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Function: Engineering (Signalling)
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Signal Design Process

ESP-25-01

Applicability

ARTC Network Wide

Publication Requirement

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Document Status

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1.0	25 Nov 24	Standards	Stakeholders	Principal Signalling Engineer	A/Manager Engineering Services 26/11/2024

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
1.0	25 Nov 24		First publication of the signal design process. Supersedes ESI-05-14 and ESB-08-01.

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1 Introduction

1.1 Purpose

This document sets out the process and specific documentation applicable to ARTC signalling design activities to guide signal designers.

1.2 Scope

The scope of this procedure is limited to those activities conducted to establish and maintain control over the design process used for ARTC signalling. This document covers:

- Design process of new and altered signalling systems impacting on ARTC controlled infrastructure;
- Design details are prepared and presented, accurately, consistently and unambiguously;
- An auditable design process is carried out;
- ARTC's specified requirements are met and the design is fit for purpose.

1.3 Document Owner

The Manager Engineering Services is the Procedure Owner and is the initial point of contact for all queries relating to this procedure.

1.4 Responsibilities

The Project Manager is responsible for the implementation of this standard.
The Signal Design Manager is responsible for managing the design process.
The design team is responsible for referring to other ARTC standards as required for the design development.
The Designer, checker and Independent verifier are responsible for the production of a designs that eliminates risk to SFAIRP.
The Design Checker is responsible for checking **all** aspects of the design (check 1).
The Independent Verifier is responsible for the independent check of the principles of the design (check 2).

1.5 Subordinate Documents and Forms

The following Forms shall be used in applying this standard:

- ESP2501F-01 – Technical Query Form
- ESP2501F-02 – Design Control Form
- ESP2501F-03 – Design Management Plan (DMP)
- ESP2501F-04 – Design Package Brief (DPB)
- ESP2501F-05 – Checking/Verification Defect Log (CVDL)
- ESP2501F-06 – Project Change Form

- ESP2501F-07 – Design Check List (CBI Design)
- ESP2501F-08 – Design Check List (SAP Design)
- ESP2501F-09 – Source Design Records Assurance and Correlation
- ESP2501F-10 – Commissioning Readiness Review
- ESP2501F-11 – Master Signalling Design Resource Plan

1.6 Reference Documents

The following documents support this standard:

- AS 7718 – Signal Design Process Management
- ESD-25-03 – Signalling Documentation and Drawings
- EGP-03-01 – Rail Network Configuration Management
- EGP-04-01 – Engineering Drawings and Documentation
- EGP-04-02 – Drawing Management System
- EGW-03-01 - Using Network Alteration Notices (NANs) for Configuration Change Management
- EGW-03-04 – Configuration Change Boards
- EGP-20-01 – Project Management
- EGP-02-01 - Engineering Waiver Management
- ESA-00-01 - Approved Signalling Items for the ARTC Network
- ESD-05-11 – ‘Microlok Data Design Records’ (Addressing, File Control, checking, and FAT Testing)
- ESD-25-01 – CAD and Drafting Manual for Signalling Drawings
- ESS-04-01 - Signal Sighting and Position
- ESI-05-12 – STOPDIST Train Braking Distance Calculation Tool User Guide
- ESP-20-01 – Signals Rail Safety Worker Competence Procedure
- ESC-21-01 - Inspection and Testing of Signalling - Roles, Responsibilities and Authorities
- ESC-21-02 - Inspection and Testing of Signalling - Plans, Programs, Documentation and Packages
- ESC-21-03 - Inspection and Testing of Signalling - Inspection and Testing Principles
- ESC-21-04 - Inspection and Testing of Signalling - Standard Forms
- ETS-07-00 – Clearances

