeli Road certified and authorized.

Without derogating from any other provisions of the Agreement, the following is a list of equipment, tools and vehicles required, *inter alia*, for OCS installation:

Specialist Equipment Required for OCS Construction, Installation and maintenance:

- Pulley hoist chain block – 800kg, 1.5-ton, 3.5 ton
- Wire clamps
- Drum trailers, reel stands A-frame
- Concrete trucks & pumping systems
- Pickup wagons and tool carriers
- Telehandlers/forklifts

OCS Installation Tools Per Team

- Personal OCS tools
- Manual Thermometer
- Infrared Thermometer
- Dynamometers (digital)
- Stagger gauge
- Hydraulic crimping tools with correct dye sizes
- Rail drilling & bonding tools
- Stainless steel clamp torque tools
- High level torque impact wrench (calibrated)
- Wire de-Kinker – Rolls Royce (or equivalent)

Electrical & Test Equipment

- HV insulation test sets (2.5–5kV)
- Continuity + earth resistance meters
- Clamp ammeters (low-resistance type)
- Step & Touch voltage meters
- Short circuit devices – earthing devices
- Live Line tester

0.34. Guaranteed Track Availability, Greenfield Area, Greyfield Area, Small Works and Works on Saturdays, Jewish Holidays and Official Rest Days

For the purposes of this Tender:

TP Start: The time of day (HH:MM) that was scheduled for the TP to start.

TP End: The time of day (HH:MM) that was scheduled for the TP to end.

The Contractor shall ensure that the Works, including all temporary works, testing activities, maintenance interventions, dismantling, integration, and any other operations performed under this Agreement, do not adversely affect the operational availability of the Network Section track beyond the limits approved in advance by ISR. All activities shall be planned and executed in a manner that preserves the continuous and safe operation of the railway network, except during duly authorized Track Possessions (TP) in accordance with **Appendix A (ISR Procedures)** hereto.

Definition of Greenfield Area:

For the purpose of this Agreement, a "Greenfield Area" shall mean a section under construction in which ISR is able to provide extended Track Possessions ("TPs") of not less than ten (10) gross hours per possession, measured from TP Start to TP End as defined in **Appendix A (ISR Procedures)**. Such duration shall be considered as gross time.

It is clarified that execution in Greenfield Areas may, in certain sections, be performed without the need for Track Possessions, subject to the operational status of the section and ISR instructions.

The above-mentioned duration represents gross time and shall include all activities and constraints related to the execution window, including but not limited to mobilization, access to track, equipment loading and unloading, rail-road machinery deployment, safety procedures, isolation and energization procedures, clearances, demobilization, site evacuation, handback activities, and any other operational or safety requirements. Accordingly, the actual networking time available for execution may be shorter than the above-mentioned duration.

Definition of Greyfield Area:

For the purpose of this Agreement, a "Greyfield Area" shall mean an operational railway section in which execution works are performed under operational restrictions and limited Track Possessions ("TPs"), and in which ISR is able to provide Track Possessions of not less than six (6) gross hours per possession, measured from TP Start to TP End as defined in **Appendix A (ISR Procedures)** hereto.

The above-mentioned duration represents gross time and shall include all activities and constraints related to the execution window, including but not limited to mobilization, access to track, equipment loading and unloading, rail-road machinery deployment, safety procedures, isolation and energization procedures, clearances, demobilization, site evacuation, return of the track to operational service, and any other operational or safety requirements. Accordingly, the actual networking time available for execution may be shorter than the above-mentioned duration.

It is clarified that Greyfield Areas may include operational lines, stations, depots, yards, interfaces with existing railway systems, and any other section subject to operational railway constraints and limited access conditions.

The Work scope under the Agreement may include both Greenfield Areas and Greyfield Areas, as determined by ISR according to operational, planning, execution, interface, and railway operation requirements. The classification of each section shall be determined solely by ISR and may vary throughout the Execution Phase.

The Contractor acknowledges that execution of the Works may be required concurrently with other contractors, infrastructure owners, system contractors, railway operators, or third parties performing works within or adjacent to the Site. Such concurrent activities, interfaces, coordination requirements, shared access conditions, or parallel execution constraints shall be deemed an inherent part of the Works' scope and shall not constitute a disturbance, disruption, delay event, or grounds for any claim for additional payment, extension of time, or compensation, except as explicitly stated otherwise in the Agreement.

Definition of OCS Small Works

Small Works shall mean limited-scope electrification works of up to three (3) kilometers of single-track railway length, intended for localized modifications, additions, adjustments, remedial works, emergency works, or interface-related works within the existing ISR railway network. For the avoidance of doubt, large-scale or continuous projects divided into phases, sections, temporary stages, or execution sequences shall not be considered Small Works, even if individual execution segments are shorter than three (3) kilometers.

Execution of Small Works shall be subject to prior written approval by ISR on a case-by-case basis. The Contractor shall perform all activities required for complete and operational delivery of the works, including but not limited to surveys, detailed design, preparation and update of sectioning diagrams, coordination with relevant authorities and third parties, obtaining permits and approvals, construction, dismantling where required, integration and interface management with existing ISR systems (including signaling, SCADA, telecommunications, power supply and traction substations), Testing and Commissioning, energization support, and submission of all drawings, calculations, reports and documentation required for Final Acceptance.

Saturdays, Jewish Holidays and Official Rest Days

For the purposes of this Agreement, "Saturday" shall mean the period commencing at the official time of Sabbath entrance and ending at the official time of Sabbath exit, in accordance with the customary religious times applicable in Israel and at the geographical location of the relevant Work Site.

"Jewish Holidays and Official Rest Days" shall mean official Jewish holidays and official national rest days as defined by applicable Laws in Israel, excluding Saturdays. The relevant period shall commence at the official entrance time of the applicable holiday or rest day and end at its official conclusion time, as observed in Israel.

The Contractor acknowledges and agrees that execution of the Works under the Agreement may require activities during Saturdays, Jewish Holidays and Official Rest Days, nighttime hours, and other restricted operational windows, in accordance with ISR operational requirements, Track Possessions ("TPs"), railway operation constraints, safety considerations and interface requirements. The Contractor shall take such requirements into account in its planning, pricing, scheduling, manpower allocation, subcontractor management, and overall execution methodology.

The Works shall be executed continuously, including, subject to ISR's prior approval and receipt of the required permits, during Jewish Holidays and Official Rest Days.

The Contractor shall bear full responsibility for obtaining, maintaining, coordinating, and complying with all permits, approvals, licenses, authorizations, labor arrangements, police permits, municipality permits, safety approvals, and any other statutory or contractual requirements necessary for execution of the Works during such periods, all in accordance with applicable Laws and ISR procedures.

No claim for extension of time, disruption or inefficiency shall be accepted in connection with execution during Saturdays, Jewish Holidays and Official Rest Days, nighttime hours, or restricted operational windows, where such execution is required by ISR or reasonably derives from the nature of railway works under operational conditions.

0.35. Manpower Requirements and Training

As of commencement of the Works under the first Work Order issued to the Contractor and throughout the Term of the Agreement, at least fifty percent (50%) of the personnel engaged by the Contractor team leaders roles and not less than ten (10) trained personnel, shall be local (Israeli).

The Contractor shall provide formal On-the-Job training as specified in paragraph 0.36 below for all local Israeli personnel in OCS works, including safety training, installation and maintenance procedures.

All personnel working on or in the vicinity of the OCS shall be trained, certified and authorized in accordance with EN 50110-1, including documented competence for work on 25 kV AC railway electrification systems where required.

Position	Minimum Requirements & Qualification	Responsibilities
OCS Team Leader (local)	5 years' experience as a team leader in construction or infrastructure projects in Israel. Trained, certified and authorized in accordance with EN 50110-1, including documented competence for work on 25 kV AC railway electrification systems. Fluent in Hebrew and English.	Overall on-site shift team management. Connection with ISR's Project Manager and ISR safety supervisors. Responsible for all equipment, tools and materials on site for completion of work per shift.
OCS linesman	5 years' experience as a linesman in OCS projects. Trained, certified and authorized in accordance with EN 50110-1, including documented competence for work on 25 kV AC railway electrification systems.	On site OCS System installation.
worker (local/foreign)	Trained, certified and authorized in accordance with EN 50110-1, including documented competence for work on 25 kV AC railway electrification systems.	On site OCS System installation.
RRV Driver (local)	Trained, certified and authorized in accordance with EN 50110-1, including documented competence for work on 25 kV AC railway electrification systems. ISR certified for RRV operation. Fluent in Hebrew and English.	On site RRV Driver.

All RRV Drivers are required to receive ISR certification according to ISR standards.

The following table specifies the minimum requirements and responsibilities of each team member:

Each OCS team will include at least one (1) team leader, one (1) OCS linesman, two (2) workers and one (1) driver.

Each Civil or Foundation installation team will include at least one (1) team leader, two (2) workers and one (1) driver.

0.36. OCS Workers Training Program

The purpose of this training program is to ensure that all OCS workers are competent, qualified, and fully aware of the technical, safety, and operational requirements related to Overhead Contact System (OCS) works on 25 kV AC railway systems.

Training Syllabus Approval and ISR Participation

The Contractor shall prepare and submit the detailed training syllabus for ISR review and approval prior to commencement of any training activities. No training shall be delivered without prior approval of the syllabus by ISR. ISR reserves the right to attend and observe classroom training sessions and to send its representatives to such sessions for monitoring and verification purposes. The Contractor shall provide full cooperation and access to all classroom training activities, materials, and records.

The training program applies to all OCS site personnel, linesmen, team leaders, workers and drivers involved in construction, adjustment, testing, and commissioning activities. All participants are required to be experienced construction workers as stated in the table above and hold relevant statutory certifications.

Training Structure

The training shall be delivered as a combination of:

- Classroom instruction
- On-site practical training
- Toolbox talks during execution
- Training shall be conducted prior to commencement of relevant activities and refreshed as required throughout the Works.

Training Modules

OCS System Overview

- OCS components and functions
- 25 kV AC system principles
- Interfaces with civil works, signaling, and track
- General layout and terminology

Safety and Electrical Awareness

- Electrical hazards in 25 kV AC systems
- Safe working distances and earthing principles
- Lock-out / tag-out procedures
- Emergency procedures and incident response

Work Methods and Installation Procedures

- Foundations and mast installation interfaces
- Assembly and installation of cantilevers, brackets, and conductors

- Tensioning, adjustment, and geometry control
- Use of MEWPs, cranes, and approved lifting equipment

Working in Live Railway Environment

- Railway rules and site access procedures
- Coordination with other contractors and third parties
- Communication protocols and chain of command
- Housekeeping and site discipline

Quality and Compliance

- Applicable standards and specifications
- Inspection and quality control requirements
- Non-conformance reporting (NCRs)
- Documentation and as-built records

On-the-Job Training

Practical training shall be conducted on site under the supervision of qualified and experienced OCS supervisors. Workers shall demonstrate competence in:

- Safe execution of assigned tasks
- Correct use of tools and equipment
- Compliance with approved method statements

Refresher and Additional Training

Refresher training shall be provided:

- Prior to commencement of new work phases
- Following incidents or near-misses
- When procedures, equipment, or standards are updated
- As required by ISR to any or all personnel.

Responsibility

The Contractor is fully responsible for planning, delivering, documenting, and updating the training program throughout the duration of the Project.

0.37. Major Equipment

In the framework of the General Mobilization Activities to be carried out by the Contractor pursuant to the Agreement, as of receipt of the First Work Order Notification and by no later than the date of the issuance of the first Work Order, the Contractor shall ship to Israel at least, but not limited to all of the following:

- Plasser & Theurer MTW 100.216 with trailer for wire drums or approved equivalent machine for OCS installation and maintenance.

- Two MEWPs with railroad trailers
- a crane truck; and
- All equipment and tools required to construct an OCS system for a 10 KM Network Section;

All Major Equipment delivered to Israel shall be new and supplied directly from the manufacturer. Such Major Equipment shall be subject to the approval of ISR at the following stages: (i) prior to the placement of the purchase order for the relevant Major Equipment; and (ii) upon arrival of the relevant Major Equipment in the State of Israel.

0.38. Manufacturer Warranty and Installation Audits

The Contractor shall provide full manufacturer warranties for all systems and components.

All components will be installed as per manufacturers' instructions and in a way that will ensure proper installation manufacturer's warranty.

If instructed, all or some component manufacturers' representatives shall conduct on site installation audits in compliance with EN and ISR standards.

0.39. Handover & Acceptance Procedure

The Contractor shall comply with ISR' Handover and Acceptance Procedure (attached in **Appendix A (ISR Procedures)** to the Technical Specifications), including submission of all required documentation, records, certificates, approvals, as- made documents and training materials.

No Works shall be deemed complete, and no final payment shall be made until full compliance with ISR's Handover and Acceptance Procedure.

0.40. Core Management and Key Personnel Qualifications and Responsibilities

The following table specifies the minimum requirements for the Core Management Team and Key Personnel to be engaged by the Contractor. The engagement of the Core Management Team and Key Personnel is subject to the prior written approval of ISR.

The members of the Core Management Team shall be engaged by the Contractor on a full time basis, and, unless with the prior approval of ISR, shall not render any work or services which are not connected to the Project.

The Core Management Team and Key Personnel shall attend all relevant meetings and be responsible for the due progress, execution and delivery of the Project.

The following table sets forth the minimum requirements for the engagement of personnel by the Contractor and does not constitute the overall human resources required to execute the Works under the Agreement. The Contractor shall be responsible for engagement of all personnel and manpower required to execute the Works in accordance and compliance with the Agreement.

ISR may require the Contractor to remove or replace any person engaged in performance of the Works, including members of the Core Management Team and Key personnel, as well as any designers, workers, drivers, OCS linesmen, surveyors and all other personnel of the Contactor, if ISR considers that such person is not performing his/her duties in accordance with the Agreement or in the best interests of the Project, or if ISR considers the conduct of such person to be unsatisfactory under the circumstances.

The replacement of any personnel of the Contractor shall not limit or derogate from the Contractor's responsibilities and obligations under and pursuant to the Agreement.

Position	Minimum Requirements & Qualification	Responsibilities	ISR Approval / Arrival to Israel
Project Director/Manager (Core Management Team)	B.Sc. in civil/ rail/ electrical or Mechanical engineering. 10 years' experience or more in management of at least 2 heavy rail electrification projects with an accumulated value of not less than 50 million Euros. At least one of the above heavy rail electrification projects include: 80km single track OCS and SCADA interface.	Responsible for the full technical, commercial, and operational delivery of the OCS from NTP (Design) or NTP (Execution) to Final Acceptance. Leading the project team, design management and resource allocation, ensuring design compliance with EN and/or ISR standards and overseeing all construction, safety, and quality activities. Main interface with ISR and its consultants, resolving issues and ensuring coordinated progress across civil, track, signaling, and power systems. Overall management of budgets, contractual obligations, procurement, testing and commissioning activities, and ensuring all documentation, as made drawings, and handover deliverables are completed to the required standard. Accountable for safely delivering the OCS scope on time, within budget, and in accordance with all required technical specifications.	ISR Approval: The Effective Date Arrival to Israel: Issuance of the first Work Order
Design Manager (Core Management Team)	BEng/MEng Electrical. 8 years' experience or more in leading OCS design and engineering teams. Involved in design process in at least 2	Responsible for leading and coordinating all engineering design activities to ensure the overhead contact system is developed in full compliance with EN standards, ISR requirements, and technical specifications.	ISR Approval: The Effective Date

Position	Minimum Requirements & Qualification	Responsibilities	ISR Approval / Arrival to Israel
	major rail electrification projects (UK, EU, or equivalent). Profound knowledge of OCS design and EN standards.	Management of the design team, overseeing production of alignment plans, cantilever layouts, wiring diagrams, tension calculations, and earthing/bonding schemes, while ensuring interfaces with civil, track, signaling, and power supply disciplines. Controls design quality, reviews and approves drawings, manages change requests, supports construction with technical solutions, and ensures timely delivery of AFC, red-line, and As- Made drawings and documentation.	Arrival to Israel: Issuance of the first Work Order
OCS Construction Manager (Core Management Team)	Minimum 10 years' experience in OCS construction in 25 kV AC rail systems. Proven delivery of at least 2 major electrification projects (UK, EU, or equivalent).	Responsible for leading and coordinating all site construction activities to ensure the works are delivered safely, on time, and in accordance with design and quality requirements. Management of supervisors, teams, and daily work fronts. Responsible for planning shift activities, resolving on-site issues, coordinating with other disciplines, and ensure compliance with safety, RAMS, and project standards. Monitoring progress and control productivity. Reporting status to project leadership. Overall responsibility for the efficient and safe execution of all construction tasks to meet Project milestones.	ISR Approval: The Effective Date Arrival to Israel: Issuance of the first Work Order
Procurement Officer (Core Management Team)	5 years of procurement or supply chain experience. Experience in construction, engineering, or industrial projects. Experience in construction, engineering, or industrial projects is an advantage.	Responsible for sourcing office spaces, materials, managing suppliers, issuing purchase orders, and ensuring that all equipment, tools, and components are delivered on time to support construction progress. Coordinating the requirements of the Project with the Project Manager and interfacing with suppliers to secure the required supply chain.	ISR Approval: The Effective Date Arrival to Israel: Issuance of the first Work Order

Position	Minimum Requirements & Qualification	Responsibilities	ISR Approval / Arrival to Israel
Head Safety Manager (Core Management Team)	Certified by Law as Safety Officer. At least 7 years' experience as head safety officer in large scale new roads or rail infrastructure projects in Israel, at least one of which has a contract value exceeding 200 million NIS. Fluent in Hebrew and English.	Supervision of civil and construction activities on site, ensuring safety compliance, coordinating safety resources, support of OCS installation sequencing, and acting as the primary local authority for safe, high-quality execution of works under Law. Interfacing with ISR inspectors, safety officers, and project engineers. Acting as the primary local liaison for Hebrew-speaking crews and third parties.	ISR Approval: the Effective Date Arrival to Israel: Issuance of the first Work Order
Work Order Manager (Key Personal)	At least 5 years' experience in OCS construction in 25 kV AC rail systems. Proven delivery of at least 2 major electrification projects (UK, EU, or equivalent). International experience required.	Primary point of contact for assigned work order activities. Coordination and follow-up of specific tasks, method statements and execution instructions. Interface coordination between the Contractor's execution teams and ISR representatives for the relevant work orders. Tracking progress, reporting status, and escalating issues related to the Project Manager. Ensuring timely submission of required documentation related to the relevant work orders, including execution records and as-built information, as applicable.	Issuance of Work Order +7 days
PMO (Key Personal)	At least 5 years' experience in large scale infrastructure projects (such as roads and/or rails), at least one of which has a contract value exceeding 200 million NIS. Proficient in MS-project or eq.	Administrative and procedural support for the management of work orders for OCS construction activities. Tracking, monitoring and updating the status of approved work orders, including schedules, milestones and deliverables. Preparation and maintenance of work order logs, reports and dashboards for review by the Project Manager and ISR. Coordination of documentation flow, including submissions, approvals and close-out records. Identification and flagging of deviations, delays or missing information, and escalation to the Project Manager. Ensuring consistency, traceability and orderly documentation throughout the work order lifecycle.	Issuance of Work Order +7 days

Position	Minimum Requirements & Qualification	Responsibilities	ISR Approval / Arrival to Israel
Quality Control Manager (Key Personal)	At least 5 years' experience in OCS projects, Quality Control management qualification, railway QA or QC experience, EN standards proficient.	Overall quality control responsibilities. Design QA and on-site work methods, Parts Tools, Equipment and Machinery approval, NCR's, EN standards approved materials and factories responsibility.	Issuance of Work Order +7 days
Interface Manager (Key Personal)	B.Sc. or B. Arc or eq. At least 5 years' experience in large scale projects in the State of Israel. Fluent in Hebrew and English.	Overall third party and internal design approval, excavation permits and deliverables, including Israel utility system coordination and all relevant authorities.	Issuance of Work Order +7 days

1. STATEMENT OF WORK

This Statement of Work establishes the technical requirements and specifications for the design and execution of the Overhead Contact System (OCS) electrification project for railway lines.

The Contractor shall deliver a fully functional OCS system that meets all operational, safety, and performance requirements while ensuring full certified compliance with applicable standards including among others TSI ENE, EN 50126, EN 50119, EN 50110-1 EN 50122-1 (SI 61228-1), EN 50163 and EN 50317.

1.1. Scope and Objectives

1.1.1. Primary Objectives

- Design and construct a complete OCS system for designated execution packages, including OCS with Motorized disconnectors and Section Insulators based on Sectioning diagram, Earthing and Bonding, integration with SCADA system.
- Ensure compliance with all applicable international and local standards
- Achieve operational readiness with full system certification, including the Certificate of Final Acceptance
- Deliver comprehensive documentation, including safety case and training materials

1.1.2. Scope Inclusions (among others but not limited to):

- Preliminary Design and Detailed Design
- Construction and installation including OCS, Earthing and Bonding including protection elements in order to comply with EN 50122-1 and Israeli electrical law/SI 62128-1
- System integration and testing
- Regulatory approvals and permits
- Static and dynamic commissioning
- Safety systems implementation
- Documentation and training
- Warranty and support services

1.2. System definition

1.2.1. 1×25 kV ≤160 km/h; 2×25 kV (AT) ≤250 km/h.
1.2.2. TSI/ENE- by the official Notified Body. The certificate shall have validity as minimum as for the next 5 years.

- The proposed OCS system shall be a proven system that has been implemented and is in operational use on other railway networks under comparable conditions.
- OCS shall consist of standardized components as similar as possible to ISR existing OCS components for conventional lines (e.g. types of poles, portals, cantilevers, clamps etc.).
- OCS shall be compatible with existing conventional OCS in ISR network, meaning that conventional electric trains shall be able to run on the electrified tracks and vice versa.

1.2.3. Compatible with ISR already-electrified lines.
1.2.4. Pole offsets, portals, foundations; no head spans on main lines.
1.2.5. CW ≥120 mm²; CW/MW tensions ≥12 kN, <18 kN;
1.2.6. Single-track lines have to be equipped with one return wire.
1.2.7. Lines with two tracks or more in parallel have to be equipped with two return wires (1 return wire for each side of the railway line).
1.2.8. The OCS-zone and pantograph zone have to comply with EN 50122-1 (X=4 meters).
1.2.9. Insulators (>60 cm) for prevention of bird electric shock, in accordance with the applicable requirements of NIP (TATAL) 18.
1.2.10. Touch voltage and step voltage protection in all surrounding areas such as but not limited to overcrossing, buildings, staircases and passengers' railway stations and stops shall be designed and installed in compliance with EN 50122-1/SI 62128-1 standard and local regulations.
1.2.11. The OCS has to be divided into feeding sections. Each Feeder line shall have individual circuit breaker.
1.2.12. The contact wire shall comply with EN 50149. The contact strips shall be made from hard carbon; the contact wire must be made of appropriate matching material, according to EN 50367, item 6.3.
1.2.13. The lateral offset of the contact wire shall use the entire width of the contact strips. The relative lateral offset (between two supports) may not be zero.
1.2.14. The OCS shall be divided into electrical sections in accordance with existing & future tracks, geometry and signaling configuration in stations and for open lines, by isolated overlaps. In case of an incident in one operational section, electrification system shall be capable of isolating from unaffected adjacent sections.
1.2.15. To allow selective switching off and using crossovers of tracks for electrical operation, longitudinal separations of the OCS within railway passenger or operational stations (as defined by ISR) are required.
1.2.16. Isolated overlaps between open line and railway station and Neutral Sections (NS) of parallel tracks shall be arranged at the same Kilometer Point (KP).
1.2.17. Isolated overlaps in the entrance to railway stations shall be arranged under protection of their home signals.
1.2.18. Such an overlap will be equipped with load breakers and earthing device for each track in order to de-energize safely the station in case of emergency.
1.2.19. All OCS poles and foundations shall be suitable for installation of future reinforcing feeder wire and additional return wire.
1.2.20. Installation of OCS structures, the maximum possible clearance shall be maintained between track centre and face of the structure. In case of the site constraints the clearance provided shall not be less than minimum values as specified in the SoD
1.2.21. All steel structures and small part steel carrying Overhead equipment shall be fully galvanized (as per standard).
1.2.22. Signages shall be provided on steel structures/ standalone boards, warning boards and critical locations.
1.2.23. The reinforcing wires shall be installed pole mounted on both sides of the railway line.
1.2.24. For each main track OCS catenary (individual main switching groups) one reinforcing wire with a cross section of at least 240 mm² AL shall be installed.
1.2.25. The reinforcement wires shall be rigidly coupled to the appropriate catenary. It means that the appendant reinforcing wire will be switched off in case of switching off a catenary section as well.
1.2.26. All OCS poles of the 1x25 kV electrification system including foundations shall be calculated as including 25 kV reinforcing wires, double return-wires and ADSS cable.
1.2.27. Therefore, the 25 kV reinforcing wires, dimensioning and preparation for a future installation of reinforcing wires as described above shall be part of the mandatory requirements for OCS.
1.2.28. Neutral sections (where necessary) shall be arranged as long version according to EN 50367, A.1.2 in open lines. Also, short neutral sections shall be allowed in main tracks up to 160 km/h; the short solution shall show appropriate installation quality and, in any case, needs ISR approval.
1.2.29. Section insulators shall not be installed in main tracks.

1.2.30. Section insulators on sidings shall be avoided if the conditions allow installing regular insulated overlaps.
1.2.31. It is strictly forbidden to use the same pole between or at the side of two main tracks to carry the OCS of both of those tracks.
1.2.32. Structural analysis for the OCS poles shall consider at least two return wires, reinforcing wires (or wires of 2x25 kV system), communication cables and ADSS cables and provisions for future and parallel projects.
1.2.33. The profile of the poles shall be HEB, unless otherwise approved by ISR.
1.2.34. The OCS shall not disrupt the visibility of signals according to ISR signaling regulation. Visibility must be demonstrated by the Contractor by appertaining simulation and approved by the signaling department of ISR.
1.2.35. Neutral sections, loading tracks and the transitions to tracks, which are not electrified, need to be indicated by electrification signals (EL-signals). The types of the EL-signals need an approval from both the Signaling Division and Operational Department but shall be installed and maintained by the electrification Contractor.
1.2.36. OCS disconnectors and load breakers shall be designed as motorized switches and shall be remotely controllable by the main SCADA control centers.
1.2.37. OCS disconnectors and load breakers: Local control and manual handling must be possible.
1.2.38. In Depots and workshops Local SCADA and interlocking system shall be applied
1.2.39. According to EN 50388, chapter 7, table 2, the OCS has to comply with the maximum train current (target): 1000 A.
1.2.40. Earthing, bonding, traction return control and touch protection requirements shall comply to the requirements of EN 50122-1 and consider mixed operation/parallel operation of 1x25kV and 2x25kV electrical systems, incl. identifying any additional measures required for earthing, bonding, traction return circuit control.
1.2.41. Maximum short circuit current shall be considered as 15 kA for 1 sec.

1.3. Characteristics of the electrification system – 160 km/h – 1x25 kV

	PARAMETERS FOR THE OCS	VALUE
1.3.1.	Max speed on main line	160 km / h (testing speed +10% = 176 km/h)
1.3.2.	Max speed on side tracks	80 km / h
1.3.3.	Pantograph	Figure B2, type 1 EN-50367:2012 (1950 mm width without insulated horns)
1.3.4.	Gauge	GC
1.3.5.	Track Gauge	UIC (1435 mm)
1.3.6.	Contact wire for main tracks	≥120 mm² (CuAg)
1.3.7.	Allowable wear of contact wire cross-section	<20%
1.3.8.	The quality of the contact wire, including its dynamic behavior and stagger, shall ensure operation over the required distance without the need for replacement of the pantograph contact strips.	120,000 km
1.3.9.	Ambient temperature minimum / maximum	-05 ºC / +50 ºC
1.3.10.	Contact wire wind speed reference	36 m/s at 10 m above ground level
1.3.11.	Pollution in industrial areas	Yes
1.3.12.	Minimum contact wire height (level crossing)	6.1 m
1.3.13.	Maximum contact wire height	6.4 m
1.3.14.	Tolerances in height and side of the contact wire:	±3 cm
1.3.15.	Minimum contact wire height	5.15 m
1.3.16.	Maximum lateral deviation of contact wire from axis track	+/- 550 mm
1.3.17.	Nominal stagger	≥+/- 200 mm (shall be supported by calculation)
1.3.18.	System height	≥1.4 m
1.3.19.	Minimum spans in overlaps	3

	PARAMETERS FOR THE OCS	VALUE
1.3.20.	Pole type	The poles types shall be HEB profile.
1.3.21.	Foundation type	Pile drilled foundation or cast concrete including galvanized steel bolts. Bolts shall be protected against mechanical damages and corrosion.
1.3.22.	Maximum number of poles types	10
1.3.23.	Cantilever type	Aluminium alloy tubes and parts. Triangular / diamond shape
1.3.24.	General distance for direct tracks between face of poles and Track Centre Line (TCL), tolerance 5 cm:	3.3 m (straight line)
1.3.25.		3.3 m (inside curve)
1.3.26.		3.3 – 3.7 m (outside curve)
1.3.27.		3.8 m (with cable ducts)
1.3.28.	Minimum distance signal – OCS pole	10 m, for maintenance purposes
1.3.29.	Lifetime	50 years for all components except dynamically stressed parts (contact wire, section insulators, disconnectors, etc.)
1.3.30.	Wire temperature range minimum / maximum	-15 °C / +80 °C (100 °C contact wire)
1.3.31.	Static contact pressure minimum / maximum	60 – 90 N (nominal 70 N) EN-50367
1.3.32.	Dynamic contact pressure minimum / maximum	0 – 200 N (recommended 40 – 240 N)
1.3.33.	Earthing and Bonding	EN 50122 EN 50152-2 Israeli Electrical Law and regulations SI 62128

1.4. Characteristics of the electrification system – 249 km/h – 2x25 kV

1.4.1.	PARAMETERS FOR THE OCS	VALUE
1.4.2.	Max speed on main line	249 km / h (testing speed +10% = 275 km/h)
1.4.3.	Max speed on sidetracks	120 km / h
1.4.4.	Pantograph	Figure B2, type 1 EN-50367:2012 (1950 mm width without insulated horns)
1.4.5.	Gauge	GC
1.4.6.	Track Gauge	UIC (1435 mm)
1.4.7.	Contact wire for main tracks	≥120 mm² (CuAg)
1.4.8.	Allowed wearing of contact wire cross section	<20%
1.4.9.	The quality of contact wire (dynamic behavior and stagger) has to allow at least a distance of runs without exchange of the contact strips:	120,000 km
1.4.10.	Ambient temperature minimum / maximum	-05 °C / +50 °C
1.4.11.	Contact wire wind speed reference	36 m/s at 10 m above ground level
1.4.12.	Pollution in industrial areas	Yes
1.4.13.	Maximum contact wire height	6.4 m
1.4.14.	Tolerances in height and side of the contact wire:	±2 cm
1.4.15.	Nominal height	5.5 m
1.4.16.	Minimum contact wire height Deviation from nominal height in highspeed only in justified cases	5.15 m
1.4.17.	Maximum lateral deviation of contact wire from axis track	+/- 550 mm
1.4.18.	Nominal stagger	≥+/- 200 mm (shall be supported by calculation)
1.4.19.	Nominal system height	≥1.4 m
1.4.20.	Minimum spans in overlaps	3
1.4.21.	Pole type	The poles types shall be HEB only
1.4.22.	Foundation type	Pile drilled foundation or cast concrete including galvanized steel bolts. Bolts shall be protected against mechanical damages and corrosion.
1.4.23.	Maximum number of poles types	10
1.4.24.	Cantilever type	Aluminum alloy tubes and parts. Triangular / diamond shape
1.4.25.	General distance for direct tracks between face of poles and Track Centre Line (TCL), tolerance 5 cm:	3.8 m (straight line)
1.4.26.		3.8 m (inside curve)
1.4.27.		3.8 – 4.2 m (outside curve)

1.4.1.	PARAMETERS FOR THE OCS	VALUE
1.4.28.		4.2 m (with cable ducts)
1.4.29.	Minimum distance signal – OCS pole	10 m, for maintenance purposes
1.4.30.	Lifetime	50 years for all components except dynamically stressed parts (contact wire, section insulators, disconnectors, etc.)
1.4.31.	Wire temperature range minimum / maximum	-15 °C / +80 °C (100 °C contact wire)
1.4.32.	Static contact pressure minimum / maximum	60 – 90 N (nominal 70 N) EN-50367
1.4.33.	Dynamic contact pressure minimum / maximum	0 – 200 N (recommended 40 – 240 N)
1.4.34.	Earthing and Bonding	EN 50122 EN 50152-2 Israeli Electrical Law

1.5. General Requirements

1.5.1. Contractor Responsibilities

- The Contractor shall perform all Project tasks required to develop, design and execute the OCS in accordance with the Project requirements that include, but are not limited to:
- Analysis and simulations including consideration of Earthing & Bonding, Touch protection requirements also related to mixed operation/parallel operation of 1x25kV and 2x25kV electrical systems, incl. identifying any additional measures required for earthing, bonding, traction return circuit control, and network protection/power supply protection.
- The Contractor's designer(s) may be required to participate in design coordination meetings related to specific ISR projects and/or projects executed by other entities, for the purpose of coordinating and adapting the OCS System design to the relevant project design, interfaces, constraints, and execution requirements.

  The Contractor shall take such coordination activities into account in its planning, scheduling, manpower allocation, and design management responsibilities, and no additional payment or extension of time shall be granted in connection therewith.

- Preliminary and Detailed Design
- Mock-up construction and testing
- Facility and system elements construction
- Interface coordination with internal/external parties
- RAMS consideration (the system shall not only be safe and easy to build but also safe and easy to operate & maintain)
- Integration with existing infrastructure
- Coordination with parallel projects
- Testing and Commissioning, including documentation required for PTO
- Handover of Works, including but not limited to as - made drawings and documentation

1.5.2. Design Review and Approval Process

The Contractor shall review all Project requirements, concepts and ISR future planning documents and shall perform designs for the Project in compliance with applicable documents. Construction work shall conform to approved design documents and be performed in compliance with mandatory requirements, applicable laws, codes, and standards.

1.6. Design Requirements

1.6.1. Design Stages and Submissions

The Contractor shall submit for each design stage, specifications, reports, calculations and other documents as per the project needs for ISR review and approval. The design shall be divided into design packages for each execution package, according to each Work Order.

Design Stages:

- Preliminary Design: Concept development and feasibility analysis
- Detailed Design: Complete engineering specifications and drawings according to ISR standards
- Construction Design: As - Made drawings and documentation and final specifications

1.6.2. Required Approvals

External Approvals (amongst others):

- Municipal authorities
- VATAL (Environmental)
- Regional committees
- CAAI (Civil Aviation) for special areas
- Third party infrastructure companies

Internal ISR Approvals (amongst others):

- Electrification Directorate
- Signaling Department
- Operational Department
- Infrastructure Division
- Safety Department

1.7. Survey and Infrastructure Analysis

1.7.1. Comprehensive Survey Requirements

The Contractor shall be responsible for coordinating and synchronizing all its tasks with all other tasks performed by ISR׳s parallel projects, including direct coordination with ISR׳s sub-contractors. The Contractor shall resurvey current and future elements and conditions of ISR infrastructure.