1.7 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
ARTC	Australian Rail Track Corporation Ltd.
Clearance Point	The position on a converging, diverging or crossing line beyond which the encroachment of any part of a vehicle would infringe the required passing clearance for a vehicle on the other line.
Contractor	The person, company, corporation or authority contracted to implement the specified works relating to ARTC infrastructure. The term contractor shall be taken to include any sub-contractors engaged in the works.
Drawings	Drawings shall be defined in this context as site specific or standard documented layouts, plans, diagrams, tables, schematics and the like that set out the design and/or configuration of signalling infrastructure assets (e.g. physical dimensions and compositions, temporal and/or spatial arrangements, physical and/or logical interconnections) either existing, pre-existing, or proposed.
Designer	A Competent engineer who is responsible for preparing SFAIRP signalling design that is safe, reliable and in accordance with the ARTC and AS standards, signalling principles and practices and operationally functional as specified.
Signal Design Manager (SDM)	The Signal Design Manager is the personnel who is responsible for overseeing that the design process is adhered to at all times; is a point of communication between the signal design team and the ARTC Project Manager, manages the interface with other projects that affect the same records and is competent senior Signalling Designer who is able to communicate with all levels of engineering personnel.
Design Checker (Independent Signalling Design Checking Engineer)	A Competent Signalling Designer who is responsible for checking that the prepared signalling design is safe and reliable and in accordance with the ARTC and AS standards, signalling principles and practices and is operationally functional as specified. Design checked shall be independent from the design team.
Design Group	One or more signalling designers knowledgeable in railway signalling principles who are providing the design. The term 'Design Group' used within this document may be one or more contractors or consultants approved by ARTC under the Engineering Authority process.
Independent Verifier	A competent Signalling Designer who is independent from the design team and verifies the safety, functionality, operational requirements, agreed scope of work, fit for purpose design and compliance with applicable ARTC and AS Standards, signalling principles and practices.

Term or acronym	Description
Project Manager (PM)	Is the person who is responsible for planning and monitoring, administration and control of a project works.
Safety Significant Form	Document containing or detailing information of a vital nature that can impact on the safety of the signalling system.
AS1	Amendment Sheet '#'
IFC	Issued For Construction
CAD	Computer Aided Design
CBI	Computer Based Interlocking
CCC	Certified Commissioning Copy
CCL	Configuration Change List
CP	Clearance Point
CP1	Control Page '#'
CVDL	Checking/Verification Defect Log
DIA	Design Interface Agreement
DCL	Design Check List
DMP	Design Management Plan
DMS	Document Management System
DPB	Design Package Brief
DSS	Detailed Site Survey
EMC	Electromagnetic Compatibility
FAT	Factory Acceptance Test
IMP	Interface Management Plan
IRJ	Insulated Rail Joint
LX	Level Crossing
NAN	Network Alteration Notice
ORS	Operational Requirement Specifications
PCF	Project Change Form
PM	Project Manager
PMP	Project Management Plan
RAMS	Reliability Availability Maintainability Safety
RATM	Requirements Analysis Traceability Matrix
RODE	Responsible Overlapping Design Engineer
SAT	Site Acceptance Test
SP	Signal Plan
SoC	Statement of Competency

Term or acronym	Description
SDM	Signal Design Manager
SER	Signalling Equipment Room
SFAIRP	So Far As IS Reasonably Practicable
SFOS	Signalling Functional & Operational Specification
TIP	Track Insulation Plan
TQF	Technical Query Form

2 Overview of the Design Process

2.1 Introduction

An overview flow diagram covering the design process is included in Appendix A.

Every project has fundamental requirements relevant to design management. These include:

- Operational Requirements
- Signal design requirements
- Engineering competence
- Review and approval process
- System validation
- Design change management
- Change control
- Parallel design
- Construction, testing and commissioning
- Asset and records management

These fundamental requirements are addressed in this document.

2.2 Design development

Design development extends throughout the life of the project from the concept to realisation of the new asset to form part of the railway. Figure 1 shows the major activity phases and the requirement for design involvement throughout; this standard covers Phase 5 and Phase 6 only:

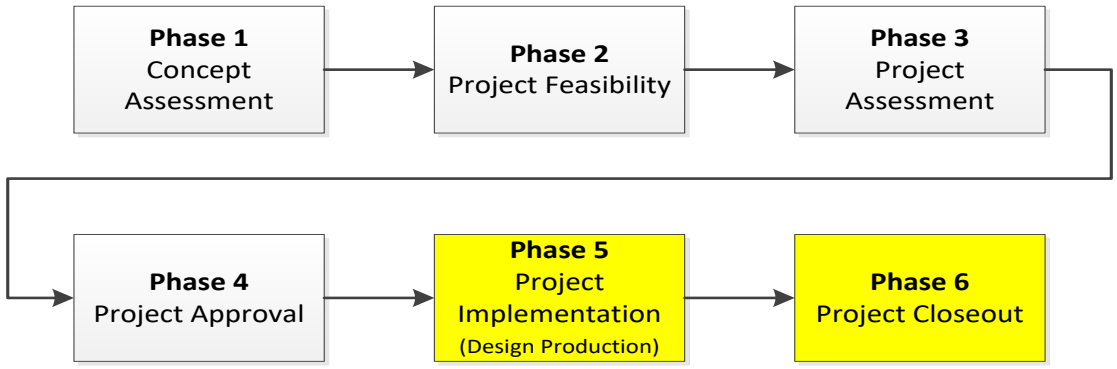


Figure 1 - Design Development

In some cases, detailed design is permitted to begin within Phase 3 to reduce the overall risk (cost and time) to the project. Phase 2 requirements shall be completed and approval granted by the relevant ARTC Project Management Team to enable detailed design to begin within Phase 3. The same design and control requirements as documented in Phase 5 shall be adhered to when commencing detailed design in Phase 3

2.3 Design obligations

The SDM shall provide the signalling design for all stages of the Works, including design approval. In providing the design, the SDM shall ensure that:

- The design is prepared, supervised and managed in accordance with the ARTC Signalling Principles & Practices and Australian/ARTC Standards.
- The design is prepared, checked and verified by individuals who are competent and have obtained relevant Competency from ARTC.
- The design of the Works is constructible and complies with the approved project requirements and a scope description in a requirements specification or design brief and supporting documentation where necessary.
- The signalling design is based on source records, which are a replica of the master as-built records and that these records accurately reflect the existing equipment configuration and installed wiring on site.
- The source records of the signalling design are correlated before the design work commences.
- The design is accurately recorded in the design submissions including calculations, verifications, detailed construction drawings, specifications, test and commissioning plans and operation and maintenance manuals.
- The design is checked and endorsed as compliant with AS and ARTC Standards by a Design Checker before sending for Independent Verification.
- The design is verified as compliant with AS and ARTC Standards by an Independent Verifier.
- The design is developed and submitted for review in the time frame as per ARTC standard ESD-25-03 unless agreed otherwise to follow the Project Management Plan and Design Management Plan.
- All design information, data, drawings and other documentation is produced for the Works in accordance with ARTC standards and procedures.
- The design supports the test and commissioning plan.
- Design meets the SFAIRP principle and is fit for purpose.

Note: Where guidance given in this standard is not used, equivalent procedures shall be followed that give the same level of safety integrity, are capable of being audited and have been agreed with the ARTC Project Manager.

2.4 Project Management

Reference shall be made to Engineering Process Procedure EGP-20-01 ‘Project Management’. The procedure outlines what is expected of those involved in ARTC projects at each stage of a project and includes the actions required for the initiation, development and implementation of an ARTC project.

3 DESIGN MANAGEMENT

3.1 Design Initiation

The design management process follows on from the completed requirements development process (refer Appendix A).

The input documents into the design management process are the deliverables from the requirements development process and shall adequately provide a clear scope definition and be approved for the design to commence. Input documentation may include but is not restricted to:

- Outline Operational requirements Specifications (ORS)
- Outline SP (includes any stagework SPs)
- Outline SFOS or design brief
- Outline DMP
- Project Management Plan (includes Project Staging Plans, etc)
- Project Status Report (PSR)

Unless the project is minor work and the scope is covered by a design brief only, these documents shall be provided as a minimum for all projects with a signalling component, whether this is part of a larger multi-disciplined project or confined to only signalling scope. They will be the basis of the final SFOS which is the primary deliverable of the first stage of the design process.