Infrastructure Element	Survey Requirements	Deliverable
Overcrossing Bridges	Structural condition, clearances, future plans	Detailed survey report
Track Alignment	Current geometry, obstacles, future modifications	Alignment analysis report
Existing Utilities	Type, condition, location, third-party utilities	Utility coordination report
Level Crossings	Current configuration, safety requirements	Level crossing analysis
Passenger Stations	Platform layouts, grounding systems, accessibility	Station survey report

1.7.2. Environmental and Regulatory Constraints

The Contractor shall study current and future documentation and constraints for each line to reach all design requirements, including:

- Subsoil conditions information (basis for selecting pole foundation type and dimensions)
- Information about future structures (planned, under design, or under construction)
- National Infrastructure Plans requirements ("TATAL")
- Environmental regulations and requirements
- Municipal, Regional and Governmental normative requirements
- Standards Institution of Israel compliance

1.8. Electrical Sectioning Design

1.8.1. Electrical Sectioning and Feeding Diagrams

Before executing the OCS layout, the Contractor shall develop electrical sectioning and feeding diagrams for each station and execution package. The design shall consider:

System Considerations:

- Track alignment and operational requirements
- Power Study of Israel network
- ISR electrical sectioning plans
- Traction power supply lines
- Parallel feeders and bypass lines
- Signaling - The OCS system shall be designed such that at least one motorized disconnector is installed for every signaling block section, ensuring full operational alignment between electrical sectioning and the signaling system configuration.

Design Elements:

- Neutral section locations
- Section insulators and Motorized disconnectors
- Voltage detectors
- Protection and switching schemes
- Emergency operation procedures

1.8.2. Approval Requirements

All electrical sectioning and feeding diagrams must be approved by ISR Operational Department before proceeding with OCS layout design. The Contractor shall obtain written confirmation of approval for each electrical package.

1.9. OCS Layout Design

1.9.1. Layout Development Process

The Contractor shall prepare OCS layout for each execution package and design stage after ensuring all electrical sectioning and feeding diagrams are approved by ISR Operational Department.

1.9.2. Design Considerations

Interfaces

Infrastructure Elements:

- On-site existing track alignment
- Infrastructure coordination with third parties
- Signaling poles locations
- Obstacles along track alignments
- Bridges and tunnels
- High Voltage and Medium Voltage power lines
- Underground pipelines
- Additional constraints such as Military or Civil Aviation authority requirements

Safety and Systems:

- Signaling cables trench coordination
- Drainage and under structure constraints
- Adjacent building and bridges considerations
- EN 50122-1 safety compliance

1.9.3. Authorization Requirements

Critical Authorization Points:

- Design solutions for poles locations and anchors on bridges/viaducts must be authorized by competent authorities (third parties – excavation permits) and by ISR
- Solutions for fixing supports at overpasses, overcrossings and station buildings must be authorized by competent authorities or owners
- All safety measures shall comply with EN 50122-1 and Israeli local regulations and standards

1.10. Special Works

1.10.1. Signaling System Coordination

The Contractor must consider the location of train signals to avoid any interference between both systems and ensure visibility of signals by the train driver. The OCS design and signaling system must be coordinated so that electrical package limits in stations are within signal stop boundaries.

1.10.2. Level Crossing Requirements

Contact Wire height at level crossings and other OCS parameters shall comply with:

- Israeli electrical regulations
- MOT guideline regulation for height limitation
- Road Traffic Regulations of Israel
- EN 50122-1
- Israeli Electrical Law and regulations
- SI 62128-1 local standard

1.11. Passenger Stations and Platforms

Contractor shall install all protective measures, including:

- Grounding of equipment and installations
- Equi-potential meshes in platforms
- Bridge connections between equi-potential meshes and tracks
- Compliance with international and local standards

1.12. Testing and Commissioning

1.12.1. Comprehensive Testing Program

For each test run, visual inspection shall be carried out by competent, highly experienced technicians in OCS systems. The testing program includes multiple phases to ensure system reliability and safety.

Test Phase	Voltage Level	Key Requirements
Disconnection Elements Verification	Without Voltage	Manual, local post, remote control operations
Electrical Insulation and Impedance	Low Voltage	Complete system verification
High Voltage Insulation	High Voltage	Insulators, overpasses, canopies
Electrical Packages Check	High Voltage	All sections powered, breaker operations
Short Circuit Tests	High Voltage	Protection coordination verification

1.12.2. Static and Dynamic Tests

Static Test Parameters (per EN 50119):

- Contact wire height measurement
- Stagger verification
- Gradient of contact wires
- Pre-sag measurement
- Wire condition and cross section
- Wear assessment

Dynamic Test Requirements (per EN 50317):

Tests carried out with calibrated pantograph (1950 mm) applying mean contact force (Fm) at running speed:

- Contact wire uplift measurement
- Mean contact forces Fm and standard deviation σmax
- Calibrated contact wire uplift detectors on supports
- Comparison with static measurements

These and additional tests shall be carried out before commissioning the whole line and comply with TSI requirements.

1.12.3. Safety Verification

Touch and step voltage testing shall be performed to verify protection of the OCS installation according to official regulations of Israel and Europe. Additional testing in accordance with good engineering practice and European standards and regulations.

1.12.4. Quality Management System

The Contractor shall implement a comprehensive independent quality management system according to ISO 9001:2015 covering all project phases from design through commissioning via a third party company. Quality assurance activities shall be documented and auditable.

1.12.5. Safety Requirements

Safety Standards Compliance:

- EN 50126
- EN 50122-1 (Railway Safety)
- Israeli electrical law and regulations
- Local safety codes and standards
- Occupational health and safety requirements (NIPs and Ministry of Environmental protection requirements)

Safety Implementation:

- Risk assessment and mitigation
- Safety training programs
- Emergency response procedures
- Incident reporting and investigation

1.13. Deliverables and Documentation

1.13.1. Design (Pre - Execution) Phase Deliverables

Deliverable Category	Documents Required	Format
Design Drawings	Layout plans, cross-sections for each pole or pole duo, details, structural designs, General Arrangement drawings Cantilever shop drawings Feeding and Sectioning diagrams	AutoCAD, PDF
Technical Specifications	Equipment specs, performance criteria	Word, PDF
Calculations	Structural, electrical, Droppers calculations thermal analysis Maximum span calculation	Excel, PDF
Simulation Results	Performance modelling, validation	Software native, PDF

1.14. Construction (Execution) Phase Deliverables

- Construction method statements and procedures
- Factory standards compliance documentation
- Material certificates and test reports
- Progress reports and photographic records
- Quality control and inspection records
- As- Made drawings and documentation

1.15. Commissioning Phase Deliverables

- Test procedures and protocols
- Test results and measurement data
- System performance verification reports
- Commissioning certificates and approvals
- Operations and maintenance manuals
- Training materials and records

1.16. Standards and Compliance

1.16.1. International Standards

European Standards (EN/IEC):

- EN 50119
- EN50126
- EN 50367
- EN 50318
- EN 50317
- EN 50122-1
- EN 50163
- EN 50121
- EN 15273-3;
- TSI SRT/ENE/OPE
- EN 50388-1/-2
- IEC 61850;
- IEC/ISA 62443

1.17.1. Local and National Standards

Israeli Standards and Regulations:

- Israeli electrical safety regulations
- Standards Institution of Israel (SII) requirements
- Ministry of Transport (MOT) guidelines for height limitations
- Road Traffic Regulations of Israel
- Any approved TATAL or other regulatory plan
- Environmental protection regulations

1.17.2. Compliance Verification

The Contractor shall demonstrate compliance with all applicable standards through:

- Design review and verification documentation
- Third-party testing and certification to the extent required
- Regulatory authority inspections and approvals
- Comprehensive testing and commissioning programs
- Ongoing monitoring and maintenance procedures

2. INTERFACE MANAGEMENT AND COORDINATION REQUIREMENTS

2.1. Introduction

2.1.1. Purpose and Scope

This document defines the interface management and coordination requirements.

It establishes the responsibilities, coordination procedures, and integration protocols between the Contractor, Supervisory Control and Data Acquisition (SCADA) and Traction Substation (TS) systems.

The scope encompasses the complete design, construction, testing, and commissioning phases of the new stages of electrification project. This document serves as the governing specification for all interface activities from commencement of the Works through to the issuance of a Certificate of Final Acceptance, Permit to Operate and final transfer of responsibility to the Infrastructure Division of ISR by the Contractor.

2.1.2. Definitions and Abbreviations

CDE (Contact Line Disconnection Element)

Portal structure with disconnectors and motors that divides the responsibility area between TS and OCS systems

LOP (Local Operating Post)

Local control facility for SCADA system operations

OCS (Overhead Contact System)

Complete overhead electrification system including contact wire, catenary, supports, and sectioning equipment

SCADA (Supervisory Control and Data Acquisition)

Computer-based control system for monitoring and controlling the electrification infrastructure

TS (Traction Substation)

Electrical substation that converts and supplies power from the 161kV national grid to the 25kV railway traction system

Interface Point

Physical or logical boundary where responsibilities transfer between contractors

Sectioning Diagram

Technical drawing showing the electrical division and disconnector locations of the OCS system

2.1.3. General Interface Management Principles

The following principles shall govern all interface management activities:

1. Clear Responsibility Definition: Each contractor shall have clearly defined areas of responsibility with unambiguous interface points.
2. Coordinated Design Development: All design activities shall be coordinated through formal interface control procedures.

3. Integrated Testing Approach: Testing and commissioning shall progress from individual systems through interface testing to full system integration.
4. Change Control: All changes affecting interfaces shall be subject to formal change control procedures involving all affected parties.
5. Quality Assurance: Interface deliverables shall be subject to joint quality assurance and acceptance procedures.
6. Documentation Control: All interface documentation shall be controlled and distributed through the established document management system.

2.2. Project Overview

2.2.1. System Description

The ISR electrification system is a 25kV, 50Hz AC traction system compliant with TSI ENE / EN 50163 standards. The system comprises three major subsystems requiring close coordination:

Traction Substation System

Traction substations converting 161kV IECo grid supply to 25kV traction voltage, including high voltage switchgear, transformers, protection systems, and auxiliary services.

Overhead Contact System

Complete overhead electrification infrastructure including contact wire, catenary system, support structures, sectioning equipment, disconnectors, and associated civil works.

SCADA System

Centralized monitoring and control system, including control centers, Local Operating Posts (LOP), communication networks, and integration with existing railway control systems.

2.2.2. Contractor Responsibilities Overview

The project operates under a Design & Build contracting strategy with the following primary responsibilities:

2.2.3. OCS Contractor (Primary Design & Build Contractor)

- Design, supply, install, test and commission the complete OCS system
- Construction of disconnectors and motors according to approved sectioning diagram
- Installation of CDE portals at locations specified by TS Contractor
- Connection of power cables to disconnectors on the CDE
- Deployment of all SCADA cables (power and communication) based on SCADA schematic design
- Overall project coordination and integration responsibility
- Obtaining a Certificate of Final Acceptance for the complete system and supporting ISR in issuance of Permit to Operate until achieved

2.2.4. SCADA Scope of work

- Design, supply, installation, testing and commissioning of the SCADA system
- Update or migrate of existing control centers to include new tracks and disconnectors (Optional)
- Construction of Local Operating Posts (LOP)
- Provision of schematic designs for SCADA cable installation
- SCADA system integration and testing

2.2.5. Traction Substation Contractors

- Design, supply, installation, testing and commissioning of traction substations
- Installation of feeding cables from TS buildings to tracks
- Specification of CDE portal locations
- Deployment of power cables, including cable ends to connection points
- Installation of control cables between TS and disconnector motors control boxes
- TS system testing and commissioning

2.3. Interface Management Framework

Interface management shall be implemented through a structured framework comprising:

Framework Element	Description	Responsible Party
Interface Control Documents (ICD)	Formal documents defining each interface in detail	OCS Contractor (Lead)
Interface Management Plan	Overall plan for managing all project interfaces	OCS Contractor
Interface Control Board	Joint committee for interface decision making	All Contractors + ISR
Interface Registers	Living documents tracking interface status	OCS Contractor
Joint Testing Protocols	Procedures for interface and integration testing	All Contractors

2.3.1. Coordination Requirements

All contractors shall participate in mandatory coordination activities including:

- Interface coordination meetings during Design Phase
- Joint design reviews at major milestones
- Coordinated construction scheduling and sequencing
- Joint factory acceptance testing where applicable
- Integrated site testing and commissioning
- Coordinated documentation delivery and handover

2.3.2. OCS - SCADA Interface

2.3.2.1. Interface Description

The OCS-SCADA interface encompasses the integration of overhead line sectioning equipment with the centralized monitoring and control system. This interface is critical for operational control, protection coordination, and maintenance management of the electrification system.

Primary Interface Points

- Disconnector control and indication systems

- Motor drive units for disconnector operation
- SCADA communication cables and infrastructure
- Local Operating Posts (LOP) integration
- Control center updates and modifications
- Power supply systems for SCADA equipment

2.3.2.2. Responsibility Matrix

Item	OCS Contractor	SCADA Contractor	Joint Responsivity
Sectioning Diagram Development	●	○	Design Review
Disconnector Specification	●	○	Technical Compatibility
Motor Drive Units	●	○	Control Interface Design
SCADA System Architecture	○	●	Integration Requirements
Control Centre Updates	○	●	User Interface Design
Local Operating Posts (LOP)	○	●	Site Preparation
SCADA Power Cables	●	○	Cable Specification
SCADA Communication Cables	●	○	Network Design
Cable Installation	●	○	Route Coordination
SCADA Equipment Installation	○	●	Site Access
System Integration Testing	●	●	Fully integrated
Commissioning	●	●	Fully integrated

Legend: ● = Primary Responsibility, ○ = Support/Input Required

2.3.2.3. Design Coordination

2.3.2.4. Sectioning Diagram Coordination

The OCS Contractor shall develop the sectioning diagram in coordination with the SCADA Contractor to ensure:

- Optimal placement of disconnectors for operational flexibility including disconnectors installed on the CDEs (feeding point)
- SCADA system monitoring and control capabilities
- Coordination with existing network sectioning
- Future expansion capability
- Maintenance accessibility requirements

2.3.2.5. Control System Integration

The SCADA Contractor shall design control system interfaces compatible with OCS disconnector systems including:

- Control signal specifications
- Status indication requirements
- Alarm and fault reporting systems
- Emergency operation procedures
- Manual/automatic operation modes

2.3.2.6. Communication Network Design

Joint design activities shall include:

- Communication network topology
- Cable routing and protection requirements
- Redundancy and backup systems
- Network security and access control
- Integration with existing ISR communication systems

2.3.3. Construction and Installation

2.3.3.1. Sequencing Requirements

Construction activities shall be sequenced as follows:

1. OCS Contractor: Procures and Install support structures and prepare cable routes
2. OCS Contractor: Procures and Install SCADA power and communication cables
3. OCS Contractor: Procures and Install disconnectors and motor drive units
4. SCADA Contractor: Install/expand LOP buildings and equipment
5. SCADA Contractor: Expand control center equipment and software
6. Joint: Cable terminations and initial connectivity testing
7. Joint: System integration and functional testing

2.3.3.2. Quality Control Coordination

Joint quality control activities shall include:

- Cable installation inspection (routing, protection, identification)
- Equipment installation verification
- Interconnection testing
- System configuration verification
- Documentation compliance checking

2.3.4. Testing and Commissioning

2.3.4.1. Individual System Testing

OCS Contractor Responsibilities:

- Disconnector mechanical operation testing
- Motor drive unit functionality testing
- Cable continuity and insulation testing
- Power supply system testing

SCADA Contractor Responsibilities:

- Control center equipment functionality testing
- LOP equipment and software testing
- Communication network testing
- Database and human-machine interface testing

2.3.4.2. Interface Testing

Joint interface testing shall verify:

- Disconnector remote control functionality
- Status indication accuracy and timing
- Alarm and fault reporting systems
- Communication system performance

- Emergency operation procedures
- Data logging and historical data systems

2.3.4.3. Integration Testing

Comprehensive integration testing shall include:

- End-to-end system functionality
- Multiple disconnector coordination
- Failure mode and backup system testing
- Operator training and validation
- System performance verification

2.3.5. Documentation Requirements

- Joint documentation deliverables shall include:
- Interface Control Document (ICD) - OCS/SCADA
- Integrated system drawings and schematics
- Joint testing and commissioning procedures
- Operation and maintenance manuals
- As- Made drawings and documentation package
- Training materials and procedures
- Warranty and service documentation

2.4. OCS Contractor - Traction Substation Contractor Interface

2.4.1. Interface Description

The OCS-TS interface represents the critical power delivery boundary between the traction substation system and the overhead contact system. This interface encompasses power transfer, protection coordination, and control integration between the 25kV distribution system and the contact line infrastructure.

Primary Interface Points

- Contact Line Disconnect Equipment (CDE) portals
- Power cable connections from TS to OCS
- Control cable systems between TS and CDE
- Protection system coordination
- Return conductor connections
- Earthing and bonding systems

2.4.1.1. Responsibility Matrix

Item	OCS Contractor	TS Contractor	Joint Responsibility
Traction Substation Design	○	●	Load Requirements
CDE Location Specification	○	●	Site Coordination
CDE Portal Construction	●	○	Foundation Requirements
Trackside CDE Disconnectors & Motors	●	○	Specification Coordination
Feeding Cables (TS to Track)	○	●	Route Coordination
Power Cable Ends	○	●	Connection Interface
Cable Connection to Disconnectors	●	○	Joint Testing
Control Cables (TS to CDE)	○	●	Signal Requirements
Return Conductor System	●	○	Connection Points
Protection System Coordination	●	●	Fully integrated
Short-Circuit Testing	●	●	Fully integrated
System Commissioning	●	●	Fully integrated

Legend: ● = Primary Responsibility, ○ = Support/Input Required

2.4.1.2. Design Coordination

2.4.1.3. CDE Location and Configuration

The TS Contractor shall specify CDE locations considering:

- Traction substation layout and cable routing

- Electrical clearance requirements
- Access requirements for maintenance
- Protection system coordination
- Future expansion capabilities

The OCS Contractor shall design CDE portals to accommodate:

- Required disconnector configurations based on the approved sectioning diagram
- Motor drive unit installations
- Cable termination facilities
- Lightning protection systems
- Access platforms and safety systems

2.4.1.4. Power System Design Coordination

Joint design activities shall ensure:

- Proper cable sizing for maximum load conditions
- Coordination of protection settings
- Short-circuit rating compatibility
- Return conductor system design
- Earthing and bonding system integration
- EMF mitigation measures coordination

2.4.1.5. Control System Integration

Control system coordination shall address:

- CDE disconnectors control from the main/secondary control center
- Status indication and alarm systems
- Interlocking systems between TS and OCS
- Emergency shutdown procedures
- Remote/local operation modes

2.4.2. Construction and Installation

2.4.2.1. Construction Sequencing

Construction activities shall be coordinated as follows:

1. TS Contractor: Complete substation building and equipment installation
2. TS Contractor: Install and terminate feeding cables from TS to designated connection points (disconnectors at the top of the CDE)
3. OCS Contractor: Construct CDE portal structures
4. OCS Contractor: Install disconnectors and motor drive units
5. TS Contractor: Install and terminate control cables

6. OCS Contractor: Connect power cables to disconnectors
7. Joint: Complete return conductor connections
8. Joint: Execute earthing and bonding connections (earthing and bonding cables are under OCS contractor scope)

2.4.2.2. Interface Point Management

Critical interface points requiring joint oversight:

- Cable termination and connection procedures
- Insulation coordination verification
- Mechanical connection integrity
- Protection system settings coordination
- Control circuit functionality

2.4.3. Testing and Commissioning

2.4.3.1. Individual System Testing

TS Contractor Responsibilities:

- Substation equipment functionality testing
- Power cable insulation and continuity testing
- Control cable testing and verification
- Protection system functionality testing
- Auxiliary systems testing

OCS Contractor Responsibilities:

- CDE portal mechanical and electrical testing
- Disconnector operation testing
- Motor drive unit functionality testing
- Return conductor system testing
- Contact line installation verification

2.4.3.2. Interface Testing

Joint interface testing shall verify:

- Power cable connection integrity
- Control system functionality end-to-end
- Protection system coordination
- Disconnector remote operation
- Return path continuity and resistance
- Earthing system effectiveness

2.4.3.3. Short-Circuit Testing

Critical short-circuit testing requirements:

- Joint planning and execution of short-circuit tests
- Protection system response verification
- Equipment withstand capability confirmation
- Arc-fault interruption testing
- System recovery and restoration procedures
- EMF measurement and verification
- Testing equipment to be arranged by TS contractor

2.4.4. Documentation Requirements

Joint documentation deliverables shall include:

- Interface Control Document (ICD) - OCS/TS
- Power system single-line diagrams
- Protection system coordination study
- Short-circuit analysis and test results
- Cable installation and termination records
- Commissioning test procedures and results
- Operation and maintenance instructions
- Emergency response procedures

2.4.5. Underground corridor technical

Design, approvals, coordination and execution of the underground corridor, for connection of the Transformer sub-station to the Railway tracks including but not limited to excavation and/or horizontal directional drilling as required, reinstatement and traffic arrangements; supply and installation of at least eight 225 mm ducts, four 160 mm ducts and two 75 mm ducts (PN10), all complete with nylon pulling ropes; proportional share of electrical and communication manholes, including welded covers, access ladders and drainage provisions, based on maximum 70 m spacing between manholes; supply, pulling, termination and testing allowance per meter for four sets of single-phase high-voltage feeder circuits comprising two 300 mm^2 single-core cables per circuit, total eight cables, and two return-current circuits comprising three 300 mm^2 cables each, total six cables, including approved cable types equivalent to N2XS(FL)H 1x300/63 36/66 kV or approved equal, cable heads, joints installed only in manholes, earthing cabinet connection near the railway track, connection to MV switchgear and CDE, communication ducting and separate 2A communication manholes where required, factory and site testing, commissioning tests, laboratory reports, certified electrical engineer inspection reports, and all ancillary materials, works, documentation and handover required for a fully functional corridor.

2.5. Mutual Coordination

2.5.1. Joint Coordination Meetings

2.5.1.1. Interface Control Board

A formal Interface Control Board shall be established comprising senior representatives from all three contractors plus ISR/PMC representatives. The board shall meet monthly during Design Phase and bi-weekly during the Execution Phase.

Board Responsibilities:

- Review and approve all Interface Control Documents
- Resolve interface disputes and technical issues
- Coordinate major design decisions affecting multiple systems
- Approve interface change requests
- Monitor interface milestone achievements
- Coordinate integrated testing and commissioning activities

2.5.1.2. Technical Coordination Meetings

Weekly technical coordination meetings shall be conducted during active design and construction phases covering:

- Design progress and milestone status
- Interface issue identification and resolution
- Construction sequencing coordination
- Quality assurance and testing coordination
- Risk identification and mitigation
- Document review and approval status

2.5.1.3. Site Coordination Meetings

- Daily site coordination meetings shall be held during overlapping construction activities addressing:
- Daily work planning and resource coordination
- Safety coordination and hazard management
- Access and logistics coordination
- Quality control and inspection scheduling
- Interface work completion verification

2.5.2. Integrated Testing Procedures

2.5.2.1. Testing Phase Structure

Phase	Description	Participants
Phase 1: Individual System Testing	Each contractor tests their own systems independently	Individual Contractors
Phase 2: Interface Testing	Testing of interfaces between pairs of systems	Relevant Contractor Pairs
Phase 3: Three-System Integration	Complete system integration testing	All Contractors + ISR
Phase 4: Operational Validation	Full system validation with simulated operations	All Contractors + ISR Operations

2.5.2.2. Critical Integration Tests

The following integration tests require the participation of all three contractors:

Power System Integration Test

- TS energization through to OCS contact line
- SCADA monitoring and control verification
- Protection system coordination verification

Control System Integration Test

- End-to-end disconnector control from SCADA system
- Status indication and alarm propagation
- Emergency shutdown procedures
- Manual override capabilities

Fault Response Integration Test

- Simulated fault conditions and system response
- Protection system coordination
- SCADA alarm and indication systems
- System restoration procedures

2.5.3. System Integration Requirements

2.5.3.1. Operational Integration

Operational integration shall ensure:

- Seamless integration with existing ISR control systems
- Operator training on integrated system functionality
- Maintenance procedure coordination
- Emergency response procedure integration

- Spare parts and logistics coordination

2.5.4. Final Acceptance and Transfer to Operations

2.5.4.1. Pre-Handover Requirements

Prior to system handover, the following shall be completed:

- All individual system commissioning complete
- All interface testing successfully completed
- Integrated system testing and validation complete
- All documentation delivered and approved
- Operator training completed and certified
- Environmental permits obtained (including "Permit to Operate")
- All defects, NCR's and punch list items resolved

2.5.4.2. Handover and Final Acceptance Process

The handover and Final Acceptance process shall include:

1. **Technical Handover:** Transfer of all technical documentation, drawings, and manuals
2. **Operational Handover:** Transfer of operational control to ISR Infrastructure Division
3. **Maintenance Handover:** Transfer of maintenance responsibility to ISR Infrastructure Division
4. **Warranty Handover:** Transfer of all Warranty procedures and documentations to ISR Electrification Division
5. **Training Completion:** Certification of all operator and maintenance training
6. Commencement of twenty-four (24) months Warranty period

2.5.4.3. Post-Handover Support

Post-handover support for a period of six months (overlapping with the Warranty Period) shall include:

- Technical support during initial operational period
- Warranty support and defect rectification in accordance with the Agreement requirements
- Performance monitoring and optimization
- Additional training as required
- System modification support as needed

2.6. Interface Management Procedures

2.6.1. Interface Control Documents

2.6.1.1. Interface Control Document Structure

Each Interface Control Document (ICD) shall be developed by the OCS contractor and contain at least the following sections:

1. Interface Overview: Description, scope, and key stakeholders
2. Technical Requirements: Detailed technical specifications and standards

3. Responsibility Matrix: Clear definition of each party's responsibilities
4. Design Requirements: Design coordination and approval procedures
5. Construction Requirements: Installation and construction coordination
6. Testing Requirements: Individual and joint testing procedures
7. Documentation Requirements: Required deliverables and formats
8. Acceptance Criteria: Criteria for interface acceptance
9. Schedule Requirements: Key milestones and dependencies
10. Risk Management: Interface-specific risks and mitigation measures

2.6.1.2. ICD Development and Approval Process

Step	Activity	Responsible Party
1	Initial ICD Draft Preparation	OCS Contractor (Lead)
2	Technical Review by Interface Partners	Relevant Contractors
3	Incorporation of Comments	OCS Contractor
4	Interface Control Board Review	Interface Control Board
5	ISR Review and Approval	ISR Technical Team
6	Final ICD Issuance	OCS Contractor

2.6.2. Change Management

2.6.2.1. Interface Change Control Process

All changes affecting interfaces shall be managed through a formal change control process:

1. Change Identification: Any party may identify the need for an interface change
2. Change Request Preparation: Formal change request document preparation
3. Impact Assessment: Assessment of technical, schedule, and cost impacts
4. Stakeholder Review: Review by all affected contractors
5. Interface Control Board Evaluation: Formal evaluation and recommendation
6. ISR Approval: Final approval by ISR /PMC
7. Implementation: Coordinated implementation of approved changes
8. Documentation Update: Update of all relevant interface documents

2.6.2.2. Change Categories and Authority

Change Category	Description	Approval Authority
Minor Administrative	Documentation updates, clarifications	Technical Coordinators
Technical Modifications	Equipment specifications, procedures	Interface Control Board
Major Changes	Scope modifications, new interfaces	ISR Project Management
Emergency Changes	Safety or critical operational issues	Expedited Process

2.6.3. Quality Assurance and Control

2.6.3.1. Interface Quality Management

Quality assurance for interface management shall include:

- Regular audits of interface documentation
- Verification of interface deliverable quality
- Review of interface testing procedures and results
- Assessment of coordination effectiveness
- Continuous improvement of interface processes

2.7. Testing and Commissioning Protocol

2.7.1. Individual System Testing

2.7.1.1. OCS System Testing Requirements

The OCS Contractor shall complete the following individual system tests:

Mechanical Systems Testing

- Support structure installation verification
- Contact wire and catenary installation testing
- Disconnector mechanical operation testing
- Tension system verification
- Clearance and gauge verification
- All required tests as per TSI/ENE requirements

Electrical Systems Testing

- Insulation resistance testing
- Continuity and bonding verification
- Return conductor system testing
- Motor drive unit functionality testing
- Power cable installation verification
- All required tests as per TSI/ENE requirements
- Electrical inspector approval to energize the system

2.7.1.2. SCADA System Testing Requirements

The SCADA Contractor shall complete the following individual system tests:

Control Center Systems

- Hardware platform functionality testing
- Software application testing
- Database integrity verification
- Human-machine interface testing
- Alarm and event management testing

Communication Systems

- Network connectivity testing
- Communication protocol verification
- Data transmission integrity testing
- Network security testing

- Redundancy and backup system testing

2.7.1.3. Traction Substation Testing Requirements

The TS Contractor shall complete the following individual system tests:

Primary Equipment Testing

- High voltage equipment testing
- Transformer functionality and performance testing
- Switchgear operation testing
- Protection system testing
- Auxiliary systems testing
- Electrical inspector approval to energize the system

Power Delivery Systems

- Feeding cable installation and testing
- Control cable verification
- Grounding system testing
- Power quality measurement
- Load capability verification
- Electrical inspector approval to energize the system

2.7.2. Interface Testing

2.7.2.1. OCS-SCADA Interface Testing

Joint testing between OCS and SCADA systems shall verify:

Test Category	Test Description	Success Criteria
Control Interface	Disconnector remote control from SCADA	100% successful operations within 30 seconds
Status Indication	Real-time status updates from field to control center	Status updates within 2 seconds, 99.9% accuracy
Alarm Systems	Fault detection and alarm propagation	All alarms transmitted within 1 second
Communication	End-to-end communication network testing	< 1% packet loss, < 100ms latency
Emergency Systems	Emergency shutdown and isolation procedures	Emergency commands executed within 5 seconds

2.7.2.2. OCS-TS Interface Testing

Joint testing between OCS and TS systems shall verify:

Test Category	Test Description	Success Criteria
Power Transfer	25kV power delivery from TS to contact line	Voltage within ±5% of nominal, stable delivery
Protection Coordination	Protective device coordination testing	Selective operation, proper coordination margins
Control Integration	CDE control from TS control room	100% successful remote operations
Return Path	Return conductor system verification	Return path resistance within specifications
Short Circuit	Short circuit testing and protection verification	Proper fault clearing within specified time

2.7.2.3. Integrated System Testing

2.7.2.4. Full System Integration Tests

Comprehensive system integration testing shall include:

Operational Scenarios Testing

- Normal operation mode testing
- Maintenance mode operations
- Emergency response procedures
- System restoration after faults
- Multiple train operation simulation

Performance Verification Testing

- System capacity and load testing
- Power quality measurement and verification
- EMF measurement and compliance verification
- System efficiency measurement
- Environmental compliance testing

Reliability and Availability Testing

- System availability measurement
- Mean time between failures (MTBF) assessment
- Mean time to repair (MTTR) verification
- Redundancy and backup system testing
- Long-term reliability demonstration

2.7.2.5. Integration Test Schedule

Week	Testing Activity	Participants	Key Deliverables
1-2	System Integration Preparation	All Contractors	Test procedures, safety plans
3-4	Basic System Integration	All Contractors	Basic functionality verification
5-6	Operational Scenario Testing	All Contractors + ISR Ops	Operational procedure validation
7-8	Performance and Compliance Testing	All Contractors + ISR	Performance test results
9-10	Final Validation and Documentation	All Contractors + ISR	Final test reports and certificates

2.7.3. Acceptance Criteria

2.7.3.1. Operational Acceptance Criteria

Operational acceptance shall require:

- Successful completion of all test procedures
- Demonstration of all operational modes
- Verification of all safety systems
- Completion of operator training and certification
- Delivery of all required documentation
- Resolution of all defects and punch list items
- Obtaining all required permits and certifications

2.7.3.2. Final Acceptance Process

- Pre-Acceptance Review: Verification of all acceptance criteria
- Acceptance Testing: Formal acceptance test execution
- Documentation Review: Final review of all deliverable documentation
- ISR Acceptance: Formal acceptance by ISR
- Certificate of Completion: Issuance of Certificate of Final Acceptance
- Operational Handover: Transfer to ISR Infrastructure division
- Warranty Period Commencement: Start of warranty obligations

2.8. OCS Foundation Works by others

2.8.1. Purpose and Scope

This document defines the interface management and coordination requirements between the OCS Contractor and Foundation Design and Execution activities. It establishes the responsibilities, coordination procedures, and integration protocols for pole foundation works supporting the Overhead Contact System (OCS) infrastructure.

The scope encompasses two distinct interface models for foundations delivery and execution, apart from the Contractor's execution:

Option 1: ISR Pre-Constructed Foundations Model - where ISR designs and constructs foundations prior to OCS Contractor engagement

Option 2: OCS Contractor Design / ISR Execution Model - where the OCS Contractor provides detailed foundation designs and ISR executes construction under the supervision of the OCS Contractor.

This document serves as the governing specification for all foundation interface activities from commencement of the Works through to the issuance of the Certificate of Final Acceptance, issuance of Permit to Operate and final transfer of responsibility to the Infrastructure Division of ISR.

2.8.2. Definitions and Abbreviations

2.8.1.1. Pole Foundation

Structural element that transfers loads from OCS support structures to the ground, including but not limited to drilled piles, spread footings, and mass concrete foundations.

2.8.1.2. Due Diligence Process

Comprehensive inspection, testing, and verification procedure undertaken by the OCS Contractor to assess the condition, quality, and suitability of pre-constructed foundations.

2.8.1.3. Handover Point

Physical and contractual boundary where responsibility for foundation performance transfers from ISR/Foundation Contractor to OCS Contractor.

2.8.1.4. CDE Portal Foundation

Specialized foundation system designed to support Contact Line Disconnection Equipment (CDE) portal structures including all associated loads and operational requirements.

2.8.1.5. OCS Pole

Vertical support structure for overhead contact system including masts, cantilevers, portals, and sectioning posts requiring foundation support.

2.8.1.6. Foundation Design Load

Complete load specifications, including vertical, horizontal, torsional, and dynamic loads that the foundation must safely support throughout its design life.

2.8.1.7. Tunnel section

Section with possibility to install cantilevers and OCS equipment without installation of masts.

2.8.3. Project Overview

2.8.3.1. System Description

The OCS foundation system provides structural support for the complete overhead electrification infrastructure of the ISR 25kV/2x25 kV, 50Hz AC traction system. Foundation requirements encompass support for various OCS elements including:

- OCS support structures and anchoring points
- Portal structures for track crossings and special locations
- Sectioning posts and disconnector support structures
- CDE (Contact Line Disconnection Equipment) portals
- Tensioning and anchoring structures
- Auxiliary equipment supports and cable routes
- Foundation design must accommodate the unique loading conditions of railway electrification systems including:
- Static loads from OCS equipment and structures
- Dynamic loads from train-induced oscillations
- Wind loads on overhead structures and equipment
- Ice loads in applicable climatic conditions
- Seismic loads per Israeli seismic design requirements
- Thermal expansion and contraction effects
- Construction and maintenance loading scenarios

2.8.4. Contractor Responsibilities regarding foundations

This project offers two additional distinct interface models for foundation delivery, based on project timing, technical requirements, and procurement strategies:

2.8.4.1. Option 1: ISR Constructed Foundations Model

Under this model:

- ISR Responsibilities: Complete foundation design, approved design documents, execution of foundation works, and performance of quality control and testing in accordance with applicable standards and ISR requirements.
- OCS Contractor Responsibilities: Performance of a comprehensive due diligence review of both the foundation design (where available and feasible) and the constructed foundations, including verification of design assumptions, and compliance with applicable standards. Verification of the constructed foundations against the approved design and site conditions; formal acceptance of the foundations. Identification, reporting, and coordination of rectification of defects or non-conformities and assumption of full responsibility for foundation performance following acceptance. Any required corrective or remedial works arising from the due diligence review or foundation acceptance process shall be executed by the OCS Contractor in accordance with the instructions of the Project Manager.
- Application: Suitable for projects where foundation construction precedes OCS Contractor engagement or where ISR wishes to maintain direct control over foundation construction.