3.2 Appoint Signal Design Manager (SDM)

Once the contract is awarded, Signal Design Manager (SDM) shall be appointed to be the single point of contact for all interfaces with other projects affecting the same master records. The SDM will also manage the technical interface between the design team and the ARTC Project Manager for all matters relating to other subsystems and disciplines.

3.3 Set Up Design Project

The Signal Design Manager will set up the project in preparation for the commencement of design. This involves reviewing the output documentation of the requirements development phase and the schedule in consultation with the ARTC Project Manager.

3.3.1 Allocate NAN Number/Project Number/Cost Code

To track and control the flow of signal design documentation, a NAN number/Project Number/Cost Code shall be allocated by ARTC for each job. The SDM will apply to ARTC for the NAN number/Project Number/Cost Code following the requirements detailed within standard EGP-04-02.

Where the introduction of new or altered signalling is divided into sequential commissioning, derivative stagework plans are required for each commissioning. The NAN shall detail all proposed stageworks as stated by ARTCs configuration and control process (refer EGP-03-01).

For large complex projects which may be delivered in stages, or a program of work which may contain multiple projects, a Master NAN and Sub NAN structure may be appropriate. This is at the discretion of the project and should be documented in the Project's Configuration Management Plan if this is to be adopted. Please refer to EGW-03-01 for more information.

3.3.2 Review and Finalise Design Management Plan (DMP)

The outline DMP or Design Brief is reviewed against any changes to the project since the requirements development process terminated.

The deliverables listed in the outline DMP or Design Brief for the detailed design stage is finalised and agreed upon with the ARTC Project Manager at this stage, becoming the final DMP *(now simply referred to as the 'DMP' in the remainder of this document*). This DMP forms a section of the overall project DMP which is maintained by the ARTC Project Manager.

The DMP (refer also 3.7.1) ensures:

- all design deliverables have been included,
- a Design Package Brief (DPB) is produced for each design deliverable
- all nominated engineers are competent to complete the tasks assigned to them (ARTC SoC),
- clear design control is in place to ensure the validity of design checking and Independent Verification

3.3.3 Resource Plan and Schedule

The SDM will review the schedule for design production and assess the complexity and urgency of the project/job scope against the availability of internal and external competent resources to deliver it. A Master Signalling Design Resource Plan shall be produced (refer to ESP2502F-11 form) to ensure independence is maintained during the design phase of any work. The plan should clearly include any designer under mentorship with the details of mentors. The resource plan needs to be accepted by the Signal Maintenance Engineer.

The SDM shall agree the schedule with the ARTC Project Manager.

3.4 Obtain Master Records and Data for Design

Signalling documentation describes the safety critical elements of the system that controls the operational safety of all train running. ARTC DMS controls its drawings and documentation and ensures the correct status of the documentation is maintained. All signalling documentation and data shall be requested and managed in accordance with EGP-04-01 and ESP2501F-09.

Signalling documentation is the property of ARTC DMS and it is the responsibility of the SDM to control and maintain documentation entrusted to them.

To ensure that, in situations where renewal or reconfiguration of signalling equipment requires changes to the engineering drawings and/or signalling data, the configuration management of the signal engineering drawings and data shall be rigorously applied.

Contractors shall meet the requirements of ARTC and what documentation is expected to be "handed back" on completion of the project works.

The SDM will determine the master as-built records of **drawings and data** required for the project.

Work shall not commence on any source documents that have not been specifically requested and released from ARTC DMS.

3.5 Design Start-up Meeting

The design start-up meeting for the design team is run by the SDM and is to ensure that the design team has a clear understanding of:

- deliverables to be produced
- who is to produce them
- by when, and
- what needs to be provided as input information prior to starting.

The design team shall also understand their role in the reporting of progress on the project and how to keep the SDM abreast of developments within the design which may impact the scope or the delivery milestone dates.