2.8.4.2. Option 2: OCS Contractor Design and ISR foundation Execution Model

Under this model:

- OCS Contractor Responsibilities: Preparation of the complete foundation design, including design basis, calculations, drawings, and technical specifications; provision of construction supreme supervision and technical guidance during execution; performance of design verification and quality assurance activities; and formal acceptance and handover of the completed foundations. The OCS Contractor shall retain full design authority and responsibility for the adequacy and performance of the foundations.
- ISR Responsibilities: Execution of the foundation works in accordance with the OCS Contractor's approved designs, specifications, and instructions; procurement of materials; and implementation of construction quality control, testing, and documentation in coordination with the OCS Contractor.
- Application: Suitable for integrated project delivery where OCS Contractor maintains design control and construction oversight.

2.8.5. Option 1: ISR Pre-Constructed Foundations Interface

2.8.5.1. Interface Description

The ISR Pre-Constructed Foundations interface model applies to situations where ISR has completed foundation design and construction prior to OCS Contractor engagement. Under this model, the OCS Contractor must conduct comprehensive due diligence to assess foundation suitability and condition before accepting responsibility for foundation performance.

Key characteristics of this interface include:

- ISR delivers completed foundations to agreed specifications
- OCS Contractor conducts detailed technical and physical assessment
- Clear accept/reject decision process with defined criteria
- OCS Contractor responsibility for defect rectification or replacement
- Comprehensive documentation and warranty transfer

2.8.5.2. Responsibility Matrix

Activity	OCS Contractor	ISR	Joint Responsibility
Foundation Design Development	○	●	Load specification coordination
Foundation location marking/ survey	○	●	Inspection protocols
Geotechnical/ Soil investigation report	○	●	Inspection protocols
Foundation Construction	○	●	Progress monitoring
Construction Quality Control	○	●	Inspection protocols
Due Diligence Assessment	●	○	Documentation provision
Foundation Testing and Verification	●	○	Test procedure approval
Defect Identification	●	○	Classification criteria
Defect Rectification	●	○	Technical coordination
Foundation Replacement (if required)	●	○	Access and coordination
Long-term Performance Responsibility	●	○	Warranty transition
Documentation Handover	○	●	Completeness verification

Legend: ● = Primary Responsibility, ○ = Support/Input Required

2.8.5.3. Pre-Construction Coordination

2.8.5.3.1. Design Information Exchange

Prior to foundation handover, ISR shall provide:

- Complete foundation design calculations and drawings
- Geotechnical investigation reports and analysis
- Material specifications and test certificates
- Quality control records and inspection reports
- As- Made drawings and dimensional surveys

2.8.5.3.2. Construction Monitoring Interface

Although not responsible for construction, OCS Contractor may request:

- Access to construction sites for progress monitoring
- Notification of key construction milestones
- Participation in critical quality control inspections
- Review of construction quality control records

2.8.5.4. Foundation Handover Process

2.8.5.4.1. Due Diligence Requirements

The OCS Contractor shall conduct comprehensive due diligence assessment of all foundations prior to acceptance. This assessment shall include:

2.8.5.4.1.1. Documentation Review

- Verification of design compliance with OCS load requirements
- Review of geotechnical investigation adequacy
- Assessment of construction quality control records
- Verification of material test certificates and specifications
- Review of dimensional survey accuracy and compliance
- Assessment of foundation load testing results

2.8.5.4.1.2. Physical Inspection Protocol

Physical inspection shall encompass:

- Visual Inspection: Surface condition, crack assessment, construction defects
- Dimensional Verification: Confirm as- made drawings dimensions against design requirements

2.8.5.4.1.3. Defect Identification and Classification

Defect Classification System

Category	Description	Action Required	Responsibility
Category A - Critical	Defects affecting structural integrity or safety	Foundation rejection or major reconstruction	OCS Contractor rectification
Category B - Major	Defects affecting performance but not safety	Repair or reinforcement required	OCS Contractor rectification
Category C - Minor	Cosmetic or minor non-conformance	Repair or acceptance with monitoring	OCS Contractor discretion
Category D - Administrative	Documentation or procedural deficiencies	Documentation correction	ISR correction

Specific Defect Examples

Category A (Critical):

- Structural cracks wider than 0.5mm
- Foundation settlement or displacement
- Inadequate concrete strength (<90% of design)
- Missing or inadequate reinforcement
- Dimensional errors exceeding 50mm

Category B (Major):

- Surface cracks 0.3-0.5mm width
- Dimensional errors 20-50mm
- Concrete strength 90-95% of design
- Minor reinforcement deficiencies
- Incomplete waterproofing systems

2.8.5.4.2. Acceptance Criteria

- Foundation acceptance requires satisfaction of all following criteria:
- Structural Adequacy: Demonstrated capacity to support all OCS design loads
- Dimensional Compliance: All dimensions within specified tolerances
- Material Compliance: All materials meeting specification requirements
- Construction Quality: No Category A defects and limited Category B defects
- Documentation Completeness: All required documentation provided and verified

2.8.5.4.3. Defect Rectification Responsibilities

2.8.5.4.3.1. OCS Contractor Rectification Obligations

Upon foundation acceptance, the OCS Contractor becomes responsible for:

- All defect rectification regardless of original cause
- Foundation replacement if rectification is not feasible
- Additional testing and verification after rectification
- All costs associated with defect rectification
- Schedule impacts resulting from defect rectification

2.8.5.4.3.2. Rectification Standards

All defect rectification shall:

- Restore foundation to original design performance standards
- Use materials and methods equivalent to or better than original construction
- Include comprehensive testing and verification
- Provide equivalent or extended design life
- Maintain warranty coverage for rectified elements

2.8.5.5. Construction Phase Coordination

During OCS construction phase, coordination requirements include:

Foundation Protection

- Protection of completed foundations during OCS construction
- Coordination of construction access and equipment movement

- Prevention of construction damage to completed foundations
- Immediate reporting and assessment of any foundation damage

Installation Interface

- Verification of foundation condition prior to OCS installation
- Coordination of anchor bolt preparation and installation
- Integration of OCS earthing connections with foundation earth electrodes
- Final dimensional verification during OCS installation

2.8.5.6. Quality Assurance and Control

Quality Control Framework

Quality control for Option 1 interfaces shall include:

- Handover Quality Assurance: Verification of ISR quality control adequacy
- Due Diligence Quality Control: OCS Contractor inspection and testing quality
- Rectification Quality Assurance: Quality control of any rectification work
- Long-term Monitoring: Ongoing foundation performance monitoring

2.8.5.7. Documentation Requirements

Complete documentation package for Option 1 handover shall include:

Design Documentation

- Foundation design calculations and analysis
- Structural drawings and specifications
- Geotechnical investigation reports
- Load analysis and capacity calculations
- Material specifications and approvals

Construction Documentation

- Quality control inspection records
- Material test certificates
- Concrete placement and curing records
- As- Made drawings and surveys

Testing and Acceptance Documentation

- Material testing certificates
- Due diligence assessment reports
- Defect identification and rectification records
- Final acceptance certificates

2.8.6. Option 2: OCS Contractor Design / ISR Execution Model

2.8.6.1. Interface Description

The OCS Contractor Design / ISR Execution model provides the OCS Contractor with complete design control while utilizing ISR's execution capabilities. Under this model, the OCS Contractor maintains full design responsibility and provides comprehensive construction supervision, while ISR acts as the executing contractor following OCS specifications and supervision.

Key characteristics of this interface include:

- OCS Contractor complete design responsibility and control
- Detailed construction specifications and supervision by OCS Contractor
- ISR execution under OCS Contractor oversight
- Integrated quality assurance throughout construction
- Direct handover from construction to OCS Contractor responsibility

2.8.6.2. Responsibility Matrix

Activity	OCS Contractor	ISR/Execution Contractor	Joint Responsibility
Foundation Design Development	●	○	Design review process
Geotechnical Investigation	●	○	Site access coordination
Construction Specifications	●	○	Specification review
Material Procurement	○	●	Material approval process
Construction Execution	○	●	Supervision and inspection
Construction Quality Control	○	●	Inspection procedures
Construction Supreme Supervision	●	○	Progress coordination
Construction Supervision	○	●	Progress coordination
Construction Quality Assurance	●	○	Inspection procedures
Testing and Verification	●	○	Test execution
Defect Rectification	○	●	Per Executed Scope
Foundation Acceptance	●	○	Handover procedures

Legend: ● = Primary Responsibility, ○ = Support/Input Required

2.8.6.3. Design Development Process

Foundation Design Specifications

The OCS Contractor shall develop complete foundation designs, including:

Structural Design Requirements

- Load Analysis: Complete analysis of all OCS loads including static, dynamic, wind, seismic, and construction loads

- Foundation Type Selection: Selection of appropriate foundation type based on geotechnical conditions and load requirements
- Structural Calculations: Complete structural analysis and design calculations per applicable codes
- Reinforcement Design: Detailed reinforcement layout and specifications
- Connection Design: Anchor bolt and connection system design

Geotechnical Design Integration

- Site-specific geotechnical investigation requirements
- Foundation bearing capacity analysis
- Settlement analysis and acceptance criteria
- Lateral load capacity evaluation
- Groundwater and drainage considerations
- Soil-structure interaction analysis

2.8.6.4. ISR Review and Approval Process

Design Review Stages

Review Stage	Deliverables
Preliminary Design	Foundation concepts and layouts
Detailed Design	Complete structural calculations and drawings
Construction Documents	Final drawings and specifications
Material Specifications	Material and testing specifications

Review Criteria

- ISR design review shall be based on:
- Compliance with Israeli structural design codes
- Conformance with railway infrastructure standards
- Integration with existing infrastructure
- Environmental and safety compliance
- Constructability and access considerations
- Long-term maintenance requirements

Design Deliverables

- Complete design package shall include:
- Design Calculations

- Load analysis and load combinations
- Structural analysis and design calculations
- Geotechnical analysis and foundation design
- Connection design and anchor bolt calculations
- Construction load analysis

Technical Drawings

- Foundation layout plans
- Foundation details and sections
- Reinforcement plans and details
- Anchor bolt layouts and details

2.8.6.5. Detailed Instructions Preparation

Technical Specifications

The OCS Contractor shall provide comprehensive technical specifications covering:

Construction Drawings

- Detailed construction drawings shall include:
- Excavation plans and sections
- Formwork layout and details
- Reinforcement placement drawings
- Anchor bolt installation details
- Construction tolerances

Construction Supervision Interface

OCS Contractor Supervision Role

The OCS Contractor shall provide comprehensive construction supervision, including:

Supervision Organization

- Site Supervision Team: Qualified engineers and inspectors with foundation construction experience
- Quality Control Manager: Senior engineer responsible for overall quality assurance
- Specialist Inspectors: Concrete, reinforcement, and geotechnical specialists as required
- Documentation Coordinator: Responsible for inspection records and documentation

Daily Supervision Activities

- Inspection of materials prior to incorporation
- Supervision of construction activities and compliance
- Quality control testing coordination

- Issue identification and resolution coordination

2.8.6.6. Construction Execution

ISR Contractor Responsibilities

ISR, acting as the executing contractor, shall be responsible for:

Construction Management

- Site establishment and safety management
- Construction equipment provision and operation
- Construction crew management and coordination
- Construction progress scheduling and control
- Interface coordination with other ISR activities

Construction Execution

- Execution of all construction activities as per OCS specifications
- Implementation of approved construction methods
- Compliance with all quality control requirements
- Coordination with OCS supervision team
- Immediate response to supervision instructions

Material Procurement and Approval

Procurement Process

Step	Activity	ISR Responsibility	OCS Responsibility
1	Supplier Selection	Supplier identification and qualification	Supplier approval and certification
2	Material Ordering	Purchase order placement and management	Order specification review and approval
3	Quality Assurance	Delivery coordination and logistics	Material inspection and acceptance
4	Documentation	Purchase documentation maintenance	Quality documentation review and filing

2.8.6.7. Direct Handover Process

Under Option 2, foundations are handed over directly from construction completion to OCS Contractor responsibility:

Handover Requirements

- Completion of all construction activities
- Successful completion of all testing and verification
- Resolution of all construction defects
- Completion of all required documentation
- Final inspection and approval by OCS Contractor

Handover Documentation

- As-made drawings and dimensional surveys
- Construction records and quality control documentation
- Material certificates and testing results
- Final inspection reports and approvals

Documentation Requirements

- Comprehensive documentation for Option 2 shall include:

Design Phase Documentation

- Complete design calculations and analysis
- Geotechnical investigation reports and analysis
- Technical specifications and construction documents
- Material specifications and approval records
- Design review records and approvals

Construction Phase Documentation

- Daily inspection reports and quality control records
- Material delivery and acceptance records
- Construction progress records and photographs
- Non-conformance reports and corrective actions
- Testing and verification results

Handover Documentation

- Final as- made drawings and documentation package
- Testing certificates and compliance reports
- Warranty documentation and service records
- Operation and maintenance instructions
- Final acceptance certificates

2.8.6.8. No Schedule Extensions for Defective Foundations

Notwithstanding anything to the contrary in this Agreement, the Contractor shall not be entitled to claim any delay, Extension of Time (EOT), or disruption to the Project Schedule on the grounds that existing foundations, or civil infrastructure are defective, non-compliant, or unfit for mast installation. The Contractor bears the absolute responsibility to survey and verify the condition of all relevant piles and interfaces well in advance of the planned execution dates. Any required rectifications, adjustments, or coordination with third parties must be proactively managed and fully absorbed within the approved Project Schedule, without causing any delay to the execution milestones.

2.8.7. Mutual Coordination (Applies to Both Options)

2.8.7.1. Joint Coordination Meetings

Interface Control Board

A formal Foundation Interface Control Board shall be established comprising representatives from the OCS Contractor, ISR, and Foundation Contractors (where applicable). The board shall meet according to the following schedule:

- Pre-Construction Phase: Monthly meetings during design and planning
- Construction Phase: Bi-weekly meetings during active construction
- Handover Phase: As required for handover completion

Board Responsibilities

- Review and approve foundation interface control documents
- Resolve foundation-related interface disputes
- Coordinate major design and construction decisions
- Approve foundation-related change requests
- Monitor foundation milestone achievements
- Coordinate foundation testing and acceptance activities

Technical Coordination Meetings

- Regular technical coordination meetings shall address:
- Design Coordination: Foundation design progress and technical issues
- Construction Coordination: Construction progress, quality issues, and schedule coordination
- Quality Coordination: Quality assurance activities, testing schedules, and results
- Risk Management: Foundation-related risk identification and mitigation
- Interface Management: Coordination with other project interfaces

Site Coordination Procedures

- Access Coordination
- Site access coordination shall ensure:
- Coordinated access for foundation construction activities
- Integration with other ISR construction activities
- Safety coordination for overlapping activities
- Equipment and material delivery coordination
- Temporary facilities and utilities coordination

Safety Coordination

- Foundation construction safety coordination includes:

- Integrated safety planning and risk assessment
- Coordinated safety training and procedures
- Joint safety inspections and monitoring
- Emergency response coordination
- Incident reporting and investigation coordination

2.8.8. Interface Management Procedures

2.8.8.1. Interface Control Documents

Foundation Interface Control Document Structure

The Foundation Interface Control Document (ICD) shall contain:

- Interface Overview: Description, scope, and stakeholder identification
- Technical Requirements: Foundation specifications and OCS integration requirements
- Responsibility Matrix: Clear definition of each party's responsibilities
- Design Requirements: Design coordination and approval procedures
- Construction Requirements: Construction coordination and supervision procedures
- Testing Requirements: Testing, verification, and acceptance procedures
- Quality Requirements: Quality assurance and control procedures
- Documentation Requirements: Required deliverables and documentation standards
- Acceptance Criteria: Criteria for foundation acceptance and handover
- Risk Management: Foundation-specific risks and mitigation measures

2.8.8.2. Change Management

Foundation Change Categories

Change Category	Description	Approval Authority	Impact Assessment
Minor Modifications	Small dimensional or specification changes	OCS Technical Manager	Technical impact only
Design Changes	Foundation type or design modifications	Interface Control Board	Technical, schedule, cost
Scope Changes	Addition/deletion of foundations	ISR Project Management	Full impact assessment
Emergency Changes	Safety or critical issue resolution	Expedited Process	Post-change assessment

Change Control Process

- Change Identification: Identification of need for foundation change
- Change Request Preparation: Formal change request documentation
- Technical Impact Assessment: Assessment of technical implications
- Schedule Impact Assessment: Assessment of schedule implications
- Cost Impact Assessment: Assessment of cost implications
- Stakeholder Review: Review by all affected parties
- Approval Decision: Formal approval or rejection decision
- Implementation: Coordinated implementation of approved changes
- Documentation Update: Update of all relevant documentation

3. DELIVERABLES DURING DIFFERENT PROJECT STAGES

3.1. Abbreviations and Definitions

NOBO: Notified Body - Independent organization designated to assess conformity with TSI requirements

IC: Interoperability Constituent - Component or assembly covered by TSI

OCS: Overhead Contact System

RAMS: Reliability, Availability, Maintainability, Safety

TSI ENE: Technical Specification for Interoperability relating to Energy subsystem

CDM: Construction (Design and Management) Regulations

RISQS: Railway Industry Supplier Qualification Scheme

QMS: Quality Management System

SMS: Safety Management System

EMS: Environmental Management System

Regulatory Framework: All submissions must demonstrate compliance with:

Commission Regulation (EU) No 1301/2014 - TSI ENE (Technical Specification for Interoperability - Energy)

Directive (EU) 2016/797 - Interoperability of the rail system within the European Union

EN 50126-1:2017+A1:2024 - Railway RAMS (Reliability, Availability, Maintainability, Safety)

EN 50119:2020 - Railway applications - Fixed installations - Electric traction overhead contact lines

EN 50122-1:2022+A1:2025 - Railway applications - Electrical safety, earthing and return circuit

EN 50163:2004+A3:2022 - Railway applications - Supply voltages of traction systems

EN 50317:2012+A1:2022 - Railway applications - Current collection systems - Dynamic interaction

EN 50388-1:2022/2025: Railway Applications - Fixed installations and rolling stock - Technical criteria for the coordination between electric traction power supply systems and rolling stock to achieve interoperability

Local standards and regulations

Submission Requirements: All documents must be submitted in digital format (PDF, DWG as specified) with appropriate quality assurance, version control, and certification. Documents must be prepared by qualified personnel and bear appropriate approvals. Translation to English required for all non-English documents.

3.2. Submission for Demonstration of Capabilities

All documents specified in this Section 3.2 shall be submitted by the Contractor and approved by ISR by the Effective Date.

3.2.1. COMPANY CREDENTIALS & EXPERIENCE

Requirement	Document/Evidence Required
Company Profile and Registration	Certificate of incorporation, business license, VAT registration
Organizational Structure	Corporate organization chart, subsidiary relationships
Minimum 3 Comparable Railway Electrification Projects	Project references with scope, value, completion certificates
High-Speed Rail Experience (>160km/h)	Project portfolio demonstrating high-speed OCS capability
25kV AC System Experience	Evidence of 25kV AC electrification project delivery
2x25kV AC System Experience	Evidence of 2x25kV AC electrification project delivery
ISO 9001 Quality Management System	Valid ISO 9001 certificate and surveillance reports
ISO 45001 Safety Management System	Valid ISO 45001 certificate or equivalent safety certification
ISO 14001 Environmental Management	Valid ISO 14001 certificate or equivalent environmental certification
RISQS Registration (or equivalent)	Current RISQS certificate and audit history

3.2.2. TECHNICAL CAPABILITY DEMONSTRATION

Requirement	Document/Evidence Required
OCS Design Capability	Design methodology document, calculation procedures
Dynamic Simulation Capability	Software licenses, simulation tool specifications, sample analyses
Pantograph-OCS Interactin Analysis	Proven capability for EN 50317 compliance simulation
Construction Experience	Construction methodology statements, equipment lists
OCS Installation Equipment	Specialized plant register, OCS installation vehicles
Testing and Commissioning Experience	T&C procedures, test equipment specifications
Laboratory Facilities	Laboratory accreditation certificates, testing capabilities
CAD/BIM Capabilities	Software licenses, BIM execution plan template
Technical Partnerships	Partner agreements, subcontractor prequalification
Supply Chain Management	Approved supplier lists, procurement procedures

3.2.3. TSI/ENE COMPLIANCE DOCUMENTATION

Standard/Requirement	Compliance Documentation Required
TSI ENE Understanding	Compliance matrix, gap analysis, implementation strategy
EN 50126-1 (RAMS)	RAMS methodology, life cycle approach, assessment procedures
EN 50119 (OCS Design)	Design compliance procedures, calculation methods
EN 50122-1 (Electrical Safety)	Safety design principles, earthing system design capability
EN 50163 (Supply Voltages)	Voltage compatibility analysis, system design parameters
EN 50317 (Dynamic Interaction)	Testing capability, measurement procedures, equipment specs
Conformity Assessment Procedures	IC assessment methodology, module selection rationale
Technical File (catalogue)	Full catalogue of the proposed electrification system
Certificates	Certificates and compliance documents of the proposed system
Interoperability Directive Compliance	Legal compliance framework, authorization procedures

3.2.4. NOBO COORDINATION & CERTIFICATION

NOBO Aspect	Evidence Required
NOBO Experience	List of previous projects with NOBO involvement
Previous NOBO Certificates	Examples of EC certificates obtained, reference letters
IC Certification Process Understanding	Process flow diagram, documentation requirements
Subsystem Verification Procedures	Integration assessment methodology, testing protocols
Documentation Management System	NOBO interface procedures, document control system
Proposed NOBO Selection	NOBO selection criteria, preliminary engagement letter
Assessment Timeline	Certification schedule, milestone planning
Change Control Process	Procedures for design changes during certification

3.2.5. DESIGN DELIVERABLES CAPABILITY

Design Deliverable	Capability Evidence Required
Preliminary Design Documents	Design development procedures, stage gate processes
Detailed Design Calculations	Calculation templates, verification procedures
Design Verification & Validation	V&V procedures, independent checking processes
Simulation Studies	Simulation methodology, software capabilities
Technical Specifications	Specification writing procedures, standards compliance

Drawing Standards	CAD standards manual, drawing templates
BIM/3D Modelling	BIM execution plan, software licenses, deliverable formats
Design Review Processes	Design review procedures, approval matrixes

3.2.6. CONSTRUCTION METHODOLOGY

Construction Aspect	Documentation Required
Construction Program	Master program template, phasing methodology
OCS Installation Procedures	Method statements, installation sequences
Specialized Equipment	OCS installation vehicle specifications, availability
Safety During Construction	Construction safety procedures, risk assessments
Quality Control	Construction QC procedures, inspection checklists
Environmental Management	Environmental procedures, mitigation measures
Traffic Management	Possession planning procedures, railway interface
Temporary Works Design	Temporary works procedures, design capability

3.2.7. TESTING & COMMISSIONING PLAN

Testing Phase	Procedures & Equipment Required
Pre-commissioning Tests	Pre-commissioning test schedule and procedures
Static Testing Procedures	Static test methodology, measurement equipment
Dynamic Testing (EN 50317)	Dynamic measurement capability, certified equipment
Pantograph-OCS Interaction	Contact force measurement systems, analysis software
Protection Coordination Tests	Protection testing procedures, coordination studies
System Integration Testing	Integration test procedures, interface verification
Performance Verification	Performance test procedures, acceptance criteria
Test Equipment Calibration	Calibration certificates, measurement uncertainty
Test Reporting	Test report templates, data analysis procedures

3.2.8. TRANSFER TO COMMERCIAL OPERATION

Final Acceptance Element	Documentation & Procedures Required
Handover Documentation	Handover procedure, document register
As- made drawings and Documentation	As- Made drawing procedures, survey requirements
O&M Manuals	Operation manual template, maintenance procedures
Training Programs	Training curriculum, competency assessment
Warranty Provisions	Warranty terms, defects liability procedures
Spare Parts Strategy	Spare parts list, provisioning strategy
Emergency Support	24/7 support arrangements, response procedures
Performance Monitoring	Performance monitoring system, KPI reporting

3.2.9. QUALITY ASSURANCE & COMPLIANCE

QA Element	System/Procedures Required
Quality Management System	ISO 9001 QMS manual, process documentation
Quality Control Plan	Project-specific QC plan, hold points
Inspection & Test Plans	ITP templates, inspection checklists
Non-conformance Management	NCR procedures, corrective action system
Document Control	Document control procedures, version control
Traceability Systems	Material traceability, certification records
Internal Audit Procedures	Audit program, auditor qualifications

3.2.10. HEALTH, SAFETY & ENVIRONMENT

HSE Element	Management System/Procedures
Safety Management System	SMS manual, safety policies and procedures
Risk Assessment Methodology	Risk assessment procedures, hazard identification
RAMS Documentation	RAMS plan template, assessment procedures
Environmental Management	EMS procedures, environmental impact assessment
CDM Compliance	CDM procedures, principal contractor capability
Safety Training Matrix	Training requirements, competency records
Emergency Response	Emergency procedures, incident management
Safety Performance	Safety KPIs, performance monitoring system

3.3. Technical Submission for OCS Technical Compliance

3.3.1. CERTIFICATION & APPROVAL DOCUMENTS

Document Type	Description	Standard Reference	Format	Due Date
EC Certificate of Conformity (IC - OCL)	NOBO-issued certificate for overhead contact line as interoperability constituent	TSI ENE 6.1	PDF	Signature Date+60 days
EC Declaration of Conformity	Manufacturer's declaration of conformity for all OCS components	Directive 2016/797	PDF	Signature Date+60 days
EC Certificate of Verification (Energy Subsystem)	NOBO certificate for complete energy subsystem verification	TSI ENE 6.2	PDF	Signature Date+60 days
NOBO Assessment Reports	Detailed technical assessment reports from notified body	TSI ENE	PDF	Signature Date+60 days
Type Approval Certificates	Type approval for all OCS component types (insulators, clamps, etc.)	EN 50119	PDF	Signature Date+60 days
Factory Acceptance Test Certificates	FAT certificates for manufactured components	Quality standards	PDF	Pre Procurement
Contact Wire Material Certificate	Material certificate and test reports for contact wire	EN 50149	PDF	Pre Procurement
Messenger Wire Material Certificate	Material certificate and test reports for messenger wire	EN 50182	PDF	Pre Procurement
Dropper Certificates	Material and performance certificates for droppers	EN 50119	PDF	Pre Procurement
ISO 9001 Certificate (Manufacturing)	Valid QMS certificate for all manufacturing facilities	ISO 9001	PDF	Signature Date+60 days
ISO 14001 Certificate	Environmental management system certification	ISO 14001	PDF	Signature Date+60 days

3.3.2. TECHNICAL DESIGN DOCUMENTATION

Document Type	Description	Standard Reference	Format	Due Date
OCS General Arrangement Drawings	Complete system layout drawings showing all OCS components	EN 50119	DWG + PDF	According to Design milestone
Standard Support Assembly Drawings	Detailed drawings of all standard support structures	EN 50119	DWG + PDF	According to Design milestone
Cantilever Design Drawings	Cantilever arm assemblies with all components and connections	EN 50119	DWG + PDF	According to Design milestone
Registration Arm Assembly Drawings	Registration arm details with steady arm connections	EN 50119	DWG + PDF	According to Design milestone
Tensioning Device Drawings	Balance weight and pulley assemblies with installation details	EN 50119	DWG + PDF	According to Design milestone
Overlap Arrangement Drawings	Insulated and uninsulated overlap details with clearances	TSI ENE	DWG + PDF	According to Design milestone
Phase Break/Section Separator Drawings	Phase break arrangements and neutral section details	TSI ENE	DWG + PDF	According to Design milestone
Special Location Drawings	Tunnel, bridge, and station-specific arrangements	EN 50119	DWG + PDF	According to Design milestone
Foundation Design Drawings	Foundation details for all support structures	EN 50119	DWG + PDF	According to Design milestone
Electrical Single Line Diagrams	OCS electrical schematics and protection arrangements	EN 50122-1	DWG + PDF	According to Design milestone
Earthing and Bonding Drawings	Complete earthing system with impedance bond locations	EN 50122-1	DWG + PDF	According to Design milestone
Lightning Protection Drawings	Lightning protection system design and earth mat	EN 62305	DWG + PDF	According to Design milestone
Design Calculations – Civil	Static and Dynamic forces, foundations	Local standards	PDF	According to Design milestone
Design Calculations – Mechanical	Mechanical load calculations, stress analysis, fatigue assessment	EN 50119	PDF	According to Design milestone
Design Calculations - Electrical	Current carrying capacity, voltage drop, fault level calculations	EN 50163	PDF	According to Design milestone

Document Type	Description	Standard Reference	Format	Due Date
Dynamic Analysis Calculations	Pantograph-OCS interaction analysis per EN 50317	EN 50317	PDF	According to Design milestone
Load Calculations	Wind, ice, temperature loading with safety factors	EN 50119	PDF	According to Design milestone
Clearance Calculations	Electrical and mechanical clearance verification	EN 50119, EN 50122-1	PDF	According to Design milestone

3.3.3. EQUIPMENT TECHNICAL DATA & CATALOGUES

Document Type	Description	Standard Reference	Format	Due Date
Contact Wire Technical Data	Complete specification including material properties, dimensions, performance	EN 50149	PDF	Signature Date + 60 days
Messenger Wire Technical Data	Material specification, tensile strength, conductivity data	EN 50182	PDF	Signature Date + 60 days
Dropper/Hanger Technical Data	Specification including load capacity, material, connection details	EN 50119	PDF	Signature Date + 60 days
Insulator Technical Data	Electrical and mechanical properties, type test certificates	EN 50124-1	PDF	Signature Date + 60 days
Tensioning Device Manual	Complete technical manual with installation and maintenance instructions	EN 50119	PDF	Signature Date + 60 days
Registration Arm Technical Data	Load capacity, deflection characteristics, material specification	EN 50119	PDF	Signature Date + 60 days
Section Insulator Technical Data	Electrical clearance, mechanical strength, operating procedures	EN 50119	PDF	Signature Date + 60 days
Balance Weight Assembly Data	Weight specifications, pulley details, installation procedures	EN 50119	PDF	Signature Date + 60 days
Termination Clamps Data	Conductor termination clamps with slip test results	EN 50119	PDF	Signature Date + 60 days
Electrical Connectors Data	Current rating, contact resistance, corrosion resistance data	EN 50124-1	PDF	Signature Date + 60 days
Earthing Components Data	Earth electrodes, bonds, connections with resistance values	EN 50122-1	PDF	Signature Date + 60 days
Support Structure Catalogue	Complete catalogue of masts, brackets, foundations	EN 50119	PDF	Signature Date + 60 days
Anti-vibration Devices Data	Vibration dampers specification and installation details (if applicable)	EN 50119	PDF	Signature Date + 60 days
Anti-climbing device data	Anti climbing devices specification and installation details	EN 50122-1	PDF	Signature Date + 60 days

Document Type	Description	Standard Reference	Format	Due Date
Bird Protection Devices Data	Bird guard specifications and installation procedures (if applicable)	Environmental req.	PDF	Signature Date + 60 days

3.3.4. COMPLIANCE DEMONSTRATION DOCUMENTS

Document Type	Description	Standard Reference	Format	Due Date
TSI ENE Compliance Matrix	Clause-by-clause compliance demonstration with evidence references	TSI ENE	PDF + Excel	According to Design milestone
EN 50119:2020 Compliance Statement	Detailed compliance statement with design evidence	EN 50119	PDF	According to Design milestone
EN 50122-1:2022 / SI 61228-1 Compliance Report	Electrical safety compliance with earthing system verification	EN 50122-1 SI 61228-1	PDF	According to Design milestone
EN 50163:2004 Compliance Verification	Supply voltage compatibility verification and analysis	EN 50163	PDF	According to Design milestone
EN 50317:2012 Dynamic Test Results	Pantograph-OCS interaction test results and analysis	EN 50317	PDF	Final Acceptance
EN 50126-1 RAMS Documentation	Reliability, Availability, Maintainability, Safety analysis and plan	EN 50126-1	PDF	According to Design milestone
Interoperability Directive Compliance	Legal compliance report with authorization procedures	Directive 2016/797	PDF	According to Design milestone
Technical File for IC Assessment	Complete technical file for interoperability constituent assessment	TSI ENE 6.1	PDF	NOBO submission
Technical File for Subsystem Verification	Subsystem technical file including integration evidence	TSI ENE 6.2	PDF	Pre-commissioning
Risk Assessment Documentation	Comprehensive risk assessment with mitigation measures	EN 50126-1	PDF	According to Design milestone
Hazard Log	System hazard log with risk controls and monitoring	EN 50126-1	PDF + Excel	Throughout the Project
Safety Case	System safety case demonstrating acceptable risk	EN 50126-1	PDF	According to Design milestone

3.3.5. SIMULATION & ANALYSIS REPORTS

Document Type	Description	Standard Reference	Format	Due Date
Pantograph-OCS Simulation Report	Dynamic interaction simulation per EN 50317 requirements	EN 50317	PDF	Design verification
Contact Force Analysis Report	Statistical analysis of contact forces (Fm, σ, Fmax, Fmin)	EN 50317	PDF	Design verification
Contact Wire Uplift Analysis	Uplift behavior analysis under pantograph forces	EN 50317	PDF	Design verification
Wave Propagation Speed Analysis	Wave speed calculation and operating speed verification	TSI ENE	PDF	Design verification
Mean Contact Force Calculation	Fm calculation report with speed-dependent analysis	EN 50317	PDF	Design verification
Statistical Analysis Report	Statistical evaluation of dynamic performance parameters	EN 50317	PDF	Design verification
Multi-Pantograph Operation Analysis	Analysis of multiple pantograph interaction effects	TSI ENE	PDF	Design verification
Aerodynamic Effects Study	High-speed aerodynamic effects on pantograph performance	EN 50317	PDF	Design verification
Temperature Effects Analysis	Temperature variation effects on OCS performance	EN 50119	PDF	Design verification
Worst-Case Scenario Analysis	Analysis of most demanding operating conditions	EN 50317	PDF	Design verification
Software Validation Report	Validation report for simulation software used	EN 50318	PDF	Before simulation
Simulation Tool Certification	Certification/validation of simulation tools and models	EN 50318	PDF	Before use

3.3.6. TYPE TESTING REPORTS

Document Type	Description	Standard Reference	Format	Due Date
Contact Wire Type Test Report	Mechanical and electrical properties testing per standard	EN 50149	PDF	Pre Procurement

Messenger Wire Type Test Report	Tensile strength, conductivity, and durability testing	EN 50182	PDF	Pre Procurement
Insulator Type Test Reports	Mechanical load and electrical withstand testing	EN 50124-1	PDF	Pre Procurement
Clamp Type Test Reports	Slip test, mechanical strength, and thermal cycling	EN 50119	PDF	Pre Procurement
Dropper Type Test Reports	Load testing and fatigue performance verification	EN 50119	PDF	Pre Procurement
Section Insulator Type Test	Electrical and mechanical performance testing	EN 50119	PDF	Pre Procurement
Registration Arm Load Test	Load testing and deflection characteristic verification	EN 50119	PDF	Pre Procurement
Tensioning Device Performance Test	Load testing and operational performance verification	EN 50119	PDF	Pre Procurement
Corrosion Resistance Reports	Salt spray and environmental corrosion testing	EN ISO 9227	PDF	Pre Procurement
Environmental Test Reports	Temperature, UV, and humidity exposure testing	IEC 60068	PDF	Pre Procurement
Short Circuit Withstand Test	Fault current withstand capability demonstration	EN 50119	PDF	Pre Procurement
Lightning Impulse Test Reports	Lightning impulse withstand testing for insulators	IEC 60060-1	PDF	Pre Procurement