The following design inputs will be discussed at the start up meeting;

- the DMP which details the deliverables required and
- the approved requirements documents which details the technical requirements from which the final SP and SFOS will be developed.

Design Package Briefs (DPBs) are to be distributed to individuals within the team in accordance with the schedule. If the scope is unclear or contains insufficient information, a technical query (TQ) will be produced to obtain that information.

For more complex projects, there may be two start-up meetings; one to brief the design team prior to commencing the initial design and one to brief the design team prior to commencing the detailed design.

3.6 Assurance Oversight and Risk Management

The SDM ensures that ARTC's management requirements are met. A list of deliverables required for each review is to be added to the DMP and form the basis of the design schedule and DPBs.

The SDM also:

- Prepares any audit reports as required by ARTC
- Regularly review the project hazard log by:
  - Adding and revising Signalling hazards
  - Reviewing other discipline hazards that impact Signalling
  - Organising suitable Signalling representation at all reviews

3.6.1 Design Assumptions, Constraints and Dependencies

Design assumptions, constraints and dependencies are to be identified and recorded in the ESP2101F-04 and should be traceable throughout the design process.

3.6.2 Safety in Design

The SDM is responsible for the application of a Safety in Design process to ensure that all design risks are identified and managed to SFAIRP. Any residual risks as agreed with the ARTC Project Manager are subsequently transferred to the following lifecycles of the assets.

3.6.3 New Equipment

Formal type approval is a prerequisite for ARTC acceptance and permission to use new equipment in ARTC's signalling systems. SDM shall ensure that only type-approved equipment is used in the signalling design.

Refer to

1. 'Type Approvals: Signalling' found within the ARTC extranet for list of type approved equipment and systems., and
2. ESA-00-01 Approved Signalling Items for the ARTC Network

Any new equipment or system that is not type approved, shall gain type approval, refer to engineering procedure EGP-21-01 'New Equipment & System Approvals'.

3.7 Design Management Plan

The SDM manages the overall design process using the DMP, form ESP2502F-03.

3.7.1 Design Management Plan (ESP2502F-03)

The DMP lists all of the design tasks, design reviews and deliverables required to produce the complete design. It contains the following:

- A list of DPBs for each design task, design review and deliverable
- Any stagework design deliverables required to deliver the project. The SDM will need to review the possessions planned for the construction, testing and commissioning of the project and any construction plan with details of scope for the possessions to determine what impact this will have on the design.
- The management requirements for any design interfaces or parallel design likely to be required, referring to the project Interface Management Plan (IMP).
- Form ESP2502F-02 listing every design deliverable to be updated with checking and verification history.

There will be some sequencing required to complete some primary design deliverables before other subsequent designs can be commenced. For example, the final SFOS is a deliverable source document which will be required as an input for all subsequent designs.

The DMP is a 'live' document and it shall be updated during the course of the project to reflect the design work as it is completed and any changes to scope, organisation, responsibilities, standards or corrective actions. It provides a reference point for designers as they progress the designs. The SDM is responsible to keep the DMP up-to-date; it is an auditable document and shall be maintained accordingly.

The DMP shall cover every NAN number/Project Number/Cost Code for the project and a current copy shall be submitted as part of each design works package submission. Design should be delivered in stages (refer to EGP-04-01) with the deliverables listed in Appendix H.

3.7.1.1 Source Documents

The source documents which are produced at the initial design stage (refer section 4.2) will be documented in the DMP and shall be kept up to date. These source documents shall be based on the fundamental design inputs listed in section 3.1.

3.7.1.2 Design Deliverables (Outputs)

The deliverables will be detailed within the DMP and the SDM shall ensure all deliverables are produced to ARTC standards, meet the approved Operational Requirements and approved SFOS requirements (Refer APPENDIX B – Signalling Functional & Operational Specification (SFOS)).

3.7.1.3 Circuit/Data Design

To ensure design integrity, the SDM shall ensure 'Self Checking' does not take place. To mitigate against this, a Design Control Form ESP2502F-02 listing every design deliverable shall be kept in the DMP. It is a 'Safety Significant Form' and provides a clear history of who has checked, verified and validated each design deliverable.

3.7.1.4 DMP Inclusions and Appendices

The following information relevant to the design shall be included and appended to the DMP:

- Any technical decisions made about the design(s)
- All submitted Technical Query Forms (TQF)
- A copy of all final approved design(s); including later revisions and any superseded revisions. Copies can be either hard or soft, but shall contain approval signatures
- Equipment and Type Approvals,
- List of Waivers
- Resource(s) Competencies
- Any training/special training requirements
- Technical Position papers

3.7.1.5 Design Package Brief

The Design Package Brief (DPB), form ESP2502F-04, is an auditable document that accompanies a design deliverable around during its design, checking and verification phases.
The deliverables list within the DMP is expanded by the SDM with a DPB produced for each deliverable. The DPB will list the following information required for each deliverable:

- Input project documents and applicable versions
- ARTC standards applicable and their versions
- Scope peculiarities associated with the deliverable
- Interfaces to other deliverables and disciplines
- Timeline dates for design production and resource allocation

The DPB shall provide a clear scope description for issue to the designer ensuring the design work is well understood and all the outputs to be produced. It shall contain sufficient detail with no ambiguity with all relevant input documents and all tick boxes suitably marked. A section is provided to ensure all nominated designers, design checkers and independent verifiers are accredited to do the works, having the relevant Engineering Authority endorsed by ARTC. The DPB shall be signed and dated (endorsed) by the SDM before forwarding to the nominated designer.

3.7.2 Allocation of Resources

Having agreed the schedule and basis of design (i.e. the DMP); the SDM is responsible for ensuring the required competent resources are provided. Should the required resources not be available or be removed from the project, the SDM shall notify the ARTC Project Manager of the impact.

3.7.3 Competency Management

The SDM is responsible for ensuring that allocated resources are competent to undertake the design work in accordance with ARTC's engineering competency procedure.

Before design work can commence, a competency review shall be conducted to assess designers', checkers' and verifiers' levels of experience with the design tasks they are to perform and record it in the Master Signalling Design Resource Plan. Please refer to section 3.3.3. Standard ESP-20-01 - Signals Rail Safety Worker Competence Procedure details the process required in order to gain competency.

3.8 Interface Management

Interface management (refer Appendix A) will either be specifically addressed in a section of the project DMP or if the project is sufficiently complex an IMP shall be provided by the ARTC Project Manager. Refer to EGP-04-01 for more details.

The SDM is the single point of contact between the signalling design team employed on the project/job and anyone outside of that team. The SDM is also responsible for managing interface communications and parallel design:

- Scheduling outstanding design work AND
- Managing project/job document configuration

3.8.1 Communication

All formal communication outside of the immediate design team will be by the SDM and the ARTC Project Manager. The only exception to this is in the management of parallel design where the SDM will communicate directly with the other design teams designing in parallel. Communication with the ARTC Project Manager will by means of a TQF ESP2502F-01 to enable queries to be logged in an auditable way. In addition to the query, the following information is conveyed:

- Project reference
- Response required by date
- Proposed resolution to the problem raised

The ARTC Project Manager will insert a response on the TQF and approve a course of action to close the request.

The SDM will maintain a register of requests and responses appended to the DMP.

3.8.2 Parallel Design Management

Parallel design shall be avoided whenever possible unless specifically agreed by the ARTC representative for that area and provided measures are in place to control the documentation.

Parallel design occurs when a design task runs in parallel with a separate design task which it depends upon for its source record. This section refers to the special case of parallel design where two jobs requiring the same source record run in parallel and is more correctly called 'overlapping design'. In this document, any references to parallel design and overlapping design are

interchangeable. Parallel Design Management shall be managed through design interface agreement as per EGP-04-01.

Parallel design can compress the time needed for multiple processes; however, the benefit of running parallel processes is negated if:

- The time spent on assessing the risks, and devising and implementing additional controls outweighs the time saved by process compression, and/or
- It is likely that the amount of rework generated by a change in one process (resulting in rework of all concurrent processes) will outweigh the time saved by process compression.