3.3.7. MANUFACTURING & QUALITY DOCUMENTATION

Document Type	Description	Standard Reference	Format	Due Date
Manufacturing Process Descriptions	Detailed process documentation for all manufactured components	ISO 9001	PDF	Pre Procurement
Quality Control Plan	Comprehensive QC plan with inspection points and criteria	ISO 9001	PDF	Pre Procurement
Inspection and Test Plan (ITP)	Detailed ITP for all components and assemblies	ISO 9001	PDF + Excel	Pre Procurement
Factory QA Procedures	Factory quality assurance procedures and work instructions	ISO 9001	PDF	Pre Procurement
Material Traceability Procedures	Material identification and traceability system	ISO 9001	PDF	Pre Procurement
Welding Procedures	Qualified welding procedures for structural connections	EN ISO 15614	PDF	Pre welding
NDT Procedures	Non-destructive testing procedures and certifications	EN ISO 9712	PDF	Pre Testing
Coating Specifications	Paint and protective coating specifications and procedures	EN ISO 12944	PDF	Pre Coating
Material Certificates (EN 10204)	Material certificates of conformity type 3.1 or 3.2	EN 10204	PDF	Upon delivery
Chemical Composition Reports	Material chemical analysis reports	EN 10204	PDF	Upon delivery
Mechanical Properties Reports	Tensile, yield, and elongation test results	EN 10204	PDF	Upon delivery
Dimensional Inspection Reports	Final dimensional inspection results for manufactured items	ISO 9001	PDF	Pre delivery

3.3.8. INSTALLATION & CONSTRUCTION DOCUMENTATION

Document Type	Description	Standard Reference	Due Date
Installation Manual	Complete installation manual for all OCS components	EN 50119	Pre-execution
Installation Method Statements	Detailed method statements for all installation activities	ISO 9001	Pre-execution

Installation Sequence Drawings	Step-by-step installation sequence illustrations	Project req.	Pre-execution
Tensioning Procedures	Wire tensioning procedures with safety requirements	EN 50119	Pre-execution
Registration Procedures	Contact wire registration and stagger adjustment procedures	EN 50119	Pre-execution
Tolerance Specifications	Installation tolerances for all OCS components	EN 50119	Pre-execution
Special Installation Procedures	Procedures for tunnels, bridges, and constrained locations	EN 50119	Pre-execution
Health & Safety Procedures	Construction safety procedures and risk assessments	CDM Regulations	Pre-execution
Quality Control During Installation	Installation QC procedures and inspection checklists	ISO 9001	Pre-execution
Pre-commissioning Checklists	Pre-energization checklists and verification procedures	Project req.	Pre-execution
Installation Equipment Specs	Specifications for specialized OCS installation equipment	Project req.	Pre-execution
Temporary Works Drawings	Temporary support structures during construction (if required)	BS 5975	Before use

3.3.9. TESTING & COMMISSIONING DOCUMENTATION

Document Type	Description	Standard Reference	Format	Due Date
Commissioning Plan	Comprehensive commissioning plan with milestones and responsibilities	Project req.	PDF	Pre-commissioning
Testing Schedule	Detailed testing schedule coordinated with project milestones	Project req.	PDF + Excel	Pre-commissioning
Pre-energization Test Procedures	Safety testing procedures before first energization	EN 50122-1	PDF	Pre-commissioning
Insulation Resistance Test Procedures	Insulation testing procedures for all electrical components	EN 50122-1	PDF	Pre-commissioning
High Voltage Test Procedures	HV testing procedures for insulators and clearances	EN 50124-1	PDF	Pre-commissioning
Static Geometry Measurement Procedures	Contact wire height, stagger, and clearance measurement procedures	EN 50119	PDF	Post-construction
Dynamic Performance Test Procedures	EN 50317 dynamic testing procedures and equipment setup	EN 50317	PDF	Post-construction
Contact Force Measurement Report	Measured contact force results (Fm, σ) with statistical analysis	EN 50317	PDF	Post-testing
Uplift Measurement Report	Contact wire uplift measurement results and analysis	EN 50317	PDF	Post-testing
Protection System Test Reports	Electrical protection coordination test results	EN 50122-1	PDF	Post-testing
Earthing System Test Reports	Earth resistance and impedance bond test results	EN 50122-1	PDF	Post-testing
Test Equipment Calibration	Calibration certificates for all test equipment used	ISO 17025	PDF	Before testing
Commissioning Test Results	Complete commissioning test results and acceptance report	Project req.	PDF	Post-commissioning

3.3.10. MAINTENANCE DOCUMENTATION

Document Type	Description	Standard Reference	Format	Approved Due Date
Maintenance Manual	Comprehensive Maintenance Manual for Complete OCS system	Project req.	PDF + Hard copy	Final Acceptance
Maintenance Schedule	Preventive maintenance schedule with frequencies and procedures	EN 50126-1	PDF + Excel	Final Acceptance
Inspection Procedures	Routine inspection procedures for all OCS components	EN 50119	PDF	Final Acceptance
Preventive Maintenance Procedures	Detailed preventive maintenance procedures	EN 50126-1	PDF	Final Acceptance
Corrective Maintenance Procedures	Fault diagnosis and repair procedures	EN 50126-1	PDF	Final Acceptance
Troubleshooting Guide	Fault finding and resolution guide with decision trees	Project req.	PDF	Final Acceptance
Spare Parts List	Comprehensive spare parts list with part numbers and suppliers	EN 50126-1	PDF + Excel	Final Acceptance
Spare Parts Catalogue	Illustrated spare parts catalogue with exploded views	Project req.	PDF	Final Acceptance
Wear Limits Specification	Component wear limits and replacement criteria	EN 50119	PDF	Final Acceptance
Safety Instructions	Safety procedures for maintenance personnel	EN 50122-1	PDF	Final Acceptance
Emergency Procedures	Emergency response procedures for system failures	Project req.	PDF	Final Acceptance
Performance Monitoring Guidelines	System performance monitoring and KPI tracking procedures	EN 50126-1	PDF	Final Acceptance

3.3.11. TRAINING MATERIALS

Document Type	Description	Standard Reference	Format	Due Date
Maintenance Training Manual	Training manual for maintenance staff covering all maintenance activities	Project req.	PDF + Hard copy	Signature Date + 90 days

Training Course Curriculum	Structured training curriculum with learning objectives	Project req.	PDF	Signature Date + 90 days
Training Presentation Materials	PowerPoint presentations and visual aids for training delivery	Project req.	PPT + PDF	Signature Date + 90 days
Video Training Materials	Video demonstrations of key procedures (if available)	Project req.	MP4	Signature Date + 90 days
Competency Assessment Criteria	Assessment criteria and testing procedures for competency verification	Project req.	PDF	Signature Date + 90 days
Personnel Certification Requirements	Certification requirements and qualification matrix for personnel	Project req.	PDF	Signature Date + 90 days

3.3.12. WARRANTY & SUPPORT DOCUMENTATION

Document Type	Description	Standard Reference	Format	Due Date
Warranty Certificate	Comprehensive warranty certificate for complete OCS system	Contract terms	PDF + Original	Final Acceptance
Warranty Terms & Conditions	Detailed warranty terms, exclusions, and claim procedures	Contract terms	PDF	Final Acceptance
Defects Liability Documentation	Defects liability period terms and rectification procedures	Contract terms	PDF	Final Acceptance
Technical Support Contact Info	24/7 technical support contact details and escalation procedures	Contract terms	PDF	Final Acceptance
Emergency Support Procedures	Emergency callout procedures and response time commitments	Contract terms	PDF	Final Acceptance
Manufacturer Guarantee Letters	Component manufacturer guarantee letters for major equipment	Contract terms	PDF + Original	Final Acceptance
After-sales Service Agreements	Long-term service and maintenance agreements (if applicable)	Contract terms	PDF + Original	Final Acceptance

3.3.13. AS- MADE DRAWINGS AND DOCUMENTATION

(Post-Construction Submission)

Document Type	Description	Standard Reference	Format	Due Date
As - Made drawings - All Disciplines	Complete as- Made drawings reflecting actual installation	Project req.	DWG + PDF	Final Acceptance
As - Made adapted Design Calculations	Updated calculations reflecting as- Made drawings conditions	EN 50119	PDF	Final Acceptance
Survey Reports (As-Made drawings)	Final survey reports with actual installed positions	Project req.	PDF + DWG	Final Acceptance
Photographic Record	Comprehensive photographic (drone video) record of completed installation	Project req.	Digital images + PDF	Final Acceptance

Site Test Reports (All Tests)	Complete set of all site test reports and results	EN 50317, EN 50122-1	PDF	Final Acceptance
Deviation Reports	Reports documenting all deviations from original design	Project req.	PDF	Final Acceptance
Modification Records	Complete record of all design modifications and approvals	Project req.	PDF	Final Acceptance
Final Commissioning Reports	Complete commissioning report with all test results	Project req.	PDF	Final Acceptance
Handover Certificates	Formal handover certificates for all sections of work	Contract terms	PDF + Original	Final Acceptance
Snag List & Rectification Record	Final snag list with rectification evidence	Project req.	PDF	Final Acceptance

APPENDIX B - SCADA SYSTEM DESIGN-BUILD TECHNICAL SPECIFICATION

1. INTRODUCTION AND PROJECT OVERVIEW

1.1 General requirements

1.1.1 Terminology and Abbreviations

Key Technical Terms:

SCADA (Supervisory Control and Data Acquisition): Industrial control system architecture comprising computers, networked data communications, and graphical user interfaces for high-level process supervisory management.

OCS (Overhead Contact System): The overhead wire infrastructure that supplies electric power to trains, including contact wire, catenary wire, support structures, and sectioning equipment.

LOP (Local Operating Post): Field installation containing equipment for local monitoring and control of OCS sectioning, typically including motorized disconnectors, RTU controllers, and local operator interface.

TSS (Traction Substation): High-voltage electrical substation that converts utility power to railway traction power, 27.5 kV AC for ISR electrification system.

RTU (Remote Terminal Unit): Microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system by transmitting telemetry data and alarms.

LOTO (Lockout/Tagout): Safety procedure ensuring dangerous equipment is properly shut off and not restarted prior to completion of maintenance or repair work.

Common Abbreviations:

- AC: Alternating Current
- API: Application Programming Interface
- BFD: Bidirectional Forwarding Detection
- BOQ: Bill of Quantities
- CCTV: Closed Circuit Television
- CPU: Central Processing Unit
- FAT: Factory Acceptance Testing
- HMI: Human Machine Interface
- HVAC: Heating, Ventilation, and Air Conditioning
- ICD: Interface Control Document
- IDS: Intrusion Detection System

- IEC: International Electrotechnical Commission
- IP: Internet Protocol
- IPS: Intrusion Prevention System
- ISR: Israel Railways
- IT: Information Technology
- KPI: Key Performance Indicator
- LACP: Link Aggregation Control Protocol
- LAN: Local Area Network
- MFA: Multi-Factor Authentication
- MMS: Manufacturing Message Specification
- NAS: Network Attached Storage
- NIS: New Israeli Shekel
- NMS: Network Management System
- OPC: OLE for Process Control
- OSPF: Open Shortest Path First
- OTDR: Optical Time Domain Reflectometer
- PDU: Power Distribution Unit
- PMD: Polarization Mode Dispersion
- QoS: Quality of Service
- RAID: Redundant Array of Independent Disks
- RBAC: Role-Based Access Control
- RTDB: Real-Time Database
- SAN: Storage Area Network
- SAT: Site Acceptance Testing
- SCL: Substation Configuration Language
- SLA: Service Level Agreement
- SNMP: Simple Network Management Protocol
- SOE: Sequence of Events
- SOP: Standard Operating Procedure
- SQL: Structured Query Language
- TLS: Transport Layer Security
- UPS: Uninterruptible Power Supply
- VLAN: Virtual Local Area Network
- VPN: Virtual Private Network
- WAN: Wide Area Network

1.1.2 Reference Documents

IEC Standards:

- IEC 60044-1: Instrument transformers - Current transformers
- IEC 60044-2: Instrument transformers - Inductive voltage transformers

- IEC 60255: Measuring relays and protection equipment
- IEC 60870-5-101: Telecontrol equipment - Transmission protocols - Companion standard for basic telecontrol tasks
- IEC 60870-5-104: Network access for IEC 60870-5-101 using standard transport profiles
- IEC 61131-3: Programmable controllers - Programming languages
- IEC 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems
- IEC 61850-6: Configuration description language for communication in electrical substations
- IEC 61850-7-1: Basic communication structure - Principles and models
- IEC 61850-7-2: Basic communication structure - Abstract communication service interface (ACSI)
- IEC 61850-7-3: Basic communication structure - Common data classes
- IEC 61850-7-4: Basic communication structure - Compatible logical node classes and data object classes
- IEC 61850-8-1: Specific communication service mapping (SCSM) - Mappings to MMS
- IEC 61850-9-2: Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3
- IEC 61970-301: Energy management system application program interface (EMS-API)
- IEC 62059: Electricity metering equipment - Dependability
- IEC 62351: Power systems management and associated information exchange - Data and communications security
- IEC 62443-2-1: Industrial automation and control systems security - Security program requirements and security lifecycle requirements
- IEC 62443-3-3: Industrial automation and control systems security - System security requirements and security levels
- IEC 62443-4-2: Industrial automation and control systems security - Component security requirements for IACS components

ISO Standards:

- ISO 9001:2015: Quality management systems - Requirements
- ISO 14001:2015: Environmental management systems - Requirements with guidance for use
- ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories
- ISO/IEC 20000-1: Information technology - Service management
- ISO/IEC 27001: Information security management systems - Requirements
- ISO/IEC 27002: Information security management - Code of practice for information security controls
- ISO/IEC 27005: Information security risk management
- ISO 31000: Risk management - Guidelines
- ISO 45001: Occupational health and safety management systems - Requirements
- ISO 50001: Energy management systems - Requirements with guidance for use

IEEE Standards:

- IEEE 80: Guide for safety in AC substation grounding
- IEEE 519: Recommended practices and requirements for harmonic control in electrical power systems
- IEEE 802.1Q: Virtual LANs
- IEEE 802.1w: Rapid reconfiguration of spanning tree
- IEEE 802.1X: Port-based network access control
- IEEE 802.3: Ethernet standards
- IEEE 802.3af: Power over Ethernet
- IEEE 802.3at: Power over Ethernet Plus
- IEEE 802.11: Wireless LAN standards
- IEEE 1588: Precision time protocol for networked measurement and control systems
- IEEE 1613: Environmental and testing requirements for communications networking devices in electric power substations
- IEEE C37.1: Standard definitions for power switchgear
- IEEE C37.90: Relays and relay systems associated with electric power apparatus

Ministry of Transport Regulations:

4000-0208-2023-000539 – Main Instruction – Local Railways

4000-0208-2023-000519 – Main Instruction – Regulation for construction of System and sub-systems for Local Railways

EN Railway Standards:

- EN 50121: Railway applications - Electromagnetic compatibility
- EN 50122: Railway applications - Fixed installations - Electrical safety, earthing and the return circuit
- EN 50124: Railway applications - Insulation coordination
- EN 50125: Railway applications - Environmental conditions for equipment
- EN 50126: Railway applications - The specification and demonstration of reliability, availability, maintainability and safety (RAMS)
- EN 50128: Railway applications - Communication, signaling and processing systems - Software for railway control and protection systems
- EN 50129: Railway applications - Communication, signaling and processing systems - Safety related electronic systems for signaling
- EN 50159: Railway applications - Communication, signaling and processing systems - Safety-related communication in transmission systems
- EN 50163: Railway applications - Supply voltages of traction systems
- EN 50388: Railway applications - Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability

1.2 Project Background and Objectives

Current System:

Israel Railways operates approximately 1,500 km of electrified railway network using 27.5 kV AC overhead contact system (OCS).

The existing SCADA system, implemented in 2018, has reached technical obsolescence with limited expansion capability, increasing maintenance costs, and operational constraints that limit ISR's ability to meet growing service demands.

Reasons for the upgrade:

- Technical obsolescence: Legacy hardware/software approaching end-of-life with limited spare parts
- Network expansion: Planned electrification of additional 1000+ km requiring SCADA coverage
- Operational efficiency: Need for improved automation, integration, and decision support
- Safety enhancement: Modern LOTO systems and enhanced operational safety features
- Cybersecurity: Compliance with evolving industrial cybersecurity standards (IEC 62443)

Objectives of the project:

The SCADA Contractor shall deliver a complete SCADA system providing:

1. Reliable Monitoring and Control: Real-time monitoring and control of all OCS infrastructure with 99.99% system availability

2. Network Coverage: Complete coverage of existing TS and LOP sites plus scalability to 250+ sites for future expansion

3. Zero-Downtime Migration: Systematic migration from legacy system without service interruption

4. Enterprise Integration: Seamless integration with external systems including SAP, Signaling and CMMS

5. Future-Ready Platform: Modern, standards-based architecture supporting 25+ year lifecycle

1.3. Minimum requirements for the SCADA Contractor

Following are the minimum, requirements for the SCADA Contractor appointed to carry out the SCADA works:

(i) At least 15 years' experience in design and execution of SCADA systems for transportation and/or energy infrastructure projects, each with a Contract Value of at least 50 million Euros; and

(ii) Completion of at least three (3) SCADA projects for railway, metro or railway electrification systems of at least three hundred (300) km (in the aggregate), and which include RTUs, field communications and a central HMI.

The engagement of the SCADA Contractor is subject to the prior written approval of ISR.

1.4 Geographic and System Scope

Network Coverage:

Existing Electrified Network (Migration Scope):

- Total electrified distance: ~1,500 km operational single track
- Nahariya to Beer Sheva with 14 Traction sub-stations and >75 Local Operational Posts (LOPs)
- Additional: Mobile units, stabling areas and depots

Future Network Expansion (Development Scope):

- Planned electrification: Additional 2000+ km over project lifecycle
- Additional LOPs: 100-150 sites
- Additional TSSs: 15-20 substations
- New corridors: Southern extensions (Be'er Sheva–Eilat), northern extensions (Carmiel–Kiryat Shmona)
- Stabling Areas/Depot expansions: 4-6 additional stabling and maintenance facilities (Ragam, Ashkelon B)

System Architecture Scope:

The SCADA Contractor shall provide:

1. Control Centers:

  - Lod Primary Control Center: 100-120 m² control room, 30-40 m² server room, complete infrastructure
  - Haifa Secondary Control Center: Mirror configuration with independent operation capability
  - Mobile Control Centers: 2 containerized units with <4 hour deployment time
  - Total capacity:
    - 14 operator positions per fixed center (6 operations + 2 maintenance + 2 LOTO + 4 training)
    - 5 operator positions per Mobile Control Center (4 Operations + 1 Maintenance + 1 LOTO)

2. Communication Network:

  - Fiber optic backbone: existing
  - Deployment of additional backbone: by others including ADSS with 96 fibers
  - Hybrid power and communication cables between LOPs and Field equipment

3. Field Equipment:

  - Migration Scope:
    - Local Operating Posts (LOPs): ~75 units
    - Traction Substations (TSSs): 14 units, including LOP + IEC 61850 gateways
    - Motorized Disconnectors: ~1000 units

  - Expansion Scope:
    - Additional LOPs: 100-150 units

- Additional TSSs (LOP+Gateway): 15-20 sub-stations
- Additional disconnectors: 1,000-1,500 units
- SCADA Contractor shall provide unit pricing for expansion equipment including all works required for integration of the equipment in the screens of the SCADA

4. Software Platform:

- SCADA software with "No Limit" data point capacity
- Active/standby redundant servers with <5 second failover
- HMI workstations supporting 15+ concurrent users
- Database systems with real-time replication (Lod ↔ Haifa)
- Historical data: 5 years online, 20+ years archive
- 8 external system interfaces (IEC 61850, IEC 60870-5-104, OPC UA, REST APIs, Modbus TCP, SNMPv3)

5. Specialized Systems:

- Training Simulator: Full-scope simulator with 6 training stations, 50+ scenarios
- LOTO System: Electronic permit management with iOS/Android mobile apps
- Network Management System (NMS): Complete network monitoring and management
- Cybersecurity Systems: Firewalls, IDS/IPS, SIEM, vulnerability management

1.5 Project Execution Approach

Dual-Track Implementation Strategy:

The SCADA Contractor shall execute the project using a dual-track approach:

- Track 1 - Migration: Systematic migration of existing sites from legacy to new SCADA system
- Track 2 - Expansion: Parallel development of expansion infrastructure supporting future network growth

Migration Requirements:

- Zero service disruption: No interruption to train operations during cutover
- Parallel operation: Legacy and new systems operation in parallel during validation (7 days minimum per site)
- Rollback capability: Full rollback capability maintained for every site cutover
- Phased approach: Ring-by-ring / Line-by-Line rollout
- Site migration rate: 10-15 LOPs + 2-3 TSSs per month during mass rollout phase

Expansion Development Requirements:

- Future-ready design: Architecture supporting seamless addition of new sites
- Unit pricing: Clear unit prices for additional LOPs, TSSs and disconnectors / Field equipment
- Plug-and-play: Standardized configurations enabling rapid deployment of expansion sites

- Capacity planning: Pre-provisioned capacity for first 200 expansion sites without infrastructure upgrade
- Documentation: Expansion procedures and templates for ISR self-deployment capability

Project Timeline:

Phase Duration Key Activities Deliverables

Phase 1: Preparation Months 1-6 Design, procurement, training simulator deployment Approved designs, simulator operational, initial training

Phase 2: Control Centers Months 7-12 Control center build-out, SCADA deployment Both control centers operational

Phase 3: Network Infrastructure Months 13-18 Fiber installation, network equipment deployment Complete network operational

Phase 4: Field Migration Months 19-36 Systematic site migration All existing sites migrated and operational

Phase 5: Integration & Closeout Months 37-48 Testing, optimization, expansion infrastructure Final acceptance, expansion capability demonstrated

1.6 Key Performance Requirements

The SCADA Contractor shall achieve the following performance targets:

System Performance:

- System availability: ≥99.99% (maximum 52 minutes downtime per year)
- Data update rates: Critical data 0.5-1 seconds, standard data 2-5 seconds
- Control command response: <2 seconds end-to-end (operator action to field device)
- Alarm propagation: <5 seconds from field event to operator notification
- Network latency: <50 ms end-to-end across entire network
- Concurrent users: 50+ simultaneous HMI users without performance degradation
- Server failover: <5 seconds with zero data loss

Capacity and Scalability:

- Current capacity: 50,000+ I/O data points (existing sites)
- Expansion capacity: "NO LIMIT" data points without system upgrade
- Field sites: 100 operational + 250 pre-provisioned capacity (350 total)
- User capacity: 25+ concurrent users, expandable to 50+
- Historical data: 5 years online storage, 20+ years archive

Safety and Compliance:

- Functional safety: IEC 61508 SIL-2 compliance for safety-critical functions
- Cybersecurity: IEC 62443 SL-2 minimum, ISO/IEC 27001 certification
- Railway standards: EN 50128, EN 50129 compliance
- Communication protocols: IEC 60870-5-104, IEC 61850 Ed 2.0, OPC UA certified

2. TECHNICAL REQUIREMENTS

2.1 Functional Requirements

2.1.1 Real-Time Data Acquisition

The SCADA system shall provide complete real-time visibility in all aspects of the railway electrification system.

Monitoring Scope:

- Geographic coverage: Complete monitoring of all electrified track sections
- Equipment coverage: All motorized disconnectors and load switches, circuit breakers at TSSs, earthing devices, protection devices, auxiliary equipment at TSSs (HVAC, sewage, LV), OCS voltage and current sensors, short-circuit current detectors, and additional equipment
- Measurement types: voltage, current, power (active/reactive), frequency, temperature, status indications (on/off/trip)
- Data quality: All data tagged with quality indicators (good/invalid/uncertain/test) and timestamp

Data Acquisition Requirements:

Parameter Type	Update Rate	Accuracy	Resolution	Timestamp Accuracy
Critical status (disconnector position, breaker status)	1-2 seconds	100%	Binary/	
Multi-state	<1 ms			
Critical measurements (OCS voltage, feeder current)	1-2 seconds	±0.5% (voltage), ±1% (current)	Volts/	
Amperes	<1 ms			
Standard measurements (power, energy)	2-5 seconds	±1.5%	kW/kWh	<10 ms
Non-critical data (temperatures, auxiliary status)	5-10 seconds	±2°C (temp)		<100 ms

Data Point Inventory:

Equipment Category	Quantity (Existing)	Points per Unit	Total Points	Expansion (Future)
LOP	~75	120-360	5,000-6,000	+150 units
TSS LOP+Gateways	14	2000	31,200	+40 units
Control Center Systems	2	NO LIMIT	NO LIMIT	-
Total (Existing)	~100 sites	-	~50,000	-
Expansion Capacity	+250 sites	-	NO LIMIT	

Historical Data Management:

The SCADA Contractor shall provide:

- Online storage: Minimum 5 years of historical data with full resolution
- Archive storage: Minimum 20 years with intelligent compression
- Query performance: <5 seconds for typical operational queries (24-hour trends, alarm history)
- Export capability: CSV, XML, database formats for external analysis

- Data retention policies: Configurable retention based on data type and criticality

2.1.2 Remote Control Operations

The SCADA system shall provide safe, reliable, and auditable remote control of all switching and protection equipment.

Control Scope:

- Motorized disconnectors: ~1,000 units (existing) + 1,000-1,500 (expansion)
- Earthing devices: 50 units (existing) + 500 (expansion)
- Circuit breakers: All TSS and feeder breakers (on/off)
- Protection devices: Enable/disable, setting groups where applicable
- Auxiliary equipment: Cooling systems, heating, lighting, locks

Control Safety Requirements:

The SCADA Contractor shall implement:

1. Select-Before-Operate (SBO) Protocol:
   - Two-step process: Select → Execute with timeout (15 seconds default, configurable)
   - Visual indication of selected equipment on all operator displays
   - Automatic deselection after timeout or cancellation
   - Command queuing prevention (only one command sequence active per operator)
2. Interlocking System:
   - Software interlocks: Configurable safety rules preventing unsafe operations
   - Hardware interlocks: Integration with physical interlocks at field equipment
   - Conditional interlocks: Context-dependent rules based on system state
   - Interlock override: Emergency override capability with dual authorization and full audit logging
   - Examples: Prevent energization with earthing applied, prevent disconnector operation under load, prevent conflicting operations
3. Authorization and Authentication:
   - Role-based access control (RBAC): Minimum 20 definable roles
   - Geographic authorization: Control authority limited by area assignment
   - Equipment-level authorization: Critical equipment requiring elevated privileges
   - Shift-based access: Automatic authority assignment based on shift login
   - Dual authorization: Critical operations requiring second operator confirmation
   - Multi-factor authentication (MFA): For administrative and critical control functions

Control Performance:

Requirement	Specification	Verification Method

Command response time	<2 seconds end-to-end (operator → field device)	Performance testing
Command success rate	≥99.95% under normal conditions	Statistical analysis over 30 days
Position feedback time	<3 seconds after operation completion	Timing measurements
Concurrent operations	Minimum 10 simultaneous control operations	Load testing
Emergency priority	Emergency commands processed within 500 ms	Priority testing

Audit and Logging:

The SCADA Contractor shall provide complete audit trail including:

- User identification: Operator name, ID, shift, location
- Command details: Equipment, command type, parameters, timestamps
- Authorization: Authorization level used, approvals obtained
- Results: Success/failure, equipment response, error codes
- System events: Interlock violations, authorization failures, communication errors
- Retention: Minimum 7 years online, permanent archive capability

2.1.3 Alarm Management System

The SCADA system shall provide intelligent alarm management reducing operator workload while ensuring critical events receive immediate attention.

Alarm Requirements:

The SCADA Contractor shall implement:

1. Alarm Priority Levels (4 minimum):
   - Critical (P1): Safety-critical alarms requiring immediate response (red, audible alarm)
   - High (P2): Equipment faults affecting service (orange, distinct sound)
   - Medium (P3): Equipment warnings and abnormal conditions (yellow, notification)
   - Low (P4): Informational events and status changes (blue/white, visual only)
2. Alarm Processing:
   - Propagation time: <5 seconds from field event to operator display (99% of alarms)
   - Alarm correlation: Automatic correlation of related alarms (e.g., circuit breaker trip correlates feeder alarms)
   - Alarm suppression: Configurable suppression during maintenance activities
   - Alarm filtering: User-configurable filtering by priority, location, equipment type
   - Alarm acknowledgment: Manual acknowledgment with operator ID and timestamp
   - Auto-acknowledgment: Configurable auto-ack for self-clearing informational alarms
3. Alarm Grouping and Escalation:
   - Alarm groups: Logical grouping by equipment, location, system
   - First-out annunciation: Identification of first alarm in cascade events
   - Escalation rules: Automatic escalation of unacknowledged critical alarms
   - Summary displays: Real-time alarm summary by priority and location

- Alarm statistics: Real-time and historical alarm statistics and analysis

4. Alarm Reduction Features:

- Deadband filtering: Configurable deadband for analog value alarms
- Hysteresis: Prevent alarm chattering on threshold crossings
- Time delays: Configurable delays before alarm generation (transient filtering)
- Rate-of-change alarms: Alarm on rate of change vs. absolute threshold
- Intelligent analysis: Machine learning identifying nuisance alarm patterns

Target Performance:

- Alarm accuracy: <1% false alarms (nuisance alarm rate)
- Alarm availability: 100% alarm availability (no missed critical alarms)
- Operator response improvement: 30% faster response to critical alarms vs. legacy
- Alarm reduction: 50% reduction in total alarm count through intelligent filtering

2.2 System Architecture

2.2.1 Control Center Architecture

The SCADA Contractor shall design and implement redundant control center architecture providing 99.99% system availability.

Server Infrastructure (per Control Center):

1. SCADA Servers:

- Configuration: Active/Standby with automatic failover
- Hardware: Dual Xeon 6/EPYC 9005 , 6TB+ DDR5, 100TB+ NVMe, 96+ PCIe 5.0 lanes, CXL 2.0
- Operating System: Windows Server 2025
- Virtualization: Support for VMware/Hyper-V virtualization
- Redundancy: N+1 configuration with hot-spare capability
- Failover: <5 seconds automatic failover with zero data loss
- Synchronization: Real-time configuration and data synchronization

2. Database Servers:

- Configuration: Primary/Replica with synchronous replication
- Database Platform: Oracle 26ai, SQL Server 2025
- Replication: Real-time replication between Lod and Haifa (<1 second lag)
- Performance: 10,000+ inserts/second, <5 second query response
- Storage: High-performance SSD storage, minimum 10TB raw capacity
- Backup: Hourly incremental, daily full backup with off-site replication
- Recovery: RPO <1 hour, RTO <4 hours

3. Application Servers:

- Web application servers: Minimum 2 per center for web-based applications
- Report servers: Dedicated servers for report generation

- Interface servers: Dedicated servers for external system interfaces
- Redundancy: N+1 for all critical application servers

Network Infrastructure:

The SCADA Contractor shall provide:

1. Core Internal Network (per Control Center):
   - Core routers: 2 units per center, 100 Gbps routing capacity
   - Core switches: 2 units per center, 1 Tbps switching capacity, stackable
   - Port configuration: 48×1GbE + 4×10GbE (minimum)
   - Redundancy: Full redundancy with sub-50ms failover
   - Protocols: OSPFv2/v3, BGP, MPLS-TE capability
2. Inter-Center Connectivity:
   - By others

Operator Workstations:

Specifications (per workstation):

- CPU: Intel Core Ultra 9 285K (24 cores/32 threads) or AMD Ryzen 9 9950X3D (16 cores/32 threads) or Threadripper PRO 9995WX (96 cores)
- RAM: 128–384 GB DDR5-6400 ECC (8x48GB modules minimum)
- Storage: 8 TB NVMe SSD (Gen5 PCIe 5.0 x4, RAID-0/1) + 20 TB HDD archival
- Graphics: NVIDIA RTX 5090 32GB GDDR7 or RTX 6000 Ada 48GB (multi-display 4K capable)
- Displays: 3 × 32″ 4K IPS (144Hz, 100% DCI-P3, 500 nits min)
- Network: Dual 10/25 GbE (Intel E810 or Mellanox ConnectX-7) + WiFi 7 + Bluetooth 5.4
- Motherboard: Workstation-grade X870E/Z890 chipset with IPMI/BMC remote management
- PSU: 1200–1600W 80+ Titanium (fully modular, ATX 3.1)
- Cooling: 360mm AIO liquid cooling + 6–8 case fans
- Operating System: Windows 11 Pro LTSC 2024 or Windows Server 2025 Standard
- Chassis: Rackmount 4U or tower with hot-swap bays, dust filters, sound dampening
- Peripherals: Industrial keyboard with backlight, optical mouse, noise-canceling headset
- Quantity: 8 per control center (6 operations + 2 maintenance) + 4 for training + 2 spares

Video Wall System:

The SCADA Contractor shall provide:

- Configuration: 3×3 display array (9 displays minimum), expandable to 4×4
- Display specifications: 55″ commercial LED, narrow bezel (<5mm), 1920×1080 minimum
- Brightness: 500 cd/m² minimum, 24/7 operation rated

- Video wall controller: Redundant controllers with automatic failover
- Input sources: 16+ video sources with flexible routing
- Content: Network overview, ring status, alarms, trends, external system status

2.2.2 Field Equipment Specifications

Remote Terminal Units (RTUs):

The SCADA Contractor shall provide RTU with following configuration for OCSs and TSSs:

- Application: LOPs with up-to 32 disconnectors or TSS breakers analog/digital data collection and control
- Digital Inputs: 24 channels, 220V DC, optically isolated, <3ms response
- Digital Outputs: 12 channels, relay outputs, 5A @ 250V AC resistive
- Analog Inputs: 8 channels, 4-20 mA / 0-220V DC selectable, 16-bit resolution
- CPU: ARM Cortex-A9 or equivalent, 1 GHz minimum, dual-core preferred
- Memory: 2 GB RAM, 8 GB flash storage
- Communication: Dual Ethernet ports (fiber SFP), IEC 60870-5-104
- Protocols: IEC 60870-5-104 client, Modbus TCP, SNMP agent
- Programming: IEC 61131-3 (ladder logic, structured text)
- Time synchronization: GPS receiver with active antenna, ±10 ms accuracy
- Power: 2x 230V AC input, internal 2x220V DC power supply, 2x16-hour battery backup
- Operating temperature: -40°C to +70°C
- Enclosure: IP65, wall-mount, with heater and fan
- Certifications: CE, IEC 61010, IEC 61131
- Digital Inputs: 48 channels
- Digital Outputs: 24 channels
- Analog Inputs: 16 channels
- Local HMI: 15″ industrial touchscreen for local operation
- Redundant communication: Dual communication processors
- Enhanced CPU: Multi-core processor for advanced control algorithms
- Cyber security

IEC 61850 Gateways (for TSSs):

The SCADA Contractor shall provide:

- Protocol translation: IEC 61850 (client) ↔ IEC 60870-5-104 (server)
- Data capacity: 800+ IEC 61850 data objects per gateway
- IEC 61850 services: MMS (reporting, control), GOOSE (publisher/subscriber)
- Time synchronization: IEEE 1588 PTP, ±1 ms accuracy
- Configuration: SCL file import (ICD, SCD formats)
- Redundancy: Dual processors with automatic failover

- Performance: <100 ms end-to-end latency, 1000+ points/second throughput
- Communication: Dual Ethernet ports (fiber SFP)
- Operating temperature: -40°C to +70°C
- Enclosure: IP65, DIN-rail or wall-mount

Motorized Disconnectors:
Electrical Specifications:

- Rated voltage: 52 kV AC (27.5 kV nominal system voltage)
- Rated current: 1,600 A continuous
- Short-circuit withstand: 25 kA RMS for 1 second
- Creepage distance: Per IEC 60815, pollution level III

Mechanical Specifications:

- Operating mechanism: Motor-driven (220V DC)
- Operation time: 3-5 seconds (opening and closing)
- Mechanical endurance: 10,000 operations minimum
- Electrical endurance: 1,000 operations at rated current
- Manual operation: Local manual override with tool
- Position indication: 3-position feedback (Open/Closed/Fault/Unknown)
- Auxiliary contacts: 4NO + 4NC for control and indication
- Mounting: Outdoor pole-mount or structure-mount

Control and Monitoring Integration:

- Control inputs: Open, Close, Emergency Off (220V DC from RTU)
- Status outputs: Position feedback via auxiliary contacts and resistive transmitter
- Motor protection: Thermal overload, current monitoring
- Interlocks: Hardware interlocks via auxiliary contacts
- Position transmitter: 0-1000 ohm resistive for analog position feedback

Communication unit:

- Control
- Status
- Protection

Environmental and Safety:

- Operating temperature: -40°C to +70°C
- Enclosure: IP65 minimum for all outdoor components
- Lightning protection: Per SI 62305, integrated with OCS protection

- Arc flash rating: NFPA 70E compliant
- Safety labels: Hebrew warning labels per ISR standards
- Standards: IEC 62271-102, IEC 60815, EN 50122

Industrial Ethernet Switches:

LOP Access Switches:

- Form factor: Compact DIN-rail mount
- Ports: 8-16 managed Ethernet ports, 10/100/1000 Mbps auto
- Fiber uplinks: 2 SFP slots for fiber connections to distribution layer
- Management: SNMP v3, CLI (SSH), web interface, NETCONF/YANG
- Features: VLANs (256+), QoS (802.1p), RSTP (802.1w), PTP transparent clock
- Power: Dual 24/48V DC inputs with reverse polarity protection
- Operating temperature: -40°C to +75°C
- MTBF: >200,000 hours
- Certifications: EN 50121-4 (EMC), IEC 61850-3
- Cyber security

TSS Access Switches:

- Similar to LOP switches with enhanced features:
- Ports: 16-24 managed ports
- PoE: IEEE 802.3at (PoE+) on selected ports for IP cameras, access points
- Layer 3: Full layer 3 routing capability
- Cyber security

2.3 Communication Network

2.3.1 Fiber Optic Infrastructure

The SCADA Contractor shall design and install a resilient fiber optic network providing high-capacity, low-latency connectivity.