Parallel processes shall not be used unless the safety risk resulting from the above considerations is controlled with appropriate mitigation (e.g. if the cost of project delay to the business of uncompressed timescales is substantially higher than the additional cost of safety management from compressing timescales).

3.8.2.1 Responsibilities

ARTC Project Manager	Responsible for the management and configuration of signalling records including the issue and receipt of records
Responsible Overlapping Design Engineer (RODE)	Appointed by the ARTC Project manager to have delegated responsibility for the design, development, safety and dependability of signalling associated with related overlapping infrastructure projects undertaken by different design groups.
Records controller (design group)	Responsible for controlling signalling records within a design group.
First design group	The design group scheduled or nominated to install and commission signalling infrastructure next, before the second design group where design has been undertaken as part of a parallel process. The term applies equally to a design group belonging to a contractor or ARTC, as appropriate.
Second (or third, etc.) design group	The design group scheduled or nominated to install and commission signalling infrastructure next after the first (or second, etc.) design group, where design has been undertaken as part of a parallel process. The term applies equally to a design group belonging to a contractor or ARTC, as appropriate.

3.8.2.2 Control Process for Parallel Design

The SDM will be informed by the ARTC Records Controller if any of the master records requested are currently booked out by other projects. If this is the case, the SDM will seek approval from the ARTC Project Manager to continue with the design and the associated cost and risk of parallel design. This communication will be by means of a TQF.

If parallel design is permitted, a Responsible Overlapping Design Engineer (RODE) shall be appointed by the ARTC Project manager to have overall responsibility for the interface between successive design alterations. The RODE will organise a meeting between the first design group SDM and the second design group SDM (and the third design group Signal Design Manager, etc.).

A Design Interface Agreement (DIA) will be created specifying times when the first design group's design will be shared as a 'for information' copy with the second design group (and third, etc.), based upon the two project's design, construction and commissioning schedules. Any subsequent projects will require a renegotiation and re-issue of the DIA. Refer Figure 2 below for a flowchart representing the process.