Fiber Specifications:

Parameter	Specification
Fiber type	ITU-T G.652.D single-mode or G.657.A1 bend-insensitive
Core/cladding	9/125 µm
Operating wavelengths	1310 nm (O-band), 1550 nm (C-band DWDM), 1625 nm (L-band OTDR)
Attenuation	≤0.35 dB/km @ 1310 nm, ≤0.25 dB/km @ 1550 nm
Dispersion	≤3.5 ps/(nm·km) @ 1550 nm

Cable construction	Loose-tube gel-filled ADSS (outdoor), tight-buffer (indoor)
Fiber counts	Backbone 96f, Local 24f, Indoor 12-24f
Spare fiber ratio	100% (50% active strands, 50% spare strands)

Installation Methods:

Method	Percentage	Application	Requirements
Overhead (ADSS)	80%	Existing pole line	Self-supporting, UV-stabilized, 3000N tensile
Underground conduit	10%	Urban areas, road crossings	HDPE conduit, pull boxes every 150m
Direct burial	5%	Remote areas	Armored cable, 1.2m depth, warning tape
Tunnel/indoor	5%	Tunnels, buildings	Indoor-rated cable, support brackets

Splicing and Testing:

The SCADA Contractor shall ensure:

- Splice method: Fusion splicing only (no mechanical splices in permanent installation)
- Splice loss: <0.05 dB per splice
- Splice protection: Heat-shrink sleeves with mechanical reinforcement
- Splice enclosures: IP68-rated, 144-fiber capacity minimum, wall/pole mount
- Connector loss: <0.5 dB for field-installed connectors
- End-to-end loss: Meet or exceed ITU-T G.652.D recommendations
- Testing: 100% OTDR testing bidirectionally at 1310nm and 1550nm
- Documentation: Splice records, OTDR traces (PDF), test certificates for all fiber spans

2.3.2 Network Equipment and Performance

Network Performance Requirements:

Parameter	Requirement	Verification Method
End-to-end latency	<50 ms (99% of packets)	Continuous latency monitoring
Packet loss	<0.01%	Network performance monitoring
Per-node capacity	1 Gbps minimum	Throughput testing
Backbone capacity	10 Gbps minimum	Throughput testing
Ring protection	<50 ms failover (RSTP/ERPS)	Failover testing
Jitter	<10 ms for time-critical traffic	QoS validation
Availability	99.99% per network segment	Continuous uptime monitoring

Quality of Service (QoS):

The SCADA Contractor shall implement traffic prioritization:

- Priority queues: Minimum 8 priority levels (DSCP marking)

- Traffic classification:
  - P0 (Highest): Time-critical control commands, GOOSE messages
  - P1: Critical alarms and status updates
  - P2: Standard SCADA data, IEC 60870-5-104, IEC 61850 MMS
  - P3: Video surveillance streams
  - P4: Management traffic (SNMP, syslog)
  - P5: Historical data synchronization
  - P6: Report generation, file transfers
  - P7 (Lowest): Best-effort traffic
- Bandwidth allocation: Guaranteed bandwidth for P0-P2 traffic
- Congestion management: Weighted Random Early Detection (WRED)

Routing and Redundancy:

The SCADA Contractor shall configure:

- Routing protocol: OSPF (Open Shortest Path First)
- OSPF areas: Area 0 (backbone) + Area 1-4 (rings)
- Load balancing: ECMP (Equal-Cost Multi-Path) for redundant paths
- Fast reroute: <200ms convergence on link failure
- Diverse paths: Minimum 3 diverse paths between any two nodes
- Path calculation: Automatic path calculation based on latency and bandwidth

Network Management System (NMS):

The SCADA Contractor shall provide:

- Architecture: Primary/backup NMS servers with automatic failover
- Discovery: Automatic topology discovery using LLDP, CDP
- Monitoring protocols: SNMP v3, syslog, NETFLOW/sFlow, ICMP
- Polling intervals: 1-2 minutes critical devices, 5 minutes standard devices
- Performance monitoring: Bandwidth utilization, latency, packet loss, errors
- Fault management: Automatic fault detection, root-cause analysis, alarm correlation
- Configuration management: Centralized configuration, version control, rollback capability
- Visualization: Interactive network maps, traffic flows, real-time statistics
- Reporting: Standard and custom reports, scheduled generation, trend analysis
- Integration: SCADA integration for network status display on HMI

2.3.3 Cybersecurity Architecture

The SCADA Contractor shall implement defense-in-depth security architecture compliant with IEC 62443.

Network Segmentation:

The SCADA Contractor shall implement:

- Security zones: Separation of control network, corporate network, external interfaces
- DMZ: Demilitarized zone for external system interfaces
- VLANs: Logical segmentation by function and security level
  - VLAN 10.x: SCADA control (highest security)
  - VLAN 20.x: SCADA monitoring
  - VLAN 30.x: Historical data
  - VLAN 40.x: HMI/operator workstations
  - VLAN 50.x: Management
  - VLAN 60.x: External interfaces (DMZ)
  - VLAN 70.x: Time synchronization
  - VLAN 100.x: LOTO system
  - VLAN 200.x: Training simulator
- Inter-VLAN routing: Controlled routing with firewall inspection

Security Appliances:

The SCADA Contractor shall provide:

1. Firewalls:
   - Location: Network boundaries, control center perimeter, DMZ
   - Type: Next-generation firewalls (NGFW) with deep packet inspection
   - Throughput: Line-rate performance at 10 Gbps
   - Features: Stateful inspection, application control, IPS, VPN
   - Redundancy: Active/standby pairs at all critical locations
   - Management: Centralized firewall management console
2. Intrusion Detection/Prevention (IDS/IPS):
   - Deployment: Inline at network boundaries, span ports for monitoring
   - Detection methods: Signature-based, anomaly-based, behavioral analysis
   - Industrial protocols: IEC 60870-5-104, IEC 61850, Modbus TCP awareness
   - Response actions: Alert, block, quarantine based on threat level
   - Updates: Automatic signature updates with ISR approval process
3. VPN Systems:
   - Use case: Secure remote access for vendor support, mobile field access
   - Protocol: IPsec with AES-256 encryption
   - Authentication: Certificate-based authentication + MFA
   - Performance: 1 Gbps aggregate VPN throughput
   - Concurrent sessions: 100+ simultaneous VPN users

Access Control:

The SCADA Contractor shall implement:

- 802.1X port authentication: For all network access (wired and wireless)
- RADIUS/TACACS+: Centralized authentication and authorization
- Role-based access: Network access based on user roles
- MAC address filtering: Whitelist of authorized devices
- Rogue device detection: Automatic detection and blocking of unauthorized devices

Security Monitoring:

The SCADA Contractor shall provide:

- SIEM (Security Information and Event Management): Centralized log collection and analysis
- Log sources: Firewalls, switches, routers, servers, SCADA applications
- Correlation rules: Real-time event correlation for threat detection
- Dashboards: Security dashboards with KPIs and threat visualization
- Alerting: Automated alerts for security events
- Compliance reporting: Automated compliance reports for ISO 27001, IEC 62443
- Retention: 1 year online, 7 years archive

Compliance:

The system shall comply with:

- IEC 62443-3-3: Network security requirements for IACS
- IEC 62443-4-2: Component security requirements
- ISO/IEC 27001: Information security management
- NIST Cybersecurity Framework: Framework implementation

3. SOFTWARE PLATFORM

3.1 SCADA Software Requirements

The SCADA Contractor shall provide a proven, industrial-grade SCADA platform with minimum 15 years market presence and 10+ similar (Railway applications) installations worldwide.

Platform Selection Criteria:

- Proven platform: 15+ years in railway sector
- Market presence: 10+ installations in similar applications
- Local support: Vendor with Israeli presence or authorized local partner
- Scalability: NO LIMIT data points with linear performance
- Standards compliance: IEC 60870-5-104, IEC 61850, OPC UA native support
- Redundancy: True hot-standby with <5 second failover
- Security: Built-in security features, IEC 62443-4-2 compliance

Core SCADA Functionality:

The SCADA Contractor shall configure:

1. Data Acquisition:

- Protocol drivers: IEC 60870-5-104, IEC 61850 (MMS/GOOSE), Modbus TCP, OPC UA, SNMP
- Connection management: Redundant connections, automatic reconnection, connection pooling
- Data quality: Quality flags (good/invalid/uncertain), timestamp validation
- Dead-banding: Configurable deadband filtering for analog values
- Data validation: Range checking, rate-of-change validation, reasonability checks

2. Control Operations:

- Select-Before-Operate: Two-step control with visual confirmation
- Interlocking engine: Configurable software interlocking rules
- Command queuing: Sequential command execution with status feedback
- Timeout handling: Configurable command timeouts with automatic cancellation
- Synchro-check: Voltage and phase verification before closing (where applicable)

3. Alarm Processing:

- Alarm types: Digital, analog (hi/lo/hihi/lolo), rate-of-change, deviation
- Alarm priority: 4+ priority levels with color coding and audio differentiation
- Alarm correlation: Parent-child relationships, consequential alarm suppression
- Alarm shelving: Temporary alarm suppression with automatic reinstatement
- Alarm filtering: User-configurable filters by priority, area, equipment type
- Alarm acknowledgment: Manual ack, group ack, auto-ack configurable
- Alarm annunciation: Audio alerts, popup windows, email/SMS notification

4. Trending and Historical Data:

- Real-time trends: Configurable multi-pen trends with zoom, pan, cursors
- Historical trends: Query historical data with time range selection
- Statistical functions: Min, max, average, standard deviation, totalization
- Data compression: Swinging door algorithm or equivalent for storage optimization
- Export: Trend data export to CSV, Excel for external analysis

5. Reporting:

- Report types:
  - Daily operations report (24-hour summary)
  - Alarm summary report (by priority, location, equipment)
  - Event log report (operator actions, system events)
  - Availability report (system and equipment availability calculations)
  - Performance report (KPIs, SLA compliance)
  - Energy report (consumption by section, substation)
  - Maintenance report (equipment run-hours, maintenance due)
- Report builder: User-configurable report designer with drag-drop interface

- Scheduling: Automatic report generation (hourly, daily, weekly, monthly)
- Distribution: Email distribution lists, FTP upload, print to network printers
- Formats: PDF, Excel, HTML, CSV

Redundancy Architecture:
The SCADA Contractor shall implement:

- Server redundancy: Active/Standby servers with automatic failover
- Data synchronization: Real-time sync of configuration, historical data, alarm state
- Failover trigger: Heartbeat monitoring (1-second intervals), automatic failover on failure
- Failover time: <5 seconds from failure detection to standby fully operational
- Failback: Automatic or manual failback to primary after recovery
- Client connectivity: Clients automatically reconnect to standby without user action
- Data integrity: Zero data loss during failover (transaction journaling)
- Dual-site redundancy: Full redundancy between Lod and Haifa control centers

Performance Requirements:

Metric	Requirement	Verification
Data point capacity	50,000+ with specified update rates	Load testing at FAT
Data throughput	10,000+ points/second sustained	Performance testing
HMI clients	25+ concurrent without degradation	Load testing
Display load time	<2 seconds for complex displays	Performance testing
Database writes	10,000+ inserts/second	Database performance testing
Query performance	<5 seconds typical operational queries	Query performance testing
Failover time	<5 seconds hot failover	Failover testing
Network latency tolerance	Operate normally with 100ms RTT	WAN simulation testing

3.2 Human-Machine Interface (HMI)

The SCADA Contractor shall develop comprehensive HMI displays enabling intuitive system operation and monitoring.

Display Hierarchy:

The SCADA Contractor shall create:

1. Level 1 - Overview Displays:
   - Network Geographic Overview: Single-line diagram of entire electrified network
   - Regional Overview: Single-line diagram of ~30-40km route of the electrified network
   - Ring Overview: Detailed view of each communication ring
   - Control Center Status: Status of all control center systems
   - Active Alarms Summary: Real-time alarm list with filtering and sorting
2. Level 2 - Area Displays:

- Substation Overviews: One display per TSS
- LOP Area Displays: Regional views grouping 10-15 LOPs
- Communication Network Status: Network topology with real-time status
- External System Interfaces: Status of all 8 external interfaces

3. Level 3 - Equipment Displays:

- LOP Detail Displays: Detailed single-line diagram per LOP
- Equipment Control Faceplate: Pop-up control faceplate for disconnectors, breakers
- Equipment Trends: Real-time and historical trends for equipment parameters
- Equipment Maintenance: Equipment information, maintenance history, run-hours

4. Level 4 - System Displays:

- Alarm Management: Advanced alarm filtering, grouping, acknowledgment
- Event Log: Comprehensive event log with filtering and search
- System Diagnostics: System health monitoring, performance metrics
- Reporting Interface: Report selection, generation, viewing

Display Design Requirements:

The SCADA Contractor shall adhere to:

- Standards: ISA-101 (HMI design), ISO 11064 (control room design)
- Color coding: Consistent color scheme (e.g., green=closed/energized, red=open/de-energized, gray=unknown, yellow=alarm, blue=selected)
- Symbol library: 1,000+ pre-built symbols for railway SCADA (disconnectors, breakers, transformers, trains, stations)
- Vector graphics: Resolution-independent graphics supporting 1080p to 4K displays
- Animation: Real-time animation based on data points (disconnector movement, current flow indication)
- Customization: User-configurable colors, alarm sounds, display layouts (saved per operator)
- Responsive design: Displays scale appropriately for different screen resolutions
- Accessibility: Support for visually impaired operators (high contrast, large fonts)

Navigation and Usability:

The SCADA Contractor shall implement:

- Context menus: Right-click menus for rapid navigation to related displays
- Breadcrumb navigation: Display path showing current location in hierarchy
- Favorites: User-definable favorite displays for one-click access
- Search function: Global search for equipment by name, ID, location
- Alarm-driven navigation: Click alarm to navigate to equipment display
- Keyboard shortcuts: Configurable keyboard shortcuts for common actions
- Touch screen support: Touch-friendly interface for touchscreen displays

3.3 Database System

The SCADA Contractor shall provide enterprise-grade database systems for real-time and historical data management.

Database Architecture:

The SCADA Contractor shall implement:

- Real-time database: High-performance in-memory database for current values
- Historical database: Relational database (same as original database)
- Replication: Synchronous replication between Lod and Haifa (<1 second lag)
- Backup strategy:
  - Real-time database: Continuous backup to historical database
  - Historical database: Hourly incremental backup, daily full backup
  - Off-site backup: Daily replication to off-site storage
- Recovery objectives: RPO <1 hour, RTO <4 hours

Data Retention:

The SCADA Contractor shall configure:

- Full-resolution data: 5 years online storage
- Compressed data: 20+ years archive storage
- Alarm/event logs: 5 years online, permanent archive
- Audit logs: 5 years online, permanent archive
- Configuration changes: Complete configuration history, permanent archive

Database Performance:

The SCADA Contractor shall achieve:

- Insert rate: 10,000+ data points per second sustained
- Query response: <5 seconds for typical operational queries
- Concurrent connections: 100+ simultaneous connections
- Storage efficiency: >10:1 compression ratio for historical data
- Index optimization: Automatic index optimization for query performance

3.4 External System Interfaces

The SCADA Contractor shall design, implement, and test 8 external system interfaces enabling enterprise integration.

Interface Requirements:

Interface	Protocol	Direction	Data Volume	Update Rate	Criticality
1. TSS SCADA	IEC 61850 IEC 60870-5-104	Bi-directional	~64,000 points	1-2 sec	Critical

2. LOP Equipment IEC 60870-5-104 Bi-directional ~30,000 points 1-5 sec Critical

3. ETCS/Signaling OPC UA Bi-directional Neutral section status, Power system status 1-2 sec High

4. SAP ERP REST API Bi-directional Availability data Hourly/daily Medium

5. Fire Safety Modbus TCP Bi-directional Fire alarms, auto shutdown <1 sec Critical

6. CMMS (Maintenance) OPC UA Bi-directional Equipment status, work orders 5 min Medium

7. Stabling Areas/Depots OPC UA Bi-directional Electrification system status 5 min Low

8. Network Management SNMPv3 Monitoring Network device status 1-5 minMedium

Interface Design:

For each interface, the SCADA Contractor shall provide:

- Interface Control Document (ICD): Detailed specification of interface including protocol, data points, message formats, error handling, security
- Interface server: Dedicated server/service for interface processing
- Data mapping: Bidirectional mapping between SCADA and external system data models
- Error handling: Comprehensive error detection, logging, and recovery procedures
- Status monitoring: Real-time interface status monitoring with alarms on failures
- Buffering: Data buffering during communication outages with automatic catch-up
- Security: Encrypted communication (TLS 1.3), authentication, authorization

3.4.1 Traction Substation (TSS) Interface

Interface Overview

Primary Communication Protocol:

- IEC 61850 Standard: International standard for power utility automation
- MMS (Manufacturing Message Specification): Client/server data exchange
- GOOSE (Generic Object-Oriented Substation Event): Fast peer-to-peer messaging for critical data
- SCL (Substation Configuration Language): Standardized configuration management

Interface Scope:

- Total TSS Quantity: 14 Traction Substations
- 14 existing TSSs requiring interface upgrade/integration)via LOP/RTU + IEC 61850)
- ~25 new TSSs with native IEC 61850 capability
- Data Points per TSS: Approximately 1000 points per substation
- 100-200 digital status points (breakers, switches, alarms)
- 200-250 analog measurement points (voltage, current, power, temperature)
- 100-150 control points (remote commands, setpoints)
- Total Interface Data Points: ~39,000 points (39 TSSs × 1000 points)

Communication Infrastructure:

- Physical Medium: Fiber optic Ethernet
- Communication Redundancy: Dual communication processors per TSS
- Time Synchronization: IEEE 1588 (PTP) or NTP for millisecond accuracy

Detailed Data Exchange Specifications

From TSS to SCADA (Monitoring Data):

Primary Electrical Equipment:

- Power Transformers (per transformer):
- Primary voltage (kV): Real-time measurement with 0.1% accuracy
- Secondary voltage (kV): Real-time measurement with 0.1% accuracy
- Primary current (A): Per-phase measurements
- Secondary current (A): Per-phase measurements
- Active power (MW): Total and per-phase
- Reactive power (MVAR): Total and per-phase
- Power factor: Leading/lagging indication
- Transformer tap position: Auto-tap changer position
- Oil temperature (°C): Top oil and winding temperatures
- Gas-in-oil levels: Dissolved gas analysis results
- Cooling system status: Fan and pump operation status
- Protection relay status: Differential, overcurrent, temperature protection

Switchgear and Protection Equipment:

- Circuit Breakers (per CB):
- Position status: Open/Closed/Invalid/Transient
- Trip coil continuity: Supervision of trip circuit integrity
- Close coil continuity: Supervision of close circuit integrity
- SF6 gas pressure (bar): For SF6 breakers
- Operation counter: Cumulative number of operations
- Spring charge status: Energy storage system status
- Protection trip cause: Detailed trip cause identification
- Disconnectors and Isolators:
- Position indication: Open/Closed/Intermediate
- Motor drive status: Normal/Fault/In-operation
- Position switches: Auxiliary contact status verification
- Motor current (A): Drive motor load current
- Operation counter: Cumulative operations for maintenance scheduling

Protection and Control Systems:

- Protection Relays (per relay):
- Trip outputs: Individual trip functions (50, 51, 87, 27, 59, etc.)
- Alarm outputs: Non-trip alarms and warnings
- Measurement values: Current, voltage, power, frequency

- Relay health status: Self-diagnostic results
- Settings status: Active setting group identification
- Event records: Time-stamped protection events

Auxiliary Systems:

- HVAC and Environmental:
- Building temperature (°C): Multiple zones
- Humidity (%RH): Relative humidity monitoring
- HVAC system status: Heating, cooling, ventilation status
- Fire detection status: Smoke and heat detectors
- Security status: Door position, intrusion detection
- Lighting control: Indoor and outdoor lighting status
- Power Supply Systems:
- Station auxiliary power status: 400V/230VAC/220 VDC supply status
- UPS system status: Battery backup system health
- DC system voltage (V): Control power supply voltage
- Battery condition: State of charge, temperature, float voltage

From SCADA to TSS (Control Commands):

Remote Control Operations:

- Circuit Breaker Control:
- Open command: With Select-Before-Operate (SBO) protocol
- Close command: With interlocking verification
- Trip command: Emergency trip capability
- Reset command: Protection system reset
- Local/Remote mode: Control authority transfer
- Disconnector Control:
- Open/Close commands: Motor-driven operation
- Emergency stop: Immediate operation halt
- Local/Remote transfer: Control mode selection

Setpoint Adjustments:

- Voltage Regulation:
- Transformer tap changer control: Raise/lower commands
- Voltage setpoint adjustment: Reference voltage setting
- Automatic voltage regulation enable/disable
- Protection Settings:
- Trip level adjustments: Overcurrent, overvoltage settings
- Time delay settings: Protection coordination adjustments
- Enable/disable protection functions: Individual trip function control

IEC 61850 Implementation Architecture

Logical Device Structure: Each TSS represented as multiple Logical Devices (LDs) based on functional groupings:

- LD_Transformer Bay: Primary transformer bay equipment
- Logical Nodes: XCBR (CB), XSWI (Disconnectors), MMXU (Measurements)
- LD_AuxiliarySystem: Station auxiliary systems
- Logical Nodes: LPHD (Physical Device), GAPC (Process Control)

Standard Logical Nodes Implementation:

- XCBR (Circuit Breaker): Complete breaker model with position, control, protection
- XSWI (Switch): Disconnectors and isolators with position feedback
- MMXU (Measurements): All electrical measurements with quality indication
- MMTR (Metering): Energy measurements and demand calculations
- PTRC (Protection Trip Conditioning): Protection relay integration
- GAPC (General Automatic Process Control): Temperature, pressure monitoring

Data Sets and Reporting:

- Fast DataSet: Critical measurements updated every 1 second
- Normal DataSet: Regular measurements updated every 5 seconds
- Event DataSet: Spontaneous reporting for status changes and alarms
- Integrity Report: Complete data refresh every 60 seconds

SCL Configuration Management:

- ICD Files: Import device capability descriptions from TSS vendors
- SCD Files: Complete substation configuration including all IEDs
- Configuration Tool: Automated configuration generation from SCL files
- Version Control: SCL file versioning and change management

3.4.2 Local Operating Post (LOP) Interface

Interface Overview

Communication Protocol:

- IEC 60870-5-104: TCP/IP-based telecontrol protocol
- Application Layer: IEC 60870-5-101 application over TCP/IP transport
- Master-Slave Configuration: SCADA as controlling station (master), RTUs as controlled stations (slaves)
- Connection-Oriented: Reliable TCP connections with automatic reconnection

Interface Scale:

- Total LOP Quantity: ~250 Local Operating Posts
- ~75 existing LOPs requiring RTU upgrade/replacement
- ~150 new LOPs with modern RTU technology
- Data Points per LOP: Variable based on LOP complexity
- Average Data Points: 128 points per LOP
- Total Interface Points: ~19,200 points (150 LOPs × 128 points average)

Communication Performance:

- Update Rates: 1-10 seconds for routine data, spontaneous for events
- Command Latency: <2 seconds end-to-end from SCADA to RTU

- Connection Recovery: Automatic reconnection within 30 seconds after communication loss
- Data Buffering: 24-hour local data buffering during communication outages

Comprehensive LOP Data Exchange
From LOP RTU to SCADA (Monitoring):
Primary OCS Equipment Status:
- Motorized Disconnectors (per disconnector):
- Position indication: Open/Closed/Invalid/Intermediate/Moving
- Motor status: Normal/Fault/Running/Stalled
- Control mode: Local/Remote/Fault
- Motor current (A): Operating current during movement
- Position switches: Auxiliary contact verification
- Operation counter: Total operations for maintenance planning
- Manual override status: Manual operation detection
-

Monitoring and Protection Equipment:
- Voltage Detectors:
- Voltage present/absent indication per monitored conductor
- Voltage level indication (if quantitative measurement available)
- Detector health status: Self-diagnostic results
- Current Measurements:
- Feeder current (A): RMS current measurement
- Direction indication: Power flow direction (if directional)
- Overload indication: Current exceeding rated values

RTU and Communication Systems:
- RTU Health Monitoring:
- Power supply status: AC mains and DC backup
- Battery voltage (V): Backup battery condition
- Internal temperature (°C): RTU cabinet temperature
- CPU status: Processor health and loading
- Memory status: Available memory and storage
- Communication Status:
- Primary link status: Main communication path health
- Secondary link status: Backup communication path (if equipped)
- Signal strength (if wireless): RF signal quality
- Data transmission errors: Communication quality metrics
- Protocol errors: IEC 104 application layer errors

Environmental and Security Monitoring:
- Physical Security:
- Cabinet door position: Open/closed status
- Intrusion detection: Motion or vibration sensors

- Tamper indication: Unauthorized access detection
- Environmental Conditions:
- Ambient temperature (°C): External temperature monitoring
- Humidity (%RH): Environmental moisture monitoring
- Water ingress detection: Cabinet flood detection

From SCADA to LOP RTU (Control and Configuration):

Equipment Control Commands:

- Disconnector Control:
- Open/Close commands: Standard SBO protocol implementation
- Emergency stop command: Immediate halt of motorized operation
- Reset fault command: Clear fault conditions and restore normal operation
- Control Mode Changes:
- Local/Remote transfer: Transfer control authority
- Maintenance mode: Special mode for maintenance activities
- Test mode: Controlled testing without affecting operations

System Configuration and Maintenance:

- RTU Configuration:
- Parameter updates: Communication settings, scan rates
- Alarm threshold settings: Configure local alarm limits
- Reporting configuration: Configure spontaneous reporting triggers
- Time Synchronization:
- Time synchronization command: Synchronize RTU clock with SCADA
- Time zone setting: Configure local time zone parameters
- Daylight saving time: Automatic DST handling configuration

IEC 60870-5-104 Protocol Configuration

Connection Parameters (per RTU):

- Network Configuration:
- RTU IP Address: Static IP address assignment
- TCP Port: Standard port 2404 or configured alternative
- ASDU (Application Service Data Unit) Address: Unique identifier (1-65534)
- Multiple IP addresses supported for redundant communication paths

3.4.3 ETCS/Signaling System Interface

Interface Overview and Architecture

Interface Purpose: The ETCS (European Train Control System) / Signaling interface provides critical coordination between the electrification SCADA system and the railway signaling control systems to ensure safe train operations while maintaining efficient power supply management.

Communication Protocol Selection:

- Primary Protocol: OPC UA (Unified Architecture) for modern integration

- Alternative Protocol: IEC 60870-5-104 if OPC UA not supported by signaling vendor
- Protocol Selection Criteria: Based on signaling vendor capabilities and ISR standards
- Future Upgrade Path: Migration to OPC UA when signaling systems upgraded

Network Architecture:

- Dedicated VLAN: Separate network segment for signaling traffic (VLAN 60)
- Network Path: Via SCADA communication backbone with quality of service (QoS)
- Redundant Communication: Dual communication paths to each signaling control center
- Security: Network segregation with firewall rules and access control

Interface Requirements:

- Latency: <2 seconds for critical safety notifications
- Availability: 99.99% minimum (safety-critical interface)
- Data Freshness: Updates within 1 second for energization status
- Redundancy: Active-standby interface servers with automatic failover

Comprehensive Data Exchange Specifications

From SCADA to Signaling System:

OCS Energization Status:

- Track Section Status (per section):
- Energization state: Energized/De-energized/Unknown/Fault
- Voltage level: Nominal voltage present (1x25kV, 2x25kV)
- Power source: Feeding TSS identification
- Isolation status: Normal/Isolated for maintenance/Emergency isolation
- Last status change: Timestamp of last energization change
- Geographic Coverage:
- Track sections defined by signaling system boundaries
- Correlation with signaling block sections
- Section length and geographical coordinates
- Adjacent section relationships
- Neutral section status in order to enable automatic on-board CB opening/closure

Maintenance and Outage Notifications:

- Planned Maintenance Windows:
- Advance notification: 24-48 hours before planned outage
- Affected track sections: Detailed list of de-energized sections
- Estimated duration: Start time, estimated completion
- Work description: Type of maintenance activity
- Contact information: SCADA operator contact for coordination
- Unplanned Outages:
- Immediate notification: Within 30 seconds of unplanned de-energization
- Cause indication: Fault/Protection trip/Emergency action
- Estimated restoration time: Best estimate based on fault type
- Alternative routing: Suggested train routing if available

Neutral Section Management:

- Neutral Zone Status (per neutral section):
- Energization status: Dead/Live-from-A/Live-from-B/Fault
- Control mode: Manual/Automatic/Maintenance
- Train coordination status: Train-approaching/Train-in-section/Section-clear
- Safety interlocks: All safety conditions satisfied/blocked

Emergency and Safety Events:

- Emergency Shutdown Events:
- Emergency de-energization: Immediate notification with affected sections
- Cause: Fire alarm/Security threat/Equipment failure/Manual emergency
- Restoration restrictions: Conditions required before re-energization
- Emergency contact: 24/7 emergency response contact information

From Signaling System to SCADA:

Train Position and Movement Data:

- Train Location Information (if available):
- Train identification: Unique train ID or service number
- Current position: Track section or kilometer marker
- Direction of travel: Up/Down track direction
- Speed: Current speed (km/h) if available from ETCS
- Destination: Final destination station
- Track Occupancy:
- Block section occupancy: Occupied/Clear/Fault status per block
- Multiple train detection: Number of trains in section (if supported)
- Occupancy duration: Time since section became occupied

Operational Coordination:

- Planned Train Schedules (if available):
- Service schedule: Regular passenger service timing
- Freight schedule: Freight train movements
- Special services: Test trains, maintenance trains
- Load prediction: Expected power demand per time period

Safety and Emergency Requests:

- Emergency Stop Requests:
- Section-specific emergency stop: Request immediate de-energization
- System-wide emergency: Network-wide power cutoff request
- Reason code: Fire/Derailment/Security/Infrastructure failure
- Acknowledgment required: SCADA must confirm emergency action
- Work Zone Protection:
- Protection request: Request de-energization for track work
- Work zone definition: Exact track sections requiring protection

- Work duration: Estimated time for track work completion
- Coordination contact: Work supervisor contact information

Integration Scenarios and Use Cases

Automatic Neutral Section Coordination:

Scenario 1: Train Approaching Neutral Zone

1. Signaling Detection: Signaling system detects train approaching neutral zone
2. Advance Notification: Signaling sends train approach notification to SCADA (2 km before neutral zone)
3. SCADA Preparation: SCADA verifies neutral zone is open/close
4. Final Approach: Signaling confirms train within 1000m of neutral zone entry
5. Train Transit: Signaling monitors train passage through neutral zone
6. Re-energization: After train clears + safety margin, signaling authorizes re-energization

Emergency Power Cutoff Coordination:

Scenario 2: Fire Alarm Emergency

1. Fire Detection: Fire alarm system triggers at station or tunnel
2. SCADA Response: SCADA automatically de-energizes affected track sections
3. Signaling Notification: SCADA immediately notifies signaling of emergency de-energization
4. Train Protection: Signaling stops all trains before entering de-energized sections
5. Emergency Services: Fire brigade coordinates with both SCADA and signaling
6. Restoration Authorization: Joint authorization required from fire services, SCADA, and signaling

Maintenance Coordination:

Scenario 3: Planned Maintenance Outage

1. Planning Phase: SCADA maintenance team coordinates outage with signaling (72 hours advance)
2. Schedule Confirmation: Signaling confirms no conflicts with train operations
3. Pre-Outage: SCADA sends final confirmation 2 hours before outage
4. Outage Execution: SCADA de-energizes sections per planned schedule
5. Work Period: Maintenance proceeds with signaling aware of exact outage scope
6. Restoration: SCADA restores power only after signaling confirms track clear

3.4.4 SAP Enterprise Integration

Interface Architecture and Technology

SAP Integration Strategy: The SAP interface provides bidirectional integration between the SCADA system and the Israel Railways enterprise resource planning (ERP) system for comprehensive asset management, maintenance planning, and operational reporting.

Integration Technology Stack:

- Primary Integration Method: SAP Process Integration (SAP PI/PO) middleware platform
- Alternative Method: Direct web services (SOAP/REST) with SAP Enterprise Services
- Data Format: XML message exchange using SAP standard formats (IDOCs, RFC)

- Message Pattern: Asynchronous messaging with guaranteed delivery
- Error Handling: Dead letter queues and retry mechanisms with exponential backoff

Network and Security:

- Network Connection: HTTPS over dedicated enterprise network connection
- DMZ Deployment: Interface server deployed in secure DMZ zone
- Authentication: X.509 certificate-based mutual authentication
- Authorization: SAP user account with restricted permissions for SCADA interface
- Encryption: TLS 1.3 end-to-end encryption with perfect forward secrecy

Data Volume and Performance:

- Peak Transaction Rate: 100 messages per minute during high activity periods
- Average Daily Transactions: 2,000-5,000 transactions per day
- Batch Processing Windows: Overnight batch processing for large data sets
- Response Time: <5 seconds for real-time transactions, <30 seconds for batch

Detailed Data Exchange Specifications

From SCADA to SAP (Operational Data to ERP):

Equipment Alarms and Failures:

- Automatic Work Order Creation:
- Alarm details: Equipment ID, alarm description, severity level, timestamp
- Location information: Geographic coordinates, station name, access instructions
- Equipment context: Manufacturer, model, serial number, installation date
- Failure impact: Service impact assessment, affected train services
- Priority assignment: Critical/High/Medium/Low based on operational impact
- Suggested actions: Pre-configured maintenance actions based on alarm type

Equipment Operational Data for Maintenance Planning:

- Operating Hours and Cycle Counts:
- Circuit breaker operations: Total operations, fault interruptions, load switching
- Disconnector operations: Total mechanical operations for wear assessment
- Transformer loading: Load hours above 80%, 90%, 100% of rating
- Motor runtime: Disconnector motor operating hours
- Protection operations: Relay trip statistics and reset counts
- Performance Metrics:
- Equipment availability: Percentage uptime per equipment item
- Failure rates: Mean Time Between Failures (MTBF) calculations
- Maintenance effectiveness: Mean Time To Repair (MTTR) tracking
- Energy efficiency: Losses and efficiency trends over time

Energy and Billing Data:

- Energy Consumption Reporting:
- Substation energy totals: Daily, weekly, monthly kWh consumption
- Feeder energy breakdown: Energy consumption per OCS feeder
- Depot energy usage: Individual depot consumption for cost allocation

- Peak demand data: Maximum demand (kW) with time-of-occurrence
- Power quality data: Power factor, harmonic distortion levels
- Cost Allocation Data:
- Service-based allocation: Passenger vs. freight service energy usage
- Geographic allocation: Energy consumption by railway corridor
- Time-based allocation: Peak vs. off-peak consumption patterns

Work Order Management:
- Scheduled Maintenance Work Orders:
- Work order details: Description, planned date, estimated duration
- Required resources: Personnel, tools, materials, outage requirements
- Safety requirements: LOTO requirements, safety procedures
- Coordination requirements: Outage scheduling, traffic coordination
- Work Order Status Updates:
- Work progress: Started, In-Progress, Completed, On-Hold
- Material consumption: Actual parts used, additional parts required
- Labor hours: Actual time spent vs. estimated time
- Work completion data: As-built information, test results, photos

3.4.5 Maintenance Management System (CMMS) Interface

Interface Overview and Architecture

CMMS Integration Scope: The Maintenance Management System interface provides comprehensive integration between the SCADA system and the computerized maintenance management system to support predictive maintenance, work order management, and field operations.

Interface Technology Options:
- RESTful API Integration: Modern HTTP-based API for real-time data exchange
- Database Synchronization: Direct database-to-database replication for bulk data
- Message Queue Integration: Asynchronous messaging for reliable data transfer
- Hybrid Approach: Combination of real-time API and batch synchronization

Communication Architecture:
- Network Connection: Secure HTTPS connection via enterprise network
- Authentication: API key authentication with role-based access control
- Data Format: JSON for API calls, CSV/XML for batch transfers
- Update Frequency: Real-time for alarms, hourly for status updates, daily for reports

Comprehensive Data Exchange

From SCADA to CMMS (Equipment Status and Alerts):

Real-Time Equipment Monitoring:
- Equipment Health Indicators:
- Transformer winding temperatures, ambient conditions

- Motor and mechanical equipment condition monitoring
- Electrical parameters: Insulation resistance, partial discharge detection
- Performance trends: Efficiency degradation, load handling capability
- Predictive Maintenance Alerts:
- Algorithm-based predictions: Equipment failure probability based on operational data
- Threshold exceedances: Parameters approaching critical limits
- Wear pattern analysis: Equipment degradation trends requiring attention
- Seasonal adjustments: Maintenance recommendations based on weather patterns

- Real time data with regards to malfunctions, faults, deenergized sections, Distance protection measurements

Operational Data for Maintenance Planning:

- Equipment Runtime Statistics:
- Operating hours: Total runtime since last maintenance
- Load cycles: Number of load/no-load cycles for electrical equipment
- Switching operations: Mechanical operation counts for breakers and disconnectors
- Environmental exposure: Operating time under extreme conditions

From CMMS to SCADA (Maintenance Information):

Maintenance Schedule Coordination:

- Scheduled Work Orders:
- Maintenance calendar: Upcoming preventive maintenance activities
- Outage requirements: Equipment that must be de-energized for maintenance
- Resource allocation: Personnel and equipment assigned to work orders
- Estimated duration: Time required for maintenance activities

Work Order Status Updates:

- Work Progress Information:
- Work initiation: Maintenance crew arrival and work start notification
- Progress updates: Intermediate status updates during extended maintenance
- Completion notification: Work finished, equipment ready for service
- Delay notifications: Work delays with revised completion estimates

Mobile Field Maintenance Portal

Web-Based Maintenance Portal:

Portal Architecture:

- Responsive Web Design: Accessible from desktop, tablet, and smartphone browsers
- Progressive Web App (PWA): Offline capability with automatic synchronization
- Role-Based Access: Different views for technicians, supervisors, and managers
- Integration: Single sign-on (SSO) integration with enterprise authentication

Real-Time Equipment Status Display:

- Equipment Dashboard:
- Current status: In-service, out-of-service, maintenance mode, fault
- Key measurements: Voltage, current, CB and Disconnectors status
- Alarm status: Active alarms, recent trips, distances to the failure from the pprotection relays reading, maintenance alerts
- Historical data: Short-term trends accessible without SCADA login
- Geographic Equipment View:
- Interactive map: Equipment location with status color coding
- Proximity alerts: Nearby equipment requiring attention
- Weather integration: Local weather conditions affecting field work

Mobile Application Features:

Native Mobile Apps (iOS/Android):

- Core Functionality:
- Equipment search and identification via barcode/QR code scanning
- Work order management: View, update, complete work orders
- Photo documentation: Capture and attach photos to work orders
- Time tracking: Log labor hours directly from mobile device
- GPS location services: Automatic location tagging for field activities
- Offline Capabilities:
- Data synchronization: Automatic sync when connectivity available
- Cached data: Essential equipment data available offline
- Offline mode indicators: Clear indication of connectivity status
- Queue management: Queue actions for upload when online

Field Personnel Safety Features:

- LOTO Integration:
- Active permits: Display active LOTO permits affecting work area
- Safety warnings: Alerts for energized equipment near work location
- Permit status: Real-time status of isolation permits
- Emergency contacts: Quick access to control room and emergency services
- Communication Features:
- Push notifications: Critical alerts and emergency communications
- Instant messaging: Communication with control room operators
- Voice calls: Direct calling to control room or emergency services
- Location sharing: Share current location with dispatch/control room

3.4.7 Fire Safety System Interface

Interface Overview and Safety Architecture

Fire Safety Integration Purpose: The Fire Safety System interface provides critical automatic power shutoff capabilities and alarm integration with fire detection systems throughout the ISR network to protect personnel, equipment, and infrastructure while enabling coordinated emergency response.

Interface Scope:

- Traction Substations: Fire detection and suppression at all 39 TSSs
- Critical LOPs: Fire detection at LOPs
- Control Centers: Integration with building fire systems at Lod and Haifa
- Passenger Stations: Integration with building fire systems at the stations
- Infrastructure: Integration with Tunnels fire systems

Safety Design Principles:
- Fail-Safe Operation: All fire safety interfaces default to safe state upon failure
- Redundant Detection: Multiple detection methods and backup systems
- Automatic Response: Immediate automatic response without manual intervention
- Manual Override: Emergency personnel can override automatic systems when necessary

Fire Detection and Response Integration
Fire Detection System Integration:
Detection Technology Support:
- Smoke Detection: Photoelectric and ionization smoke detectors
- Heat Detection: Fixed temperature and rate-of-rise heat detectors
- Flame Detection: IR flame detectors for liquid fire detection
- Gas Detection: CO detection for early fire indication
- VESDA (Very Early Smoke Detection): Aspirating smoke detection for critical areas

Interface Methods:
- Hardwired Digital Inputs: Direct discrete inputs to SCADA RTUs (primary method)
- Voltage-free contacts from fire alarm control panels
- Protocol-Based Integration: Digital communication with fire alarm systems
- Modbus TCP/RTU for modern fire alarm panels
- BACnet integration where supported
- Detailed alarm information including location and type

Automated Emergency Response Procedures
TSS Fire Emergency Response:

Scenario 1: Transformer Fire Detection
1. Automatic Detection: Multiple fire detectors confirm transformer fire
2. Immediate SCADA Action (within 1 second):
- Trip all TSS circuit breakers (AC and DC)
- Open all incoming and outgoing disconnectors
- Activate TSS emergency shutdown sequence
- Display emergency alarms in control center
External Notifications:
- Fire department automatic alarm
- ISR emergency response team notification

- Utility company notification

Scenario 2: Control Room Fire

1. Detection and Verification: Smoke detection in control room
2. SCADA Response:

- Isolate affected control systems
- Transfer control to backup systems
- Preserve critical data and configurations
- Maintain essential TSS protection functions

1. Personnel Safety:

- Activate building evacuation alarms
- Emergency lighting activation
- Smoke extraction system activation

Tunnel/Station Fire Emergency Response:

Scenario 3: Tunnel Fire Detection

1. Fire Detection: Tunnel fire detection system activates
2. Automatic De-energization (with operator intervention):

- Immediate de-energization of affected tunnel section
- Adjacent section isolation to prevent fire spread

1. Emergency Services Support:

- Coordinate with fire brigade for selective re-energization

Manual Override Capabilities:

- Fire Brigade Override Authority:
- Selective re-energization for rescue equipment
- Override automatic systems when necessary for firefighting
- Temporary power restoration for emergency movement of trains

3.4.8 Stabling/Depot and Maintenance Facility Interface

Depot Interface Overview

Stabling/Depot Electrification Scope: The depot interface provides monitoring and control of electrification systems at train depots and maintenance facilities (workshops) throughout the ISR network, ensuring safe and efficient power supply for train maintenance operations.

Covered Facilities:

- Primary Maintenance Depots: 5 major facilities (Lod, Haifa, Be'er Sheva, etc.)
- Washing Facilities: Train washing stations with specialized power requirements
- Testing Facilities: Rolling stock testing and commissioning areas

Stabling/Depot Electrification Systems:

- OCS Extensions: Overhead contact system within depot boundaries
- Sectionalizing Equipment: Isolators and switches for area control

- Workshop Power: High-voltage power for maintenance equipment
- Auxiliary Systems: Lighting, ventilation, crane power, testing equipment

Depot Data Exchange and Control

From Depot Systems to SCADA:

Power Supply Status:

- Main Depot Feed:
- Incoming supply status: Energized/De-energized/Fault
- Supply voltage and current measurements
- Energy consumption monitoring for cost allocation
- Power quality monitoring (harmonics, voltage variations)
- Sectionalizing Switch Status:
- Individual track section energization status
- Workshop area power status (overhead cranes, heavy equipment)
- Testing facility power (for rolling stock testing)
- Emergency isolation switch positions

Operational Data:

- Track Occupancy (if available): Which tracks are occupied by rolling stock
- Maintenance Activity Status: Active maintenance operations requiring power isolation
- Environmental Monitoring: Temperature, humidity in maintenance facilities
- Security Status: Access control, intrusion detection for depot facilities

From SCADA to Depot Systems:

Remote Control Operations:

- Sectionalizing Switch Control:
- Remote opening/closing of depot section switches
- Emergency isolation capability
- Coordinated switching for maintenance activities
- Power Management:
- Load shedding during peak demand periods
- Scheduled outages coordination
- Emergency power cutoff capability

4. SPECIALIZED SYSTEMS

4.1 Training Simulator

The SCADA Contractor shall provide a full-scope training simulator enabling comprehensive operator, maintenance, and engineering training.

Simulator Architecture:

The SCADA Contractor shall implement:

- Dedicated simulator server: Separate from production SCADA (no impact on operations)
- Training stations: 6 concurrent operator training positions
- Instructor station: 1 dedicated instructor control and monitoring position

- Network: Isolated training network with optional connection to production for shadow mode
- Software: Full SCADA software stack with simulation engine

Simulation Scope:

The simulator shall accurately model:

- Complete network: All existing field sites (LOPs + TSSs) + expansion sites
- Equipment behavior: Realistic timing, interlocks, faults, wear characteristics
- Electrical system: TSS Breakers status, OCS disconnector status, Voltage, power consumption, fault currents
- Protection systems: Realistic protection relay behavior and trip scenarios
- Communication: Communication delays, failures, protocol behavior
- External systems: Simplified models of ETCS, fire safety, and other interfaces
- Weather: Temperature, wind, rain effects on equipment and operations

Scenario Management:

The SCADA Contractor shall provide:

1. Pre-Programmed Scenarios (100+ minimum):
   - Normal operations (20): Routine switching, train service support, load management
   - Planned maintenance (10): Isolations, equipment removals, staged restoration
   - Equipment failures (55): Single and cascading OCS faults, protection trips
   - Emergency response (10): Fire events, storms, external power loss, train accidents
   - External events (5): Signaling failures, utility power disturbances, cyber events
2. Scenario Builder Tool:
   - Graphical interface: Drag-drop scenario construction
   - Event triggers: Time-based, operator-action-based, or equipment-state-based triggers
   - Malfunctions: Inject malfunctions/ failures, communication failures, protection mis-operations
   - Environmental conditions: Set weather, temperature, loading conditions
   - Difficulty levels: Easy, medium, hard, expert
   - Save/load: Save custom scenarios for reuse and sharing
3. Instructor Capabilities:
   - Scenario control: Start, pause, resume, reset, fast-forward scenarios
   - Event injection: Inject events during scenario execution (equipment failures, alarms, etc.)
   - Freeze: Freeze simulation for discussion and teaching points
   - Student monitoring: Real-time view of all student operator actions
   - Playback: Record and playback training sessions for debriefing
   - Performance scoring: Automatic scoring of student actions (correct, incorrect, missed)
   - Assessment reports: Detailed student performance reports with recommendations

Training Programs:

The SCADA Contractor shall deliver:

1. Operator Training (~100 hours per student):

- Module 1: System overview and familiarization (4 hours)
- Module 2: Normal operations and routine switching (8 hours)
- Module 3: Alarm response and troubleshooting (16 hours)
- Module 4: Emergency procedures (8 hours)
- Module 5: Advanced scenarios and competency assessment (16 hours)
- Module 6: Practical assessment (40 hours)
- Target: 80-100 operators trained

2. Maintenance Personnel Training (32 hours per student):

- Module 1: System architecture and components (8 hours)
- Module 2: Preventive maintenance procedures (8 hours)
- Module 3: Troubleshooting and diagnostics (8 hours)
- Module 4: Emergency repairs and system restoration (4 hours)
- Module 5: Hands-on field equipment training (4 hours)
- Target: 40-50 maintenance personnel trained

3. Engineering Staff Training (24 hours per student):

- Module 1: System design and architecture deep-dive (8 hours)
- Module 2: Configuration and system administration (8 hours)
- Module 3: Performance monitoring and optimization (4 hours)
- Module 4: Interface management and integration (4 hours)
- Target: 15-20 engineering staff trained

Training Materials:

The SCADA Contractor shall deliver:

- Training curricula: Detailed lesson plans for all training modules
- Instructor guides: Comprehensive instructor manuals with teaching notes
- Student workbooks: Student materials with exercises and reference information
- Assessment materials: Written tests, practical assessments, grading rubrics
- E-learning modules: Computer-based training modules for self-paced learning
- Video tutorials: Video demonstrations of key procedures and operations
- Language: All materials in Hebrew and English

4.2 LOTO (Lock-Out Tag-Out) System

The SCADA Contractor shall provide an electronic LOTO system ensuring worker safety during maintenance activities.

LOTO System Architecture:

The SCADA Contractor shall implement:

- LOTO server: Dedicated server for permit management (can be virtualized)
- LOTO database: Centralized permit database with complete audit trail
- Web interface: Browser-based permit management for control center and engineering
- Mobile applications: Native iOS and Android apps for field personnel
- SCADA integration: Real-time integration with SCADA for equipment status and interlocking

Permit Management Workflow:

The Contractor shall configure:

1. Permit Request:
   - Requestor: Maintenance supervisor creates permit via SCADA (web) or mobile app
   - Equipment selection: Select equipment to be isolated from system database
   - Work description: Describe maintenance work and personnel involved
   - Time window: Specify planned start and end time
2. Engineering Review:
   - Isolation analysis: System automatically identifies required isolation points and earthing devices installation location
   - Verification: Engineer verifies isolation and earthing points and adds additional requirements
   - Documentation: Engineer attaches isolation procedures and drawings
   - Approval: Engineer approves permit for operations review
3. Operations Approval:
   - Operations review: Operations manager reviews permit and checks schedule conflicts
   - Operational impact: Assess impact on train operations and other maintenance
   - Coordination: Coordinate with signaling, traffic control, other maintenance activities
   - Approval: Operations manager approves permit for field execution
4. Field Verification:
   - Field technician: Assigned technician receives permit on mobile device
   - Physical isolation: Technician physically isolates equipment and applies earthing devices, locks/tags
   - GPS verification: Mobile app uses GPS to verify technician at correct location
   - Photo documentation: Technician takes photos of applied locks/tags
   - Status update: Technician confirms isolation complete, permit status changes to "Active"
5. SCADA Interlocking:
   - Equipment locking: SCADA system locks tagged equipment preventing remote control
   - Operator notification: Operators see clear indication of LOTO on HMI displays
   - Control blocking: Any attempt to control tagged equipment generates alarm and is rejected
   - Adjacent equipment: Related equipment highlighted with warnings about nearby LOTO
6. Work Execution:
   - Work proceeds: Maintenance work performed under protection of LOTO

- Permit status: Permit remains active and visible throughout work period
- Permit extension: Permit can be extended if work requires additional time

7. Permit Closure:

- Work completion: Supervisor confirms work complete and area clear
- Physical removal: Technician removes earthing devices, locks/tags and confirms via mobile app
- Photo verification: Technician takes photos confirming removal
- SCADA unlock: SCADA system releases equipment interlock
- Testing: Equipment tested and returned to service
- Permit closure: Permit closed with complete documentation

Permit Types:

The SCADA Contractor shall support:

- Simple permits: Single equipment, single-point isolation, automatic approval for low-risk work
- Complex permits: Multiple equipment, multi-point isolation, coordination required
- Emergency permits: Expedited approval process for urgent safety-related work
- Planned permits: Scheduled maintenance permits coordinated weeks in advance

Safety Interlocking:

The SCADA Contractor shall implement:

- Real-time status: SCADA provides real-time equipment status for permit verification
- Control blocking: Automatic blocking of control commands for tagged equipment
- Override protection: No operator override of LOTO protection (except emergency with dual authorization and full logging)
- Alarm generation: Alarms generated for any attempted control of tagged equipment
- Visual indication: Clear HMI indication of LOTO status (distinctive color, flashing, etc.)
- Adjacent equipment identification: Automatic identification of equipment adjacent to LOTO requiring caution
- Conflict detection: Detection of permit conflicts (multiple permits on same equipment or conflicting permits)

Mobile Application Features:

The SCADA Contractor shall provide:

- Permit viewing: View active, pending, and historical permits
- Equipment search: Search equipment database by name, ID, location, type
- Barcode/QR scanning: Scan equipment tags for rapid identification
- GPS location: GPS-based location verification
- Photo attachment: Attach photos to permit records (before/after isolation)
- Offline capability: Basic permit viewing and data entry with limited connectivity

- Push notifications: Receive notifications for permit approvals, expirations, nearby LOTO
- Digital signature: Digital signature capability for permit approvals

Compliance and Reporting:

The SCADA Contractor shall provide:

- Permit history: Complete history of all permits with full audit trail
- Compliance tracking: Track permit compliance with ISR safety procedures
- Training integration: Link permits to personnel training and competency records
- Authorization verification: Verify only authorized personnel create/approve permits
- Performance metrics: Metrics on permit processing time, violations, near-misses
- Regulatory reports: Reports for safety audits and regulatory compliance
- Violation reports: Reports on attempted control of tagged equipment
- Audit trail: Complete audit trail suitable for safety investigations

5. MIGRATION AND IMPLEMENTATION

5.1 Migration Strategy

The SCADA Contractor shall execute a systematic migration from the legacy SCADA system to the new system without service disruption.

Zero-Downtime Migration Approach:

The SCADA Contractor shall:

- Parallel operation: Legacy and new systems operate simultaneously during transition period
- Gradual cutover: Site-by-site cutover minimizing risk
- Rollback capability: Full rollback capability maintained at every stage
- Validation period: Minimum 7-day parallel operation before final cutover per site
- 24/7 operations: Migration activities coordinated to avoid service disruption

Migration Phases:

Phase 1: Preparation

- Activities:
  - Detailed design and engineering
  - Equipment procurement and factory testing
  - Control center facility preparation
  - Training simulator deployment and configuration
  - Initial operator training on simulator
  - Migration procedures development and approval
- Deliverables:
  - Approved design documents

- Training simulator operational
- Initial training completed (20% of operators)
- Migration procedures approved by ISR

Phase 2: Control Center Deployment

- Activities:
  - Control center infrastructure installation (servers, workstations, network, video wall)
  - SCADA software installation and configuration
  - Database setup and replication configuration
  - Interface development and initial testing
  - Operator training (all operators on simulator)
- Deliverables:
  - Lod control center operational
  - Haifa control center operational
  - All operators trained and certified
  - Basic SCADA functionality demonstrated

Phase 3: Communication Network Deployment

- Activities:
  - Network equipment installation and configuration
  - Cybersecurity systems deployment
  - Network management system deployment
  - End-to-end network testing
- Deliverables:
  - Complete network operational
  - All network devices installed and configured
  - Cybersecurity systems operational
  - Network performance validated

Phase 4: Field Equipment Migration

Pilot:

- Scope: 15 LOPs + 3 TSSs
- Approach: Pilot implementation with intensive support and monitoring
- Activities:
  - RTU installation and commissioning
  - IEC 61850 gateway installation
  - Disconnector retrofit/replacement

- Site-by-site cutover with 7-day parallel operation
- Lessons learned documentation

- Deliverables:
- Pilot sites fully operational
- Migration procedures refined based on lessons learned
- Cutover time reduced from 8 hours to 4-6 hours per site

Mass Rollout:

- Migration rate: 12-15 LOPs + 2-3 TSSs per month
- Installation teams: 5 teams minimum working in parallel

Phase 5: Integration and Closeout

- Activities:
- External interface commissioning and testing
- End-to-end system integration testing
- Performance optimization
- Expansion infrastructure demonstration
- Training completion (maintenance and engineering staff)
- Documentation completion
- 90-day performance monitoring period
- Legacy system decommissioning

- Deliverables:
- All sites operational on new SCADA
- All external interfaces operational
- Expansion capability demonstrated
- Final acceptance achieved
- Legacy system decommissioned

5.2 Site Migration Procedures

The SCADA Contractor shall develop and execute detailed site migration procedures for each site type.

Pre-Migration Site Assessment:

For each site, the SCADA Contractor shall:

- Site survey: Physical site survey confirming installation space, power, cable routes
- As-built verification: Verify as-built drawings match actual field conditions
- Legacy system documentation: Document existing RTU configuration and wiring
- Access coordination: Coordinate site access and possession windows with operations

- Risk assessment: Identify and mitigate site-specific risks

Site Preparation:

The SCADA Contractor shall:

- Equipment delivery: Deliver pre-configured equipment to site
- Pre-staging: Stage equipment at site prior to possession window
- Tool and material preparation: Ensure all tools, materials, test equipment available
- Team briefing: Brief installation team on site-specific requirements and safety

Installation Phase:

The SCADA Contractor shall execute:

- Equipment installation: Install RTU, disconnector drives, communication equipment
- Wiring: Wire RTU to disconnectors, power supply, communication links
- Power-up: Energize equipment and perform initial functional tests
- Communication: Establish communication with SCADA servers
- Configuration: Download configuration to RTU and verify
- Functional testing: Test all inputs, outputs, disconnector control, interlocks

Parallel Operation Phase:

The SCADA Contractor shall conduct:

- Duration: Minimum 7 days of parallel operation
- Monitoring: Both legacy and new systems monitoring same field equipment
- Data comparison: Continuous comparison of data from legacy vs. new system
- Control testing: Test control operations on new system (without field execution initially)
- Operator familiarization: Operators monitor new system in parallel with legacy
- Issue resolution: Identify and resolve any discrepancies before cutover

Cutover Execution:

The SCADA Contractor shall:

- Cutover window: Execute cutover during off-peak period (typically 4-8 hours)
- Go/No-Go meeting: Decision meeting 1 hour before cutover with ISR approval
- Legacy system isolation: Disconnect legacy system from field equipment
- New system activation: Activate new system for monitoring and control
- Functional verification: Verify all monitoring and control functions
- Rollback readiness: Maintain rollback read

5.3 Post-Migration Validation

Following each site cutover, the SCADA Contractor shall execute comprehensive validation procedures ensuring system reliability and performance.

Immediate Post-Cutover Validation (0-24 hours):

The SCADA Contractor shall verify:

- All data points: Verify 100% of configured data points are updating with correct values
- Control operations: Test all control functions (minimum 3 operations per disconnector)
- Alarm functionality: Verify alarm generation, propagation, and acknowledgment
- Communication redundancy: Test primary and backup communication paths
- Time synchronization: Verify GPS time sync accuracy (±10 ms)
- Performance metrics: Confirm response times meet specifications (<2 seconds control, <5 seconds alarms)

Extended Validation Period (1-7 days):

The SCADA Contractor shall monitor:

- System stability: Continuous monitoring for communication failures, data errors, unexpected alarms
- Performance trending: Trending of response times, data quality, communication statistics
- Operator acceptance: Operator feedback on HMI functionality and system behavior
- Fault injection testing: Simulate communication failures and verify automatic recovery
- Load testing: Test system performance during peak operational periods
- Integration verification: Verify external system interfaces (SAP, ETCS, fire safety) operational

Validation Criteria:

The SCADA Contractor shall achieve:

Parameter	Acceptance Criteria	Measurement Period
Data availability	>99.5% of configured points updating	7-day continuous
Control success rate	>99% successful operations	All operations during 7 days
Communication uptime	>99.9% per communication path	7-day continuous
Response time compliance	>95% of operations meet specification	All operations during 7 days
Alarm accuracy	<2% false/nuisance alarms	7-day continuous
System stability	Zero system crashes or restarts	7-day continuous

Non-Conformance Resolution:

For any validation failures, the SCADA Contractor shall:

- Immediate response: Response within 2 hours of detection
- Root cause analysis: Complete analysis within 24 hours
- Corrective action: Implement corrections within 48 hours

- Rollback option: Maintain rollback capability for 7 days post-cutover
- Re-validation: Repeat full validation cycle after corrections

5.4 Rollback Procedures

The SCADA Contractor shall maintain complete rollback capability for every migration stage ensuring operational continuity.

Rollback Triggers:

The SCADA Contractor shall initiate rollback for:

- Critical system failures: System crashes, major data loss, complete communication failure
- Performance degradation: Failure to meet minimum performance criteria (>5 second response times)
- Safety violations: Any condition compromising operational safety
- Operator rejection: Unanimous operator request due to usability issues
- ISR direction: ISR management decision to rollback

Rollback Execution (per site):

The SCADA Contractor shall execute:

- Decision point: Maximum 4 hours to decide rollback vs. repair
- Legacy system reactivation: Reconnect legacy RTU to field equipment
- Data synchronization: Update legacy system with any changes during parallel period
- Functional verification: Verify legacy system fully operational
- New system isolation: Safely isolate new equipment without affecting legacy operation
- Documentation: Complete rollback documentation including root cause

Rollback Timeline:

Rollback Scope	Maximum Duration	Success Criteria
Single LOP	4 hours	Legacy system controlling all equipment
Multiple LOPs (5-10)	8 hours	All sites operational on legacy
Ring section	12 hours	Full ring operational on legacy
Complete ring	24 hours	All ring sites operational
Control center	12 hours	Backup center operational

System Recovery:

Following rollback, the SCADA Contractor shall:

- Root cause analysis: Complete analysis within 48 hours

- Corrective measures: Develop and implement corrections
- Validation testing: Comprehensive testing in lab/simulator environment
- Re-migration planning: Revised migration plan addressing root cause
- ISR approval: Obtain ISR approval before attempting re-migration

5.5 Expansion Implementation

The SCADA Contractor shall design and demonstrate the system's expansion capability supporting future network growth.

Expansion Design Principles:

The SCADA Contractor shall implement:

- Plug-and-play architecture: Standardized configurations enabling rapid site deployment
- Pre-provisioned capacity: Infrastructure capacity for first 250 expansion sites without upgrade
- Automated configuration: Tools for rapid site configuration and deployment
- Centralized management: All expansion sites managed from existing control centers

Expansion Infrastructure:

The SCADA Contractor shall provide:

Network Infrastructure:

- Equipment capacity: Network equipment sized for 170+ additional sites
- IP addressing: Reserved IP ranges for expansion sites (subnets pre-allocated)
- VLAN capacity: Reserved VLANs for expansion sites by type and location

Control Center Capacity:

- Server capacity: SCADA servers sized for 50,000+ data points
- Database storage: Storage capacity for additional data points with 5-year retention
- Network equipment: Switch port capacity for expansion site connections
- Operator positions: Capacity planning for additional operator workstations

Expansion Procedures:

The SCADA Contractor shall provide:

Site Design Process:

- Site survey templates: Standardized survey forms for expansion sites
- Design standards: Standard designs for expansion LOPs
- Equipment selection: Standard equipment selection based on site requirements
- Configuration templates: Pre-configured templates reducing engineering time

Deployment Process:

- Equipment procurement: Unit pricing and lead times for expansion equipment
- Installation procedures: Detailed procedures for expansion site installation
- Testing procedures: Streamlined testing procedures for expansion sites
- Commissioning procedures: Rapid commissioning procedures

Expansion Demonstration:

During Phase 5, the SCADA Contractor shall:

- Mock expansion site: Create simulated expansion site demonstrating full process
- Site templates: Demonstrate all three LOP type templates
- Configuration tools: Demonstrate automated configuration and deployment tools
- Performance verification: Verify expansion site meets same performance criteria
- Documentation: Provide complete expansion procedures and templates for ISR use
- Training: Train ISR engineering staff on expansion procedures

6. TESTING AND COMMISSIONING

6.1 Factory Acceptance Testing (FAT)

The SCADA Contractor shall conduct comprehensive factory testing of all major system components prior to delivery and installation.

FAT Scope and Location:

The SCADA Contractor shall test:

- SCADA servers and software: Complete server hardware/software configuration
- RTU and gateway equipment: All LOP/TSS types and IEC 61850 gateways
- Network equipment: Core routers, switches, cybersecurity appliances
- Control room equipment: Operator workstations, video wall systems
- Training simulator: Complete simulator system with scenario library
- Location: SCADA Contractor's facility or authorized test facility
- Duration: 4 weeks SCADA systems, 2 weeks field equipment

SCADA System FAT:

The SCADA Contractor shall demonstrate:

Core Functionality:

- Data acquisition: 50,000+ data points at specified update rates
- Control operations: SBO sequences, interlocking, timeout handling

- Alarm processing: All priority levels, correlation, filtering, acknowledgment
- HMI displays: All display types, navigation, customization
- Redundancy: Server failover <5 seconds with zero data loss
- Database operations: Real-time updates, historical queries, replication

Performance Testing:
- Load testing: Maximum configured data points with full update rates
- Stress testing: 150% normal load for 24 hours continuous
- User load: 50+ concurrent HMI users without performance degradation
- Response times: All operations meet specification (<2s control, <5s alarms)
- Memory usage: Stable operation with memory usage <80% maximum
- Network resilience: Operation with simulated network delays up to 200ms

Integration Testing:
- Protocol drivers: IEC 60870-5-104, IEC 61850, OPC UA, Modbus TCP, SNMP
- External interfaces: Simulated connections to all 8 external systems
- Cybersecurity: Security testing with vulnerability scanning
- Time synchronization: GPS and NTP synchronization accuracy

Field Equipment FAT:

The SCADA Contractor shall test:
RTU Testing:
- I/O functionality: All digital inputs/outputs, analog inputs at specified accuracy
- Communication: IEC 60870-5-104 client with redundant connections
- Control logic: IEC 61131-3 programming functionality
- Time synchronization: GPS accuracy ±10 ms
- Environmental: Operation at temperature extremes (-40°C to +70°C)
- Power: Operation on battery backup, power consumption verification
- EMC testing: Per IEC 61000 series standards

IEC 61850 Gateway Testing:
- Protocol translation: IEC 61850 ↔ IEC 60870-5-104 accuracy and completeness
- Data throughput: 800+ data objects per gateway at 1-second updates
- GOOSE messaging: Publisher/subscriber functionality
- MMS services: Reporting, control, file transfer
- Time synchronization: IEEE 1588 PTP accuracy ±1 ms
- Redundancy: Dual processor failover

Disconnector Testing:

- Electrical verification: High-voltage testing at rated voltage/current
- Mechanical operation: 100 operations under test conditions
- Motor drive: Operation time, torque, power consumption
- Position feedback: Accuracy and repeatability of position indication
- Auxiliary contacts: Contact operation and timing
- Environmental: Outdoor exposure testing simulation

FAT Acceptance Criteria:

Test Category	Success Criteria	Failure Threshold
Functional Tests	100% pass rate	Any critical function failure
Performance Tests	Meet all specifications	>5% deviation from specification
Load/Stress Tests	Stable operation 24+ hours	System crash or significant degradation
Integration Tests	All protocols operational	Any protocol failure
Environmental Tests	Operation within specified range	Any out-of-range failure

FAT Documentation:

The SCADA Contractor shall provide:

- Test plans: Detailed test procedures for all equipment types
- Test results: Complete test results with measurements and observations
- Non-conformance reports: Documentation of any failures and corrective actions
- Certificates: Test certificates from authorized laboratories where required
- FAT report: Comprehensive report summarizing all testing activities and results

6.2 Site Acceptance Testing (SAT)

The SCADA Contractor shall conduct comprehensive site testing following installation at ISR facilities.

SAT Scope:

The SCADA Contractor shall test:

- Control centers: Complete end-to-end testing of both Lod and Haifa centers
- Communication network: Full network
- Field equipment: All sites (LOPs + TSSs) with complete functionality
- External interfaces: All interfaces with actual external systems
- Training simulator: Full simulator with ISR operator participation
- LOTO system: Full simulator with ISR operator participation
- Duration: 10 weeks total (6 weeks control centers, 4 weeks field sites)

Control Center SAT:

Infrastructure Testing:

- Power systems: UPS, generators, automatic transfer operation
- Environmental systems: HVAC, fire suppression, access control
- Network infrastructure: All switches, routers, cybersecurity systems
- Server hardware: All servers, storage systems, backup/recovery
- Operator positions: All workstations, displays, peripherals

SCADA System Testing:

- End-to-end functionality: Complete data flow from field to HMI
- Redundancy verification: Server failover, communication redundancy
- Performance validation: Response times, data throughput, concurrent users
- Security verification: Access control, audit logging, intrusion detection
- Backup/recovery: Database backup, system recovery procedures

Communication Network SAT:

Network Performance:

- Latency testing: <50 ms end-to-end across network
- Throughput testing: Full capacity utilization without packet loss
- Redundancy testing: Ring protection with <50 ms failover times
- QoS verification: Priority traffic handling during congestion
- Security testing: Firewall rules, VPN connectivity, intrusion detection

Network Management:

- Device discovery: Automatic discovery of all 370+ network devices
- Performance monitoring: SNMP polling, threshold alarming
- Configuration management: Centralized configuration, backup/restore
- Fault management: Automated fault detection and notification

Field Equipment SAT:

Site-by-Site Testing:

- Communication verification: Redundant communication paths operational
- Data acquisition: All configured data points updating correctly
- Control operations: All disconnectors, breakers controllable from SCADA
- Local control: Local control panels and emergency stops functional

- Interlocking: Software and hardware interlocks operational
- Protection integration: Protection relay integration where applicable

Performance Verification:

- Response times: Control commands <2 seconds, alarms <5 seconds
- Data quality: >99.5% good quality data points
- Communication reliability: >99.9% communication availability
- Control success: >99% successful control operations

External Interface SAT:

The SCADA Contractor shall test each interface:

Interface	Test Requirements	Acceptance Criteria
TSS IEC 61850	All TSSs	<100ms latency, 100% data availability
LOP IEC 60870-5-104	All LOPs	<2s response, 99.5% data quality
ETCS/Signaling	Neutral section status, disconnectors status, track status	Real-time updates, bi-directional
SAP ERP	Availability data sync, work orders	Daily synchronization, error handling
Fire Safety	Emergency shutdown integration	<1 second response to fire alarm
CMMS	Equipment status, maintenance orders	5-minute updates, workflow integration
Depot /Stabling Areas Management	Electrification system status	Integration with depot systems
Network Management	Network device monitoring	SNMP integration, alarm correlation

SAT Acceptance:

The SCADA Contractor shall achieve:

- Functionality: 100% of specified functions operational
- Performance: All performance specifications met or exceeded
- Integration: All external interfaces operational and tested
- Documentation: All documentation delivered and accepted
- Training: All specified personnel trained and competency verified

6.3 System Integration Testing

The SCADA Contractor shall conduct comprehensive integration testing verifying end-to-end system operation.

Integration Test Scope:

The SCADA Contractor shall verify:

- End-to-end data flow: Field sensors → RTUs → Network → SCADA → HMI displays
- Control operations: HMI commands → SCADA → Network → RTUs → Field equipment

- Alarm propagation: Field events → RTUs → SCADA → HMI → Operator notification
- External system data: External systems → Interfaces → SCADA → HMI integration
- Cross-system functionality: LOTO integration with SCADA, training simulator accuracy
- Multi-site scenarios: Complex operational scenarios involving multiple sites

Operational Scenario Testing:
The SCADA Contractor shall execute:
Normal Operations Scenarios:

- Daily operations: Routine switching, train service support
- Shift changes: Operator handover, authority transfer, system state preservation
- Planned maintenance: LOTO procedures, equipment isolation, staged restoration
- Load variations: System behavior during peak/off-peak loading conditions

Emergency Scenarios:

- Equipment failures: Single and cascading failures, protection trips, isolation procedures
- Communication failures: Network outages, RTU communication loss, automatic recovery
- Power system disturbances: External power loss, TSS trips, feeder failures
- Fire emergency: Fire detection integration, automatic shutdown procedures
- Storm conditions: High wind/lightning, equipment protection, service restoration

Integration Performance Testing:

- Maximum load: All sites operational with maximum data throughput
- Concurrent operations: Multiple operators performing simultaneous control actions
- Alarm storms: System behavior during high alarm rates (equipment failures)
- Database stress: System performance with maximum historical data queries
- Network congestion: System behavior during network congestion conditions

Multi-Center Integration:

- Center-to-center failover: Lod to Haifa control transfer procedures
- Data synchronization: Real-time data consistency between centers
- Distributed control: Operations from both centers simultaneously
- Communication redundancy: Inter-center link failures and automatic recovery

Integration Test Criteria:

Test Category	Acceptance Criteria
End-to-End Response	<2 seconds operator action to field response
Data Consistency	<1% variance between centers during normal operation
Alarm Processing	<5 seconds field event to operator notification

System Recovery <5 minutes recovery from communication failures
Load HandlingNo degradation with 150% normal operational load
Concurrent Operations 50+ operators without performance impact

6.4 Performance Testing

The SCADA Contractor shall conduct extensive performance testing verifying system meets all specifications under maximum load conditions.

Performance Test Categories:

System Capacity Testing:

- Data point capacity: Verify 50,000+ data points with specified update rates
- User capacity: 50+ concurrent HMI users without degradation
- Control capacity: 100+ simultaneous control operations
- Alarm capacity: 1000+ alarms per minute processing without loss
- Historical data: Query performance with 5 years of historical data
- Report generation: Complex report generation without impacting operations

Response Time Testing:

The SCADA Contractor shall verify:

Operation Type	Specification	Test Method
Control commands	<2 seconds end-to-end	Automated timing measurement
Alarm propagation	<5 seconds field to HMI	Event injection testing
HMI display updates	<2 seconds screen refresh	Performance monitoring
Database queries	<5 seconds typical queries	Query performance testing
Server failover	<5 seconds automatic	Failover simulation
Network failover	<50 ms path switching	Network fault simulation

Throughput Testing:

- Data acquisition: 10,000+ points per second sustained
- Database writes: 10,000+ inserts per second
- Network utilization: 80% capacity without packet loss
- Alarm processing: 1000+ alarms per minute
- Control operations: 100+ operations per minute

Stress Testing:

- Sustained load: 150% normal load for 72 hours continuous
- Peak load: 200% normal load for 1 hour

- Memory stress: System operation with 90% memory utilization
- Storage stress: Operation with 90% disk utilization
- Network stress: Operation with 90% network utilization

Scalability Testing:

- Future expansion: Verify capacity for 500+ sites (50,000 data points)
- User scaling: Performance with 100+ concurrent users
- Geographic scaling: Performance across 400+ km network
- Database scaling: Performance with 20+ years historical data

Performance Monitoring:

The SCADA Contractor shall provide:

- Real-time monitoring: Continuous performance metrics collection
- Performance baselines: Establishment of performance baselines for future reference
- Performance trends: Long-term performance trending and analysis
- Threshold alerts: Automated alerts for performance degradation
- Performance reports: Daily/weekly/monthly performance reports

6.5 Security Testing

The SCADA Contractor shall conduct comprehensive cybersecurity testing ensuring IEC 62443 compliance and robust defense against cyber threats.

Security Test Scope:

The SCADA Contractor shall test:

- Network security: Firewalls, IDS/IPS, network segmentation
- Application security: SCADA software, HMI applications, databases
- Endpoint security: Workstations, servers, RTUs, network devices
- Access control: User authentication, authorization, privilege management
- Communication security: Protocol security, encryption, certificates
- Physical security: Console access, USB controls, device tampering

Vulnerability Assessment:

The SCADA Contractor shall conduct:

- Network vulnerability scanning: Automated scanning of all network devices
- Application vulnerability testing: Security testing of all software components
- Protocol security analysis: IEC 60870-5-104, IEC 61850, OPC UA security verification

- Penetration testing: Simulated cyber attacks by qualified security professionals
- Social engineering testing: Phishing and social engineering simulation
- Physical security assessment: Physical access controls and monitoring

Security Control Verification:

Network Security:
- Firewall rules: Verification of all firewall rules and policies
- Network segmentation: VLAN isolation and inter-VLAN access controls
- Intrusion detection: IDS signature effectiveness and alert generation
- VPN security: IPsec configuration, certificate management, access controls
- Network monitoring: Security monitoring and log analysis capabilities

Access Control Testing:
- User authentication: Multi-factor authentication verification
- Role-based access: Verification of user roles and permissions
- Privilege escalation: Testing for unauthorized privilege escalation
- Account management: User account lifecycle management
- Session management: Session timeout, concurrent session limits

Application Security:
- Input validation: Testing for injection attacks (SQL, command, script)
- Session security: Session hijacking and fixation testing
- Data encryption: Encryption of sensitive data at rest and in transit
- Error handling: Security error message handling
- Audit logging: Comprehensive audit log generation and protection

Industrial Protocol Security:
- IEC 60870-5-104: Authentication, encryption, message integrity
- IEC 61850: MMS security, GOOSE message integrity, certificate management
- OPC UA: Security policies, certificate management, user authentication
- Modbus TCP: Security implementation where applicable

Compliance Testing:

The SCADA Contractor shall verify compliance with:
- IEC 62443-3-3: Network security requirements for IACS (SL-2 minimum)
- IEC 62443-4-2: Component security requirements (SL-2 minimum)

- ISO/IEC 27001: Information security management system requirements
- NIST Cybersecurity Framework: Framework implementation verification

Security Test Documentation:

The SCADA Contractor shall provide:

- Security test plan: Comprehensive security testing procedures
- Vulnerability assessment reports: Detailed findings and remediation recommendations
- Penetration testing report: Results of simulated cyber attacks
- Compliance assessment: Verification of standards compliance
- Security configuration guides: Secure configuration documentation
- Incident response procedures: Cybersecurity incident response plan

7. TRAINING REQUIREMENTS

7.1 Training Program Overview

The SCADA Contractor shall deliver comprehensive training programs ensuring competent operation, maintenance, and engineering of the SCADA system.

Training Objectives:

The SCADA Contractor shall ensure participants:

- Understand system architecture, capabilities, and limitations
- Operate the system safely and efficiently according to ISR procedures
- Perform routine maintenance and basic troubleshooting
- Configure and administer system components as required
- Respond appropriately to normal and emergency situations

Training Approach:

The SCADA Contractor shall use:

- Blended learning: Classroom instruction, hands-on practical, computer-based training, simulator exercises
- Competency-based: Training targeted to specific job roles and competency requirements
- Progressive complexity: Basic concepts building to advanced operations
- Practical application: Extensive hands-on practice using actual system and simulator
- Assessment and certification: Formal assessment with competency certification

Training Categories and Participants:

Training Category	Target Participants	Duration	Priority
Operator Training	80-100 Operations Staff	100 hours	Critical
Maintenance Training	40-50 Maintenance Technicians	32 hours	Critical
Engineering Training	15-20 Engineering Staff	400 hours	High
Management Training	10-15 Supervisors/Managers	16 hours	Medium
Train-the-Trainer	5-8 ISR Training Staff	48 hours	High

Training Delivery Schedule:

The SCADA Contractor shall deliver:

- Phase 1: Initial operator training (20% of operators) on training simulator
- Phase 2: Full operator training (remaining operators) before system deployment
- Phase 3: Maintenance personnel training concurrent with network deployment
- Phase 4: Engineering training during field migration phase
- Phase 5: Refresher training and advanced topics
- Ongoing: Additional training for new hires and system updates

7.2 Operator Training

The SCADA Contractor shall provide comprehensive training for control room operators ensuring safe and efficient system operation.

Operator Training Curriculum:

Module 1: System Overview and Familiarization

- Railway electrification fundamentals: 25 kV AC system, OCS components, safety principles
- SCADA system architecture: Control centers, communication network, field equipment
- System scope: Geographic coverage, equipment inventory, operational boundaries
- User interface overview: HMI displays, navigation, alarm handling, control operations
- Safety and security: Operational safety procedures, cybersecurity awareness

Module 2: Normal Operations

- System monitoring: Data interpretation, trend analysis, status verification
- Routine switching: Normal switching procedures, equipment preparation, coordination
- Load management: Load monitoring, load transfer procedures, efficiency optimization
- Shift operations: Shift handover procedures, log entries, status updates
- Coordination: Coordination with maintenance, signaling, traffic control
- Practical exercises: 6 hours hands-on training using training simulator

Module 3: Alarm Management and Troubleshooting

- Alarm system: Alarm priorities, acknowledgment, filtering, correlation
- Alarm response: Standard response procedures, escalation procedures, documentation
- First-level troubleshooting: Common problems, basic diagnostic procedures
- Communication with maintenance: Problem reporting, coordination procedures
- Practical exercises: 4 hours simulator training with alarm scenarios

Module 4: Emergency Procedures

- Emergency classifications: Equipment failures, power system disturbances, external events
- Emergency response: Immediate actions, equipment isolation, system restoration
- Emergency coordination: Coordination with emergency services, management, external agencies
- LOTO integration: Emergency LOTO procedures, safety verification
- Incident documentation: Incident logging, reporting, post-incident procedures
- Practical exercises: 4 hours simulator training with emergency scenarios

Module 5: Advanced Operations and Special Procedures

- Advanced control: Complex switching sequences, system reconfiguration
- Maintenance support: Planned outage support, equipment isolation, testing support
- Performance optimization: Energy efficiency, system optimization techniques
- System administration: User management, display customization, report generation

Module 6: Competency Assessment

- Written examination: System knowledge, procedures, safety requirements
- Practical assessment: Simulator-based practical evaluation
- Scenario evaluation: Response to normal and emergency scenarios
- Competency certification: ISR competency certification upon successful completion

Operator Training Materials:

The SCADA Contractor shall provide:

- Student workbooks: Comprehensive training materials in Hebrew and English
- Quick reference guides: Laminated quick-reference cards for common procedures
- Video tutorials: Video demonstrations of key procedures and operations
- E-learning modules: Computer-based training for self-paced learning
- Simulator scenarios: 50+ training scenarios covering normal and emergency operations

7.3 Maintenance Training

The SCADA Contractor shall provide specialized training for maintenance personnel responsible for system upkeep and troubleshooting.

Maintenance Training Curriculum:

Module 1: System Architecture Deep Dive

- Control center systems: Servers, workstations, network equipment, power systems
- Communication network: Fiber optic systems, network equipment, protocols
- Field equipment: RTU hardware/software, IEC 61850 gateways, disconnector drives
- System integration: Interface connections, data flow, control sequences
- Maintenance philosophy: Preventive maintenance, condition-based maintenance, reliability

Module 2: Preventive Maintenance Procedures

- Maintenance schedules: Equipment-specific maintenance intervals and procedures
- Control center maintenance: Server maintenance, UPS testing, environmental systems
- Network maintenance: Fiber testing, equipment cleaning, performance monitoring
- Field equipment maintenance: RTU maintenance, disconnector maintenance, communication testing
- Documentation: Maintenance logging, work order management, spare parts management
- Practical exercises: 4 hours hands-on maintenance procedures

Module 3: Troubleshooting and Diagnostics

- Diagnostic tools: Test equipment, software tools, network analyzers
- Systematic troubleshooting: Problem identification, root cause analysis, solution implementation
- Control center troubleshooting: Server problems, network issues, software faults
- Field equipment troubleshooting: RTU faults, communication problems, equipment failures
- Performance analysis: Performance monitoring, trending, optimization
- Practical exercises: 4 hours troubleshooting scenarios

Module 4: Emergency Repairs and System Restoration

- Emergency response: Rapid problem identification and temporary repairs
- Spare parts management: Critical spare parts, emergency procurement procedures
- System restoration: Systematic restoration procedures, testing, verification
- Escalation procedures: When to escalate, vendor support, external resources

Module 5: Specialized Equipment Training

- Disconnector drives: Motor maintenance, position adjustment, testing procedures
- IEC 61850 gateways: Configuration, diagnostics, firmware updates
- Network equipment: Configuration, diagnostics, performance optimization
- Cybersecurity systems: Maintenance, log analysis, incident response

Maintenance Training Materials:

The SCADA Contractor shall provide:

- Technical manuals: Detailed technical documentation for all equipment
- Maintenance procedures: Step-by-step maintenance procedures with photos/diagrams
- Troubleshooting guides: Systematic troubleshooting flowcharts and procedures
- Spare parts catalog: Comprehensive spare parts catalog with ordering information
- Tool requirements: Required tools and test equipment specifications

7.4 Engineering Training

The SCADA Contractor shall provide advanced training for engineering staff responsible for system configuration, administration, and optimization.

Engineering Training Curriculum:

Module 1: System Design and Architecture

- Design principles: Redundancy, scalability, performance, security
- Communication network design: Topology, protocols, performance analysis
- SCADA architecture: Server design, database design, interface architecture
- Integration design: External system interfaces, data mapping, protocol selection
- Expansion planning: Capacity planning, infrastructure requirements, growth strategies

Module 2: System Configuration and Administration

- SCADA configuration: Point configuration, display development, alarm setup
- Database administration: Database management, backup/recovery, performance tuning
- Network administration: Switch configuration, routing, security policies
- User administration: User management, role definition, security administration
- System monitoring: Performance monitoring, health checks, optimization
- Practical exercises: 4 hours hands-on configuration

Module 3: Performance Monitoring and Optimization

- Performance metrics: KPI definition, measurement, trending
- System optimization: Performance tuning, bottleneck identification, capacity planning
- Troubleshooting tools: Advanced diagnostic tools, performance analysis software
- Reporting: Performance reporting, SLA monitoring, trend analysis

Module 4: Interface Management and Integration

- Interface design: Protocol selection, data mapping, error handling

- Interface testing: Testing procedures, validation methods, troubleshooting
- External system coordination: Coordination procedures, change management
- Future interfaces: Planning for additional interfaces, technology evolution

Engineering Training Materials:

The SCADA Contractor shall provide:

- System documentation: Complete system design documentation
- Configuration guides: Detailed configuration procedures and best practices
- Administration manuals: System administration procedures and tools
- API documentation: Complete API documentation for system interfaces
- Best practices guides: Industry best practices for SCADA system management

7.5 Training Documentation

The SCADA Contractor shall provide comprehensive training documentation supporting all training programs.

Training Documentation Requirements:

Instructor Materials:

- Instructor guides: Detailed lesson plans with teaching notes, timing, objectives
- Presentation materials: PowerPoint presentations for all training modules
- Assessment materials: Written tests, practical assessments, grading rubrics
- Instructor resources: Background materials, reference documents, FAQ

Student Materials:

- Student workbooks: Comprehensive training materials with exercises and examples
- Reference guides: Quick-reference materials for operational use
- Procedure cards: Laminated procedure cards for common operations
- Certificate templates: Training certificates for competency certification

Multimedia Materials:

- Video training: Professional video demonstrations of key procedures
- Interactive simulations: Computer-based simulations for self-paced learning
- Virtual reality training: VR training modules for hazardous procedure training (if applicable)
- Mobile learning: Mobile-compatible training materials for smartphone/tablet access

Language Requirements:

- Primary language: All materials in Hebrew

- Secondary language: All materials also available in English
- Translation quality: Professional technical translation with ISR review and approval
- Cultural adaptation: Materials adapted for Israeli railway operational culture

Documentation Standards:

- Format standards: Professional layout, consistent formatting, ISR branding
- Version control: Version numbering, change tracking, update procedures
- Distribution: Electronic and printed versions as requested
- Updates: Annual updates included in maintenance contract

8. DOCUMENTATION REQUIREMENTS

8.1 Design Documentation

The SCADA Contractor shall provide complete design documentation enabling system understanding, operation, and future modifications.

System Design Documentation:

Overall System Design:

- System requirements specification: Detailed functional and performance requirements
- System architecture document: Overall system architecture with interfaces and data flows
- Network design document: Communication network topology, protocols, performance analysis
- Security architecture document: Cybersecurity design, threat analysis, mitigation measures
- Integration design document: External system interfaces, protocols, data mapping

Control Center Design:

- Control center layout drawings: Detailed layout of control room, server room, support areas
- Equipment specifications: Complete specifications for all control center equipment
- Infrastructure design: Power, cooling, fire protection, physical security systems
- Network design: Control center network architecture, cabling, equipment layout
- Environmental design: HVAC design, temperature monitoring, environmental controls

Field Equipment Design:

- Site design standards: Standard designs for LOP, standard design for TSS
- Equipment specifications: Detailed specifications for RTUs, gateways, disconnectors
- Installation standards: Standard installation procedures and requirements
- Communication design: Field communication architecture, redundancy, performance

Software Design:

- Software architecture document: SCADA software architecture, modules, interfaces
- Database design document: Database schema, relationships, performance considerations
- HMI design document: Display hierarchy, navigation, user interface standards
- Interface design documents: Detailed design for each external system interface

Design Review Process:

The SCADA Contractor shall:

- Submit preliminary designs at 30% completion for ISR review
- Incorporate ISR comments and submit revised designs at 60% completion
- Submit final designs at 90% completion for final approval
- Obtain written ISR approval before proceeding to procurement/installation
- Maintain design change control throughout project execution

8.2 As-Built Documentation

The SCADA Contractor shall provide complete as-built documentation reflecting the actual installed system configuration.

As-Built Drawing Requirements:

Control Center As-Builts:

- Equipment layout drawings: Actual equipment positions with dimensions
- Cable routing drawings: All power, communication, and control cables
- Network diagrams: Actual network connectivity with IP addresses, VLANs
- Rack elevation drawings: Server rack layouts with equipment identification
- Infrastructure drawings: Power distribution, HVAC, fire protection as-installed

Network As-Builts:

- Fiber route drawings: Actual fiber routes with splice locations, test results
- Network topology diagrams: Complete network with all devices and connections
- IP address documentation: Complete IP address allocation and VLAN assignments
- Equipment location drawings: Physical locations of all network equipment
- Cable schedules: Complete cable schedules with termination information

Field Site As-Builts:

- Site layout drawings: Equipment locations, cable routing, access paths
- Single-line diagrams: Electrical connections for each site
- RTU wiring diagrams: Complete RTU termination information
- Communication connections: Communication cable routing and terminations

- Equipment identification: Complete equipment tags and identification

Configuration Documentation:

SCADA Configuration:

- Point database: Complete database of all monitoring and control points
- Display library: All HMI displays with revision control
- Alarm configuration: Complete alarm database with priorities and actions
- User configuration: User accounts, roles, and permissions
- Report configuration: All configured reports with schedules and recipients

Network Configuration:

- Switch configurations: Complete configuration files for all network switches
- Router configurations: Complete configuration files for all routers
- Firewall rules: Complete firewall rule sets and security policies
- VLAN configuration: VLAN assignments and inter-VLAN routing rules
- QoS configuration: Quality of service policies and implementation

Field Equipment Configuration:

- RTU configurations: Complete configuration files for all RTUs
- IEC 61850 configurations: SCL files and gateway configurations for all TSSs
- Control logic: All control logic programming for RTUs
- Communication parameters: Communication settings for all field devices

8.3 Operational Documentation

The SCADA Contractor shall provide comprehensive operational documentation enabling efficient system operation and maintenance.

Operating Procedures:

Normal Operations:

- System startup/shutdown: Complete procedures for planned system start/stop
- Daily operations: Routine operational procedures and checklists
- Shift procedures: Shift change procedures, handover checklists
- Switching procedures: Standard switching procedures for common operations
- Load management: Procedures for load monitoring and management
- Coordination procedures: Coordination with external parties (signaling, maintenance, etc.)

Emergency Procedures:

- Emergency response: Procedures for different emergency classifications
- Equipment failure response: Response to major equipment failures
- Communication failure: Procedures for communication system failures
- Power system restoration: Step-by-step restoration procedures
- Incident management: Incident classification, response, and recovery procedures
- Emergency contacts: Complete emergency contact information

System Administration:

- User management: Procedures for user account management and security
- Backup procedures: Database backup, system backup, recovery procedures
- Performance monitoring: System monitoring procedures and performance analysis
- Maintenance scheduling: Coordination of maintenance activities
- Change management: Procedures for system changes and updates

Operating Manuals:

Control Room Operations Manual:

- System overview: Complete system description for operators
- HMI operation: Detailed HMI operation procedures with screenshots
- Alarm handling: Comprehensive alarm response procedures
- Control operations: Step-by-step control procedures with safety requirements
- Troubleshooting: First-level troubleshooting guide for operators
- Emergency procedures: Emergency response procedures specific to control room operations

Field Operations Manual:

- Field equipment operation: Local operation procedures for field equipment
- Safety procedures: Field safety procedures and requirements
- Maintenance coordination: Procedures for coordinating with maintenance activities
- Emergency procedures: Field emergency procedures and contacts
- Equipment identification: Equipment identification and location information

8.4 Maintenance Documentation

The SCADA Contractor shall provide complete maintenance documentation ensuring reliable long-term system operation.

Preventive Maintenance Procedures:

Control Center Maintenance:

- Server maintenance: Preventive maintenance procedures for all servers

- UPS maintenance: Battery testing, UPS servicing, transfer switch testing
- HVAC maintenance: Air conditioning, heating, ventilation system maintenance
- Environmental monitoring: Temperature, humidity, air quality monitoring procedures
- Backup system testing: Regular testing of backup and recovery procedures
- Network equipment maintenance: Switch, router, firewall maintenance procedures

Field Equipment Maintenance:

- RTU maintenance: Preventive maintenance for all RTU types
- Disconnector maintenance: Mechanical and electrical maintenance procedures
- IEC 61850 gateway maintenance: Gateway hardware and software maintenance
- Communication equipment maintenance: Fiber equipment, switch maintenance
- Power system maintenance: Power supply, battery, surge protection maintenance
- Environmental protection: Enclosure maintenance, weatherproofing, corrosion protection

Maintenance Schedules:

Equipment Category	Maintenance Interval	Key Activities
Control Center Servers	Monthly	Performance monitoring, log analysis, disk cleanup
Power Supply Systems	Quarterly	Battery testing, transfer testing, maintenance records
HVAC Systems	Quarterly	Filter changes, performance testing, calibration
Network Equipment	Semi-annually	Cleaning, configuration backup, performance testing
RTUs	Semi-annually	Cleaning, calibration, communication testing
IEC 61850 Gateways	Annually	Performance testing, configuration backup, updates
Fiber Optic Systems	3 years	OTDR testing, splice inspection, equipment cleaning

Troubleshooting Guides:

Systematic Troubleshooting:

- Problem identification: Systematic approach to problem identification
- Diagnostic procedures: Step-by-step diagnostic procedures with decision trees
- Root cause analysis: Procedures for determining root causes
- Solution implementation: Systematic solution implementation and verification
- Documentation requirements: Requirements for documenting problems and solutions

Equipment-Specific Troubleshooting:

- Control center troubleshooting: Server, network, software troubleshooting procedures
- SCADA troubleshooting: SCADA software, database, interface troubleshooting
- Network troubleshooting: Communication network fault isolation and repair
- Field equipment troubleshooting: RTU, gateway, disconnector troubleshooting

- Performance troubleshooting: System performance problem identification and resolution

8.5 Training Documentation

Reference Section 0.37 for complete training documentation requirements.

9. WARRANTY AND SUPPORT

9.1 Warranty Terms

The SCADA Contractor shall provide comprehensive warranty coverage ensuring system reliability and performance throughout the warranty period.

Warranty Period:

- System warranty: Minimum 3 years from Final Acceptance
- Equipment warranty: Minimum 5 years from individual equipment commissioning
- Software warranty: Minimum 5 years including updates and patches
- Extended warranty option: Available for up to 5 additional years

Warranty Coverage:

Included in Warranty:

- All hardware: Control center equipment, field equipment, network equipment
- All software: SCADA software, operating systems, applications, databases
- Design defects: Errors in system design, configuration, integration
- Manufacturing defects: Equipment manufacturing defects and premature failures
- Performance deficiencies: Failure to meet specified performance requirements
- Documentation errors: Errors in documentation requiring system modifications

Warranty Performance Guarantees:

Parameter	Guaranteed Performance	Remedy for Non-Compliance
System Availability	≥99.99% annually	Service credits, system improvements
Data Point Availability	≥99.5% monthly	Equipment repair/replacement
Control Response Time	<2 seconds 95% of operations	System optimization, upgrades
Alarm Propagation Time	<5 seconds 95% of alarms	System tuning, improvements
Network Availability	≥99.9% per link monthly	Link repair, redundancy improvements
Server Failover Time	<5 seconds	Configuration optimization

Warranty Exclusions:

- Force majeure events: Natural disasters, war, terrorism
- Customer modifications: Unauthorized changes or modifications by ISR or third parties

- Misuse or abuse: Operation outside specified parameters or improper use
- Environmental damage: Damage from environmental conditions exceeding specifications

9.2 Support Services

The SCADA Contractor shall provide comprehensive technical support services ensuring optimal system operation.

Support Organization:

Local Support Team (Israel):

- Support manager: Full-time support manager based in Israel
- Field service engineers: Minimum 3 full-time engineers for field support
- Remote support engineers: Minimum 2 engineers for remote diagnostics and support
- Spare parts warehouse: Local spare parts inventory with 24-hour delivery
- 24/7 hotline: Hebrew language support hotline

Global Support Resources:

- Level 3 support: Access to manufacturer engineering support
- Software development: Access to software development resources for bug fixes
- Specialized expertise: Access to specialized technical expertise as needed
- Training resources: Ongoing access to training materials and resources

Support Response Requirements:

Priority Level	Response Time	Resolution Time	Escalation
P1 (Critical - System Down)	<2 hours	<8 hours	Immediate to global resources
P2 (High - Major Impact)	<4 hours	<24 hours	12 hours to Level 3
P3 (Medium - Minor Impact)	<8 hours	<72 hours	48 hours to Level 3
P4 (Low - Question/Request)	<24 hours	<1 week	As needed

Support Services Included:

Technical Support:

- Remote diagnostics: Remote access for problem diagnosis and resolution
- On-site support: Field engineer dispatch for complex problems
- Software support: Bug fixes, patches, minor enhancements
- Configuration support: Assistance with system configuration changes
- Performance optimization: System tuning and optimization
- Consultation: Technical consultation on system operation and expansion

Preventive Support:

- Health checks: Quarterly system health assessments
- Performance monitoring: Continuous remote performance monitoring
- Preventive maintenance: 2 preventive maintenance visits annually
- Upgrade planning: Planning assistance for system upgrades and expansion
- Best practices: Sharing of best practices from other installations

Documentation and Training:

- Documentation updates: Updates to documentation based on system changes
- Knowledge transfer: Ongoing knowledge transfer to ISR staff
- Training updates: Updates to training materials and additional training as needed
- User groups: Participation in user groups and technical forums

9.3 Spare Parts Management

The SCADA Contractor shall establish a comprehensive spare parts program ensuring rapid restoration of failed equipment.

Spare Parts Philosophy:

- Strategic sparing: Intelligent sparing based on criticality, failure rates, lead times
- Local inventory: Critical spare parts maintained in Israeli inventory
- Global supply chain: Access to global spare parts inventory for specialized items
- Obsolescence management: Proactive management of obsolete parts with alternatives

Spare Parts Categories:

Critical Spare Parts (0-4 hour availability):

- Control center: Server components, power supplies, network interface cards
- Network: Fiber optic transceivers, switch modules, router cards
- Field equipment: RTU CPU modules, communication boards, power supplies
- Infrastructure: UPS batteries, HVAC components, critical electrical components
- Inventory level: 2+ units for each critical component type

Standard Spare Parts (4-24 hour availability):

- Control center: Workstation components, display components, peripheral devices
- Network: Standard switches, routers, cables, connectors
- Field equipment: RTUs, I/O modules, sensors, mechanical components
- Infrastructure: Standard electrical components, cables, connectors
- Inventory level: 1+ unit for each standard component type, or guaranteed delivery within 24 hours

Long-Lead Spare Parts:

- Specialized equipment: specialized gateways, major assemblies
- Major components: Servers, large network equipment, motorized disconnectors
- Availability: Guaranteed availability or lead time disclosure with alternatives
- Inventory: Based on criticality analysis and ISR risk tolerance

Spare Parts Services:

Inventory Management:

- Parts database: Complete database of all spare parts with specifications and suppliers
- Inventory tracking: Real-time inventory tracking with automatic reorder points
- Forecasting: Spare parts demand forecasting based on usage history and trends
- Procurement: Spare parts procurement and logistics management
- Quality control: Incoming inspection and quality control for spare parts

Parts Availability Guarantee:

- 15-year availability: Guarantee spare parts availability for minimum 15 years
- Obsolescence notification: 24-month advance notification of parts obsolescence
- Alternative parts: Identification and qualification of alternative/upgraded parts
- Long-term support: Options for extended spare parts support beyond 15 years
- Emergency procurement: Expedited procurement for emergency situations

9.4 Software Updates and Patches

The SCADA Contractor shall provide ongoing software maintenance ensuring system security, reliability, and functionality.

Software Maintenance Scope:

- Operating systems: All server and workstation operating systems
- SCADA software: All SCADA applications and related software
- Database software: Database management systems and related tools
- Network software: Network management, security, and infrastructure software
- Security software: Antivirus, firewall, intrusion detection software

Update Categories:

Security Updates (Immediate):

- Critical security patches: Deploy within 72 hours of release
- Security updates: Deploy within 2 weeks of release
- Emergency patches: Immediate deployment for active threats

- Testing: Accelerated testing process for security updates
- Rollback: Rapid rollback capability for problematic security updates

Bug Fixes and Patches (Regular):

- Bug fix patches: Monthly patch deployment cycle
- Minor enhancements: Quarterly minor enhancement releases
- Compatibility updates: Updates for hardware/software compatibility
- Testing: Comprehensive testing in development environment before deployment
- Documentation: Complete documentation of all changes and impacts

Major Updates (Planned):

- Version upgrades: Annual major version upgrades
- Feature enhancements: New features and significant improvements
- Technology updates: Updates for new technologies and standards
- Migration support: Full support for major version migrations
- Training: Training updates for new features and capabilities

Software Update Process:

Development and Testing:

- Development environment: SCADA Contractor maintains development environment matching ISR production
- Testing procedures: Comprehensive testing including regression testing
- ISR testing: ISR approval required for major updates
- Rollback procedures: Complete rollback procedures and testing

Deployment:

- Maintenance windows: Updates deployed during approved maintenance windows
- Phased deployment: Critical updates deployed in phases (test, production)
- Monitoring: Extensive monitoring during and after deployment
- Support: Enhanced support during update deployment periods
- Documentation: Updated documentation delivered with each update

Support for Custom Modifications:

- Change control: Formal change control process for custom modifications
- Compatibility: Ensure custom modifications remain compatible with updates
- Testing: Additional testing for systems with custom modifications
- Support: Continued support for approved custom modifications

10. PROJECT MANAGEMENT

10.1 Project Organization

The SCADA Contractor shall establish a comprehensive project organization ensuring successful project delivery.

Project Management Structure:

SCADA Contractor Project Team:

- Project Manager: Senior project manager with minimum 15 years SCADA project experience
- Deputy Project Manager: Deputy with minimum 10 years' experience for backup and continuity
- Technical Manager: Senior technical manager responsible for technical delivery
- Quality Manager: Quality assurance manager ensuring compliance with standards
- Safety Manager: Safety manager ensuring compliance with safety requirements

Functional Managers:

- Engineering Manager: Responsible for system design and engineering
- Software Manager: Responsible for software development and configuration
- Installation Manager: Responsible for field installation and commissioning
- Testing Manager: Responsible for all testing and acceptance activities
- Training Manager: Responsible for training program delivery

Discipline Leads:

- Control Systems Engineer: SCADA systems design and configuration
- Communication Engineer: Network design and implementation
- Field Equipment Engineer: RTU, gateway, and disconnector engineering
- Cybersecurity Engineer: Security design and implementation
- Integration Engineer: External system interfaces and integration

ISR Project Organization:

- Project Director: ISR senior management representative
- Project Manager: Day-to-day project management and coordination
- Technical Manager: Technical oversight and acceptance
- Operations Manager: Operational requirements and procedures
- Engineering Manager: Engineering standards and long-term support

10.2 Key Personnel Requirements

The SCADA Contractor shall provide experienced key personnel for critical project roles.

Key Personnel Minimum Qualifications:

Project Manager:

- Education: Engineering degree or equivalent
- Experience: 15+ years project management, 10+ years SCADA projects
- Certifications: PMP certification preferred
- Language: Fluent English
- Location: Based in Israel for project duration

Technical Manager:

- Education: Electrical engineering degree
- Experience: 15+ years SCADA systems, 5+ years technical management
- Expertise: IEC 61850, IEC 60870-5-104, railway electrification systems
- Previous projects: Minimum 3 similar railway SCADA projects
- Standards knowledge: Deep knowledge of relevant international standards

Engineering Manager:

- Education: Electrical/Control systems engineering degree
- Experience: 12+ years SCADA engineering, 3+ years management
- Expertise: System architecture, communication networks, cybersecurity
- Design experience: Large-scale SCADA system design and implementation
- Integration experience: Complex multi-vendor system integration

Software Manager:

- Education: Computer science/engineering degree
- Experience: 10+ years SCADA software development/configuration
- Programming: Multiple programming languages, database management
- SCADA platforms: Experience with major SCADA platforms
- Quality: Software quality assurance and testing experience

Installation Manager:

- Education: Electrical/mechanical engineering or equivalent
- Experience: 10+ years field installation, 3+ years railway experience
- Certifications: Relevant electrical and safety certifications
- Safety: Extensive safety training and experience
- Logistics: Experience managing large-scale installations

Personnel Commitment:

The SCADA Contractor shall:

- Maintain key personnel: No changes without ISR approval and 60-day notice
- Provide backups: Qualified backup personnel for all key positions
- Local presence: Key personnel based in Israel during critical project phases
- Continuity: Ensure personnel continuity throughout project lifecycle
- Performance: Replace non-performing personnel within 30 days of ISR request

10.3 Schedule Management

The SCADA Contractor shall develop and maintain detailed project schedules ensuring on-time delivery.

Master Schedule Requirements:

The SCADA Contractor shall provide:

- Master schedule: CPM schedule with minimum 2,000 activities
- Detail level: Activities of maximum 2-week duration
- Critical path: Clear identification of critical path activities
- Milestones: Major milestones aligned with contract requirements
- Resources: Resource loading and leveling
- Risk integration: Integration with risk management and mitigation

Schedule Control:

Progress Monitoring:

- Weekly updates: Weekly schedule updates with progress measurement
- Variance analysis: Analysis of schedule variances and corrective actions
- Look-ahead schedules: 4-week and 12-week look-ahead schedules
- Milestone tracking: Detailed tracking of milestone achievement

Schedule Reporting:

- Monthly reports: Detailed monthly schedule progress reports
- Dashboard reporting: Executive dashboard with key metrics and trends
- Variance reporting: Schedule variance analysis and recovery plans
- Milestone reports: Status reports for major milestones
- ISR integration: Schedule integration with ISR systems and procedures

Key Project Milestones:

Milestone	Target Month	Description	ISR Approval Required
Design Approval	Month 6	Final design approval	Yes
Simulator Operational	Month 6	Training simulator commissioned	Yes
Lod Control Center Complete	Month 9	Lod control center operational	Yes
Haifa Control Center Complete	Month 12	Haifa control center operational	Yes
Network Infrastructure Complete	Month 18	Complete fiber network operational	Yes
Pilot Complete	Month 24	Pilot fully migrated	Yes
Field Migration Complete	Month 36	All sites migrated	Yes
System Integration Complete	Month 42	All interfaces operational	Yes
Final Acceptance	Month 48	Project complete and accepted	Yes

10.4 Risk Management

The SCADA Contractor shall implement comprehensive risk management ensuring project success despite uncertainties.

Risk Management Process:

Risk Identification:

- Risk register: Comprehensive risk register updated monthly
- Risk categories: Technical, schedule, cost, external, operational risks
- Risk sources: Lessons learned, expert judgment, historical data, stakeholder input
- Risk workshops: Monthly risk identification workshops with project team
- External risks: Coordination with ISR for external and interface risks

Risk Assessment:

- Probability assessment: Quantitative probability estimates (0-1 scale)
- Impact assessment: Cost, schedule, performance, and safety impact assessment
- Risk scoring: Probability × Impact risk scoring matrix
- Risk prioritization: Focus on high-probability, high-impact risks
- Risk tolerance: Definition of acceptable risk levels

Risk Response Planning:

- Mitigation strategies: Proactive measures to reduce probability or impact
- Contingency plans: Response plans for high-impact risks if they occur

- Risk ownership: Clear assignment of risk ownership and response responsibility
- Resource allocation: Resources allocated for risk mitigation and response
- Schedule buffers: Schedule contingencies for high-impact schedule risks

Key Project Risk Categories:

Technical Risks:

- System integration: Risks related to multi-vendor system integration
- Performance: Risks of not meeting performance specifications
- Compatibility: Compatibility risks with existing systems and interfaces
- Technology: Technology obsolescence and vendor support risks
- Cybersecurity: Security vulnerabilities and cyber attack risks

Schedule Risks:

- Resource availability: Availability of skilled personnel and materials
- Permit and approvals: Delays in permits, approvals, and regulatory processes
- Weather: Weather impacts on outdoor installation activities
- Site access: Limitations and restrictions on site access for installations
- Dependencies: Dependencies on ISR, external parties, and interface providers

External Risks:

- Regulatory changes: Changes in regulations affecting system requirements
- External interfaces: Risks related to external system interfaces and coordination
- ISR operations: Impact of ongoing operations on project activities
- Supply chain: Supply chain disruptions and vendor performance issues
- Economic: Economic conditions affecting costs and resource availability

10.5 Change Management

The SCADA Contractor shall establish formal change management procedures ensuring controlled project evolution.

Change Control Process .Change Management and Migration .As a condition precedent to the commencement of any SCADA Works involving the live ISR network or any migration activities, the Contractor shall submit to ISR, for its prior written approval, a comprehensive Change Management Plan and a Migration Risk Assessment .These documents shall detail the procedures, fallback plans, and risk mitigation measures required to ensure absolute continuity and zero disruption to the operational railway network during the execution of the SCADA Works. ISR reserves the right to reject, suspend, or halt any SCADA Works if it deems, at its sole discretion, that the Contractor's change management procedures pose a risk to the live network

Change Identification:

- Change sources: ISR requests, design improvements, regulatory changes, vendor changes

- Change documentation: Formal change request documentation with technical details
- Impact assessment: Technical, cost, schedule, and risk impact analysis
- Stakeholder review: Review by affected stakeholders and technical experts
- Change classification: Classification by magnitude, urgency, and approval authority

Change Evaluation:

- Technical review: Technical feasibility and integration impact analysis
- Cost analysis: Detailed cost impact including direct and indirect costs
- Schedule analysis: Schedule impact and critical path analysis
- Risk assessment: Risk analysis for proposed changes
- Alternative analysis: Evaluation of alternative approaches

Change Implementation:

- Implementation planning: Detailed implementation plans for approved changes
- Documentation updates: Updates to all affected documentation
- Testing requirements: Additional testing requirements for changes
- Training updates: Updates to training materials and programs
- Configuration control: Updates to configuration management systems

Change Control Documentation:

- Change log: Comprehensive log of all changes with status tracking
- Change orders: Formal change orders for significant changes
- Impact analysis: Detailed impact analysis for each change
- Approval records: Complete approval documentation and audit trail
- Lessons learned: Documentation of lessons learned from change management

11. QUALITY CONTROL and ASSURANCE

11.1 Quality Management System

The SCADA Contractor shall implement a comprehensive Quality Management System (QMS) ensuring delivery of high-quality systems and services.

QMS Requirements:

ISO 9001:2015 Compliance:

- QMS certification: ISO 9001:2015 certified organization
- Quality policy: Documented quality policy aligned with project requirements
- Quality objectives: Measurable quality objectives for project delivery
- Management responsibility: Senior management commitment and oversight
- Resource management: Adequate resources allocated to quality activities
- Continuous improvement: Systematic approach to continuous improvement

Quality Planning:

- Quality plan: Project-specific quality plan addressing all project phases
- Quality standards: Compliance with all applicable quality standards
- Quality procedures: Documented procedures for all quality-critical activities
- Quality metrics: Key quality metrics and performance indicators
- Quality reviews: Regular quality reviews and management assessments

Quality Organization:

Quality Management Team:

- Quality Manager: Full-time quality manager for project duration
- Quality Engineers: Quality engineers assigned to major work packages
- Quality Inspectors: Field quality inspectors for installation activities
- Independent verification: Independent verification and validation team
- Quality auditors: Internal quality audit team

Quality Responsibilities:

- Quality Manager: Overall quality responsibility and management system oversight
- Technical disciplines: Quality responsibility within each technical discipline
- Project Manager: Quality integration and overall quality accountability
- Subcontractors: Quality requirements flow-down to all subcontractors
- ISR interface: Quality coordination and reporting to ISR

11.2 Quality Control Procedures

The SCADA Contractor shall implement systematic quality control procedures for all project deliverables.

Design Quality Control:

Design Reviews:

- Preliminary design review: 30% design review focusing on requirements compliance
- Critical design review: 60% design review focusing on technical adequacy
- Final design review: 90% design review focusing on implementation readiness
- Peer reviews: Independent peer reviews for critical design elements
- ISR reviews: ISR review and approval at each design milestone

Design Verification:

- Requirements traceability: Complete traceability from requirements to design
- Design calculations: Verification of all design calculations and assumptions
- Standards compliance: Verification of compliance with all applicable standards

- Interface verification: Verification of all interface designs and compatibility
- Design validation: Validation of design against operational requirements

Manufacturing Quality Control:

Supplier Quality:
- Supplier qualification: Qualification of all major suppliers and subcontractors
- Quality agreements: Quality agreements with all suppliers
- Source inspection: Source inspection of critical components at supplier facilities
- Receiving inspection: Inspection of all delivered components and equipment
- Supplier monitoring: Ongoing monitoring of supplier quality performance

Configuration Management:
- Configuration control: Strict control of hardware and software configurations
- Change control: Controlled change processes for all configuration items
- Version control: Version control for all software and documentation
- Configuration audits: Regular configuration audits to verify compliance
- Asset management: Complete asset management and tracking

Installation Quality Control:

Installation Procedures:
- Work procedures: Detailed work procedures for all installation activities
- Quality checkpoints: Quality checkpoints at critical installation stages
- Inspection holds: Mandatory inspection points requiring quality approval
- Workmanship standards: Clear workmanship standards and acceptance criteria
- Installation records: Complete installation records and documentation

Testing and Commissioning Quality:
- Test procedures: Detailed test procedures for all testing activities
- Test documentation: Complete test documentation and result recording
- Non-conformance handling: Systematic handling of test failures and non-conformances
- Acceptance criteria: Clear acceptance criteria for all tests and commissioning activities
- Performance verification: Verification of performance against specifications

11.3 Inspection and Testing

The SCADA Contractor shall perform comprehensive inspection and testing throughout the project lifecycle.

Inspection Program:

Design Inspections:

- Document reviews: Systematic review of all design documents
- Calculation checks: Independent checking of all design calculations
- Standards verification: Verification of compliance with applicable standards
- Interface reviews: Reviews of all system interfaces and integration points
- Design walkthrough: Systematic walkthrough of complete system design

Manufacturing Inspections:

- Incoming inspection: Inspection of all materials and components upon receipt
- In-process inspection: Inspections during manufacturing and assembly processes
- Final inspection: Final inspection before shipment from manufacturing facility
- Quality records: Complete quality records for all manufactured items
- Certification: Certificates of compliance for all manufactured components

Installation Inspections:

- Pre-installation inspection: Verification of site conditions and readiness
- In-process inspection: Inspections during installation activities
- Completion inspection: Final inspection upon completion of installation work
- Safety inspections: Safety inspections throughout installation process
- Environmental inspections: Inspections for environmental compliance

Testing Program:

Component Testing:

- Unit testing: Testing of individual components and subsystems
- Integration testing: Testing of integrated subsystems
- Environmental testing: Testing under environmental conditions
- Performance testing: Verification of performance specifications
- Reliability testing: Testing for reliability and endurance

System Testing:

- Factory Acceptance Testing: Comprehensive testing of supplier facilities
- Site Acceptance Testing: Complete system testing at installation sites
- Integration testing: End-to-end system integration testing
- Performance verification: Verification of system performance requirements
- Stress testing: Testing under maximum load conditions

Acceptance Testing:

- Functional testing: Verification of all specified functions
- Performance testing: Verification of all performance requirements
- Interface testing: Testing of all external system interfaces
- Security testing: Verification of cybersecurity requirements
- Operational testing: Testing under actual operational conditions

11.4 Non-Conformance Management

The SCADA Contractor shall implement systematic non-conformance management ensuring effective resolution of quality issues.

Non-Conformance Identification:

Detection Methods:

- Inspections: Detection during planned inspections and reviews
- Testing: Detection during testing activities
- Audits: Detection during internal and external audits
- Customer feedback: Detection through ISR feedback and observations
- Self-reporting: Self-reporting by project team members

Documentation:

- Non-conformance reports: Formal documentation of all non-conformances
- Classification: Classification by severity, impact, and urgency
- Tracking: Tracking system for all non-conformances through resolution
- Notification: Notification to affected parties and management
- Recording: Recording in quality management system

Non-Conformance Resolution:

Root Cause Analysis:

- Investigation: Systematic investigation of non-conformance causes
- Analysis methods: Use of appropriate root cause analysis tools (5-why, fishbone, etc.)
- Documentation: Documentation of root cause analysis results
- Verification: Verification of root cause analysis conclusions
- Reporting: Reporting of root cause analysis to management

Corrective Actions:

- Action planning: Development of corrective action plans

- Implementation: Implementation of corrective actions
- Verification: Verification of corrective action effectiveness
- Prevention: Preventive actions to prevent recurrence
- Documentation: Complete documentation of corrective actions

Non-Conformance Categories:

Category	Response Time	Resolution Time	Escalation
Critical (Safety/Security)	<2 hours	<24 hours	Immediate to senior management
Major (Performance Impact)	<8 hours	<72 hours	24 hours to project management
Minor (Documentation/Process)	<24 hours	<1 week	72 hours to quality manager
Administrative	<72 hours	<2 weeks	Weekly quality review

Quality Metrics:

The SCADA Contractor shall track and report:

- Non-conformance rates: Number and rate of non-conformances by category
- Resolution times: Time to resolve non-conformances by category
- Root cause trends: Trending of root causes for systemic improvements
- Corrective action effectiveness: Effectiveness of corrective actions in preventing recurrence
- Quality costs: Costs associated with quality issues and improvements

12. STANDARDS AND COMPLIANCE

12.1 International Standards

IEC 60870-5-104 Implementation Requirements:

- Master/slave configuration: Multiple master capability, slave redundancy
- Data transmission: Cyclic, spontaneous, and interrogated data transmission
- Time synchronization: Accurate time synchronization with GPS reference
- Security extensions: Authentication, encryption, digital signatures per IEC 62351
- Quality descriptors: Complete implementation of quality bits and descriptors
- Testing: Interoperability testing with certified test tools

IEC 61850 Implementation Requirements:

- Edition 2.1 compliance: Full compliance with latest IEC 61850 edition
- Logical nodes: Complete implementation of relevant logical nodes (XCBR, XSWI, MMXU, etc.)
- GOOSE messaging: High-speed peer-to-peer communication for protection applications

- MMS services: Manufacturing Message Specification for client-server communication
- SCL configuration: System Configuration Language for engineering tools
- Sample values: Implementation of sampled value transmission where applicable
- Security: Implementation of IEC 62351 security extensions

IEC 62443 Cybersecurity Standards:

- IEC 62443-3-3: System security requirements and security levels (SL-2 minimum)
- IEC 62443-4-2: Component security requirements for IACS components
- Security levels: Implementation of Security Level 2 throughout system
- Security lifecycle: Complete security lifecycle management
- Risk assessment: Systematic cybersecurity risk assessment and mitigation
- Security testing: Comprehensive security testing and validation

IEC 61508 Functional Safety:

- Safety lifecycle: Complete safety lifecycle implementation
- SIL assessment: Safety Integrity Level assessment for safety functions
- SIL 2 compliance: Minimum SIL 2 for safety-related functions
- Safety case: Complete safety case documentation
- Verification and validation: Independent V&V of safety functions

ISO Standards Compliance:

ISO 9001:2015 Quality Management Systems:

- QMS certification: ISO 9001:2015 certified organization required
- Quality policy: Documented quality policy and objectives
- Process approach: Process-based quality management system
- Risk-based thinking: Integration of risk management in quality processes
- Continuous improvement: Systematic continuous improvement processes

ISO/IEC 27001 Information Security Management:

- ISMS certification: ISO 27001 certified organization preferred
- Security policy: Comprehensive information security policy
- Risk management: Systematic information security risk management
- Security controls: Implementation of relevant security controls from ISO 27002
- Security monitoring: Continuous security monitoring and assessment

IEEE Standards Compliance:

IEEE 802 Series - Local and Metropolitan Area Networks:

- IEEE 802.1Q: VLAN implementation with priority tagging
- IEEE 802.1w: Rapid Spanning Tree Protocol for network redundancy
- IEEE 802.1X: Network access control and authentication
- IEEE 802.3af/at: Power over Ethernet for powered devices
- IEEE 802.11: Wireless LAN standards for mobile applications

IEEE 1588 Precision Time Protocol (PTP):

- PTP v2 implementation: IEEE 1588-2008 implementation
- Accuracy requirements: ±1 microsecond accuracy for time-critical applications
- Clock hierarchy: Master/slave clock hierarchy implementation
- Network support: PTP-aware network equipment throughout system

IEEE 1613 Environmental and Testing Requirements:

- Environmental conditions: IEC 61850-3 environmental requirements
- EMC requirements: Electromagnetic compatibility per IEC 61000 series
- Power supply: AC and DC power supply requirements
- Testing: Type testing and routine testing requirements

ISR Standards and Procedures:

Operational Procedures:

- Train operations: Integration with train operation procedures
- Maintenance procedures: Alignment with ISR maintenance procedures
- Safety procedures: Compliance with ISR safety management system
- Emergency procedures: Integration with ISR emergency response procedures
- Documentation standards: Compliance with ISR documentation standards

12.3 Railway-Specific Standards

The SCADA Contractor shall comply with European railway-specific standards.

EN 50128 - Railway Software Standards:

- Software safety: Software development according to railway safety standards
- Safety integrity levels: SIL classification and development processes
- Verification and validation: Independent V&V processes for safety software
- Configuration management: Software configuration management throughout lifecycle
- Quality assurance: Quality assurance processes for software development

EN 50129 - Safety Related Electronic Systems:

- Safety lifecycle: Complete safety lifecycle for electronic systems
- Hazard analysis: Systematic hazard analysis and risk assessment
- Safety case: Development of complete safety case documentation
- Independent safety assessment: Independent assessment of safety systems
- Safety approval: Safety approval processes and certification

EN 50121 - Railway EMC Standards:

- EMC emissions: Electromagnetic emission requirements for railway equipment
- EMC immunity: Electromagnetic immunity requirements and testing
- Installation requirements: EMC installation requirements and practices
- Testing procedures: EMC testing procedures and acceptance criteria
- Certification: EMC type approval and certification requirements

EN 50126: Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

- Identification of the RAMS effects of the system concept
- Identification of RAMS requirements for similar systems
- Identification of RAMS-related strategy and RAMS-related goals
- Establishing the RAMS plan and the validation plan
- Facilitation of the RAMS risk analysis
- Establishing the RAMS requirements specification
- Establishing and updating the hazard log according to CSM-RA and the RAMS management report
- Updating RAMS and validation plan
- Updating RAMS analysis
- Performing RAM and safety demonstration
- Updating the RAMS management report
- Establishing the RAMS validation report
- Definition and coordination of the application conditions for the system (SRAC)
- Updating the hazard log
- Implementation and maintenance of a FRACAS process
- Continuous reporting on RAM performance and evaluation
- Evaluation of the RAMS-related impacts of decommissioning and disposal
- Updating the operator's hazard log

Railway Electrification Standards:

- IEC 62128: Railway power supply systems' requirements

- EN 50163: Supply voltages of traction systems (25 kV AC 50 Hz)
- EN 50122: Railway earthing, bonding and return circuit requirements
- EN 50124: Railway insulation coordination requirements
- EN 50125: Railway environmental conditions and testing
- ISO/TS 22163: Railway applications — Railway quality management system — ISO 9001:2015 and specific requirements for application in the railway sector
- EN 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems
- EN 60300: Dependability management
- EN 50716: Railway applications — Requirements for software development
- EN 50129: Railway applications — Communication, signaling and processing systems — Safety related electronic systems for signaling
- EN 50562: Railway applications — Fixed installations — Electrical safety, earthing and the return circuit
- EN 50657: Railway applications — Rolling stock applications — Software on board rolling stock
- EN 50159: Railway applications — Communication, signaling and processing systems — Safety-related communication in transmission systems

Interoperability Standards:

- ERA TSI Energy: Technical Specification for Interoperability - Energy subsystem
- ERA TSI Control-Command: Technical Specification for Interoperability - CCS
- ETCS specifications: European Train Control System interface requirements

12.4 Cybersecurity Standards

The SCADA Contractor shall implement comprehensive cybersecurity measures complying with industrial cybersecurity standards.

IEC 62443 Industrial Automation and Control Systems Security:

IEC 62443-3-3 System Security Requirements:

- Security Level 2 (SL-2): Minimum security level implementation throughout system
- Security zones: Network segmentation into appropriate security zones
- Conduits: Secure communication conduits between security zones
- Security functions: Implementation of required security functions by SL
- Risk assessment: Systematic cybersecurity risk assessment

Security Level 2 Requirements:

- Identification and authentication: Unique identification and authentication of users
- Use control: Authorization and access control for users and processes
- System integrity: Protection against unauthorized system modifications

- Data confidentiality: Protection of sensitive information
- Restricted data flow: Control of information flows between zones
- Timely response to events: Detection and response to security events
- Resource availability: Protection against denial of service attacks

IEC 62443-4-2 Component Security Requirements:
- Component classification: Security classification of all system components
- Security capabilities: Implementation of required security capabilities
- Security lifecycle: Security lifecycle management for all components
- Vulnerability management: Systematic vulnerability identification and management
- Security testing: Security testing of all components

ISO/IEC 27001 Information Security Management:
- ISMS implementation: Complete Information Security Management System
- Security policy: Comprehensive information security policy and procedures
- Risk management: Information security risk assessment and treatment
- Security controls: Implementation of relevant controls from ISO 27002
- Management review: Regular management review of ISMS effectiveness

NIST Cybersecurity Framework:
- Framework implementation: Implementation aligned with NIST CSF structure
- Identify: Asset management, governance, risk assessment, risk management
- Protect: Access control, awareness training, data security, protective technology
- Detect: Anomaly detection, continuous monitoring, detection processes
- Respond: Response planning, communications, analysis, mitigation, improvements
- Recover: Recovery planning, improvements, communications

Network Security Implementation:

Perimeter Security:
- Firewalls: Next-generation firewalls with deep packet inspection
- Intrusion detection: Network-based intrusion detection and prevention systems
- VPN systems: Secure VPN systems for remote access
- Network access control: 802.1X network access control implementation
- Network segmentation: VLAN-based network segmentation and micro-segmentation

Endpoint Security:
- Antivirus/anti-malware: Enterprise-grade endpoint protection

- Host-based firewalls: Host-based firewall on all endpoints
- Patch management: Systematic patch management for all systems
- Device control: USB and removable media control
- Application whitelisting: Application control and whitelisting where appropriate

Security Monitoring:

- SIEM system: Security Information and Event Management system
- Log management: Centralized log collection and management
- Security monitoring: 24/7 security monitoring and incident response
- Threat intelligence: Integration of threat intelligence feeds
- Forensic capabilities: Digital forensic capabilities for incident response

12.5 Environmental Standards

The SCADA Contractor shall comply with environmental standards ensuring sustainable and environmentally responsible system implementation.

ISO 14001 Environmental Management Systems:

- EMS certification: ISO 14001 certified organization preferred
- Environmental policy: Documented environmental policy and objectives
- Environmental planning: Environmental planning and impact assessment
- Implementation: Environmental management system implementation
- Monitoring: Environmental monitoring and measurement
- Improvement: Continual environmental improvement

Equipment Environmental Standards:

IP Ratings (Ingress Protection):

- Outdoor equipment: Minimum IP65 rating for all outdoor equipment
- Indoor equipment: Minimum IP20 rating for indoor equipment
- Special environments: Higher IP ratings for harsh environments
- Testing: IP rating verification testing per IEC 60529

Operating Temperature Ranges:

- Outdoor equipment: -40°C to +70°C operating temperature range
- Indoor equipment: 0°C to +50°C operating temperature range
- Humidity: 5% to 95% relative humidity (non-condensing)
- Altitude: Operation up to 2000m above sea level

EMC and Environmental Testing:

- IEC 61000-4-2: Electrostatic discharge immunity testing
- IEC 61000-4-3: Radiated electromagnetic field immunity testing
- IEC 61000-4-4: Electrical fast transient immunity testing
- IEC 61000-4-5: Surge immunity testing
- IEC 61000-6-2: Generic immunity standard for industrial environments

Regulatory Compliance:

RoHS Directive Compliance:

- Restricted substances: Compliance with EU RoHS directive restrictions
- Lead-free: Lead-free soldering and manufacturing processes
- Documentation: RoHS compliance documentation for all equipment
- Testing: Third-party testing for RoHS compliance verification
- Supply chain: RoHS compliance throughout supply chain

APPENDIX C – EXAMPLES OF TYPICAL CROSS-SECTION DESIGNS*

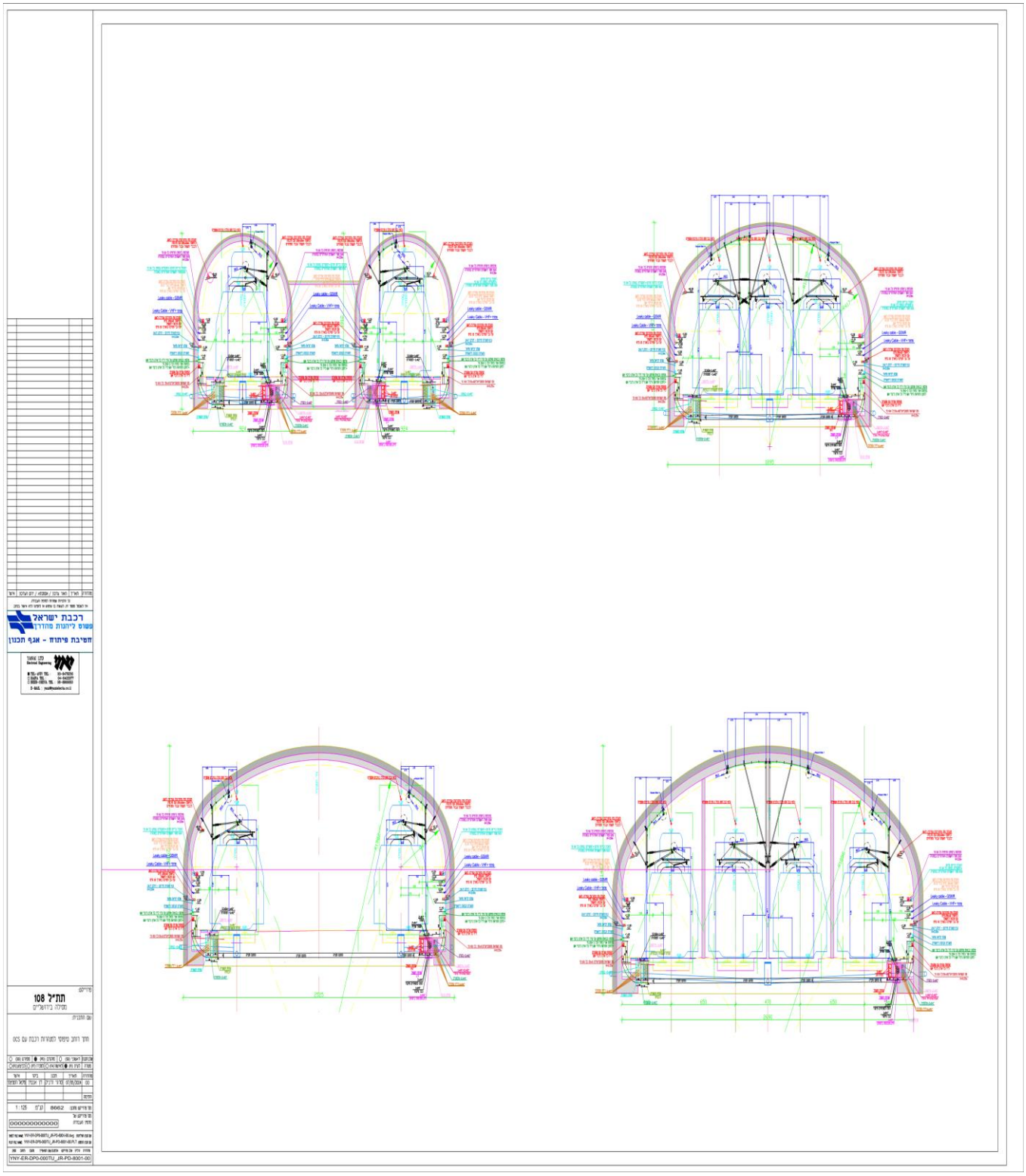


FIGURE 1 – TUNNEL TYPICAL CROSS SECTION

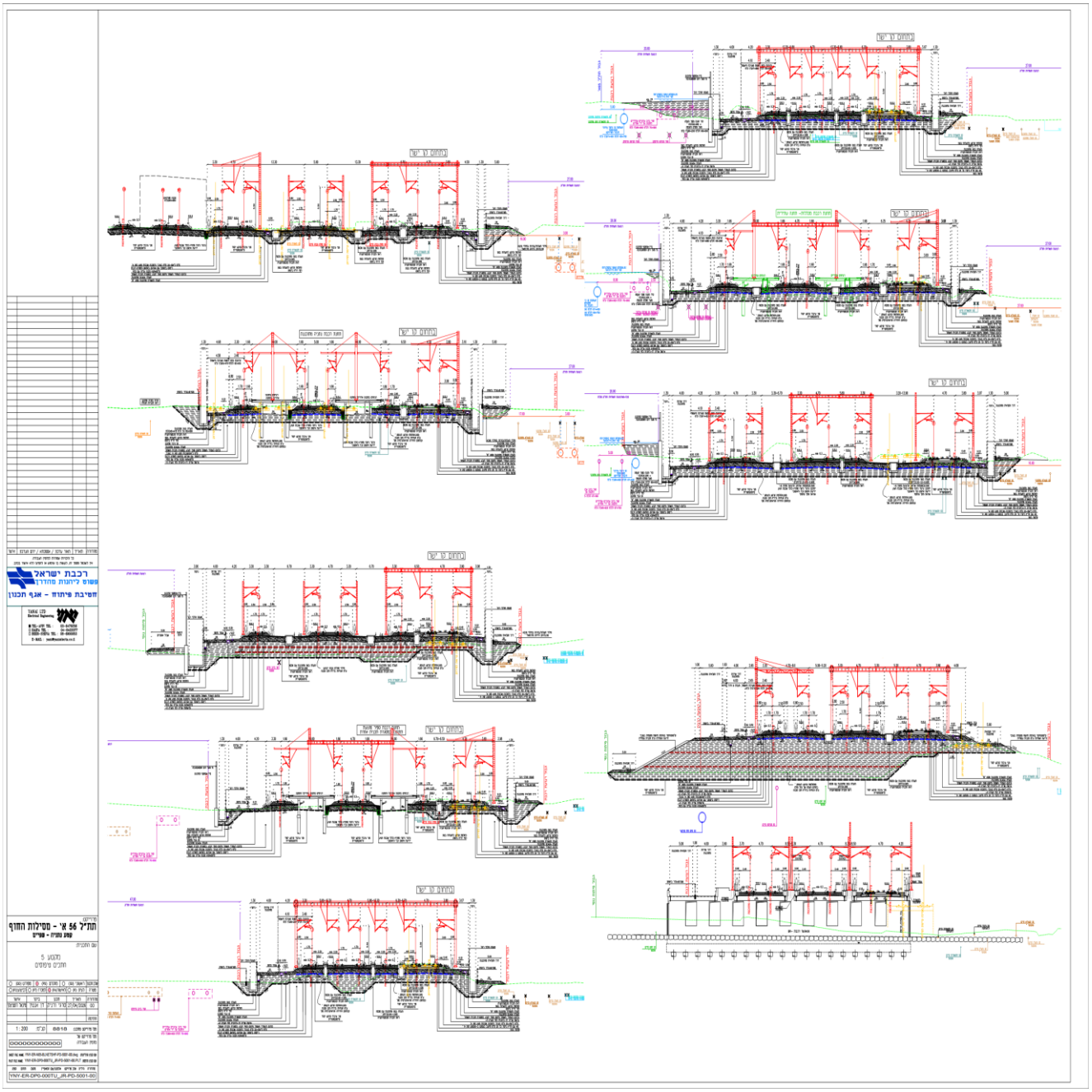
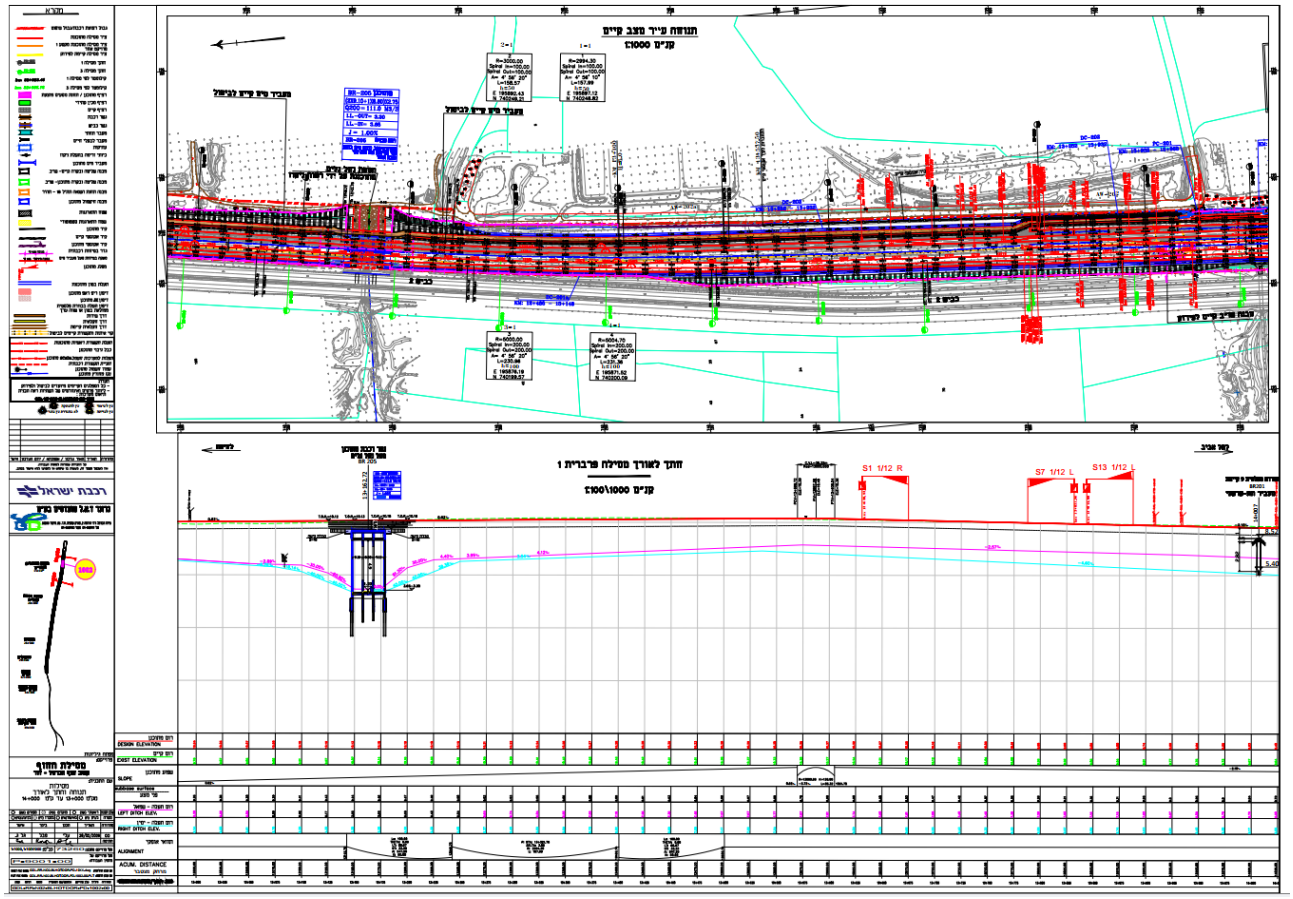


FIGURE 2 – TATAL 65 TYPICAL CROSS SECTIONS (Section 5)

* The information included in this Appendix C is provided to the Bidders for reference purposes only and is subject to the provisions of Section 2.15 (Information Supplied to Bidders) of the ITB.

APPENDIX D – EXAMPLES OF TYPICAL PLAN AND PROFILE



* The information included in this Appendix C is provided to the Bidders for reference purposes only and is subject to the provisions of Section 2.15 (Information Supplied to Bidders) of the ITB.