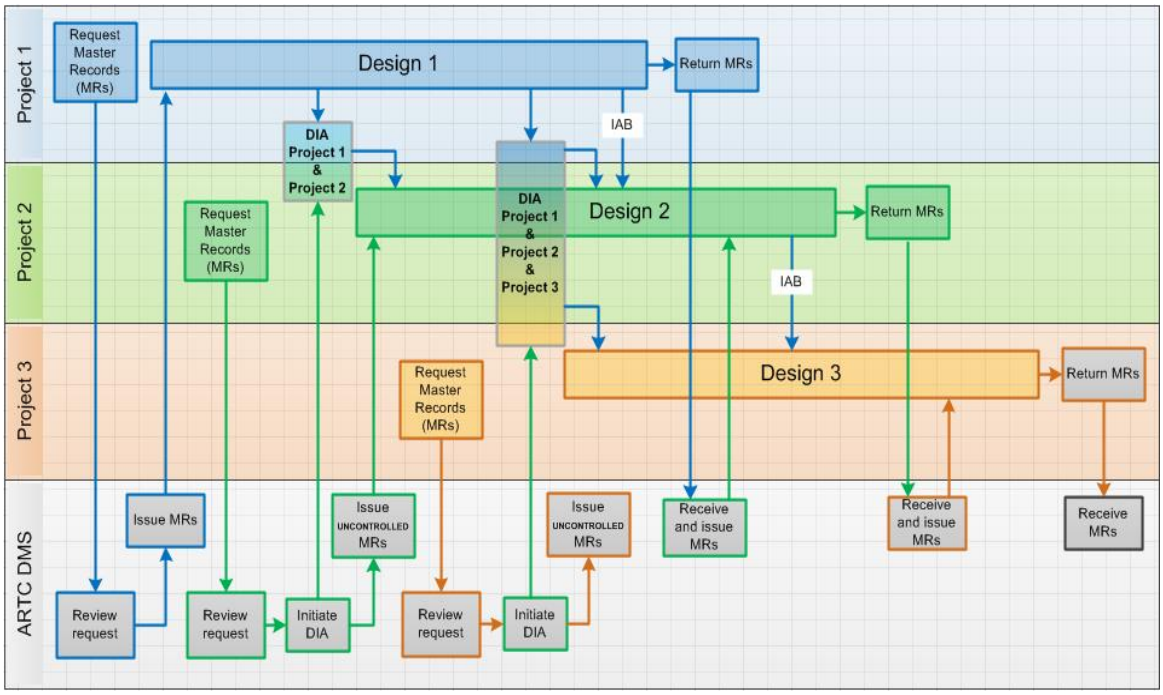


Figure 2 – Parallel Design Process Flowchart

Any future change to the schedules will require a review of the DIA. If the schedule change results in a change to the order of commissioning, the SDM will review the quantum of work required to modify the design. The cost of the change to the schedule will be borne by the project whose schedule has changed. Cost recovery will be dealt with by the ARTC Project Manager.

The SDM will ensure that the design team produces the deliverables required by the DIA schedule in a timely manner. The SDM will also follow up with the RODE and/or the other design group's SDM if the design deliverables are not provided on the dates specified in the DIA.

The SDM will determine the most appropriate way that information provided by the previous design group in the chain is incorporated into their design. To minimise repeated CAD work, it is recommended that only those parts of the circuits or analysis directly affected by the preceding uncommissioned project designs are updated to the 'for information' copies. This will also reduce any subsequent re-work if the commissioning order changes.

3.9 Change Control

Change control (refer Appendix A) applies after the design requirements have been agreed. The design requirements are fixed at the completion of the requirements development phase and at Design Contract award.

Change can be proposed from a client derived scope adjustment or from the detailed design, construction and testing process as a log. In all cases, the proposed change passes through the ARTC Project Manager before being issued to design through the SDM using a PCF (refer section 3.9.4). Each proposed change shall be assessed for its impact on the rest of the design and its compliance with standards prior to being implemented. The process for assessing the change is as follows:

- Clarify scope of change
- Assess change with respect to ARTC standards, agreed baseline scope and requirements
- Assess change with respect to its impact on design schedule and cost

3.9.1 Clarify Scope Change

The SDM reviews the change request with the design team to ensure that it is clear in its intent. If it is not clear, the SDM will clarify with the ARTC Project Manager by means of a TQF. The ARTC Project Manager may choose to update the initial change request or rely on the response to the technical query to provide additional clarity.

If a change is initiated from the design team, it shall first be approved by the ARTC Project Manager as a scope change.

3.9.2 Assess Standards Compliance and Scope Compatibility

The SDM and the design team assess whether the result of implementing the change will make the design non-compliant with ARTC standards and whether the result will meet the project requirements.

If the proposed change is non-compliant with ARTC standards, the SDM and the ARTC Project Manager will coordinate a risk/benefit workshop and consider a waiver to the ARTC standard.

If the proposed change modifies the project requirements, the ARTC Project Manager shall seek approval from the project sponsor/client.

3.9.3 Assess Impact on Schedule and Cost

With an agreed revised scope, the SDM initially assesses the amount of work required to change the design, including whether it needs to be supported by a waiver to ARTC standards. An assessment is also made as to whether the change needs to be incorporated into other project documents, in particular the SFOS.

Once the amount of work has been determined, the impact on the design cost and schedule of the job and the knock-on to other jobs is assessed and reported to the ARTC Project Manager. The SDM will provide design schedule information to the ARTC Project Manager so the impact of the design change on the overall project schedule can be assessed.

Once the impacts are fully understood, the ARTC Project Manager shall approve the change before any design work commences.

3.9.4 Project Change Form (PCF)

The Project Change Form (PCF) is an auditable document used to capture any change required to the approved SFOS, refer form ESP2502F-06. In certain situations, it may not warrant updating the SFOS depending on the nature of the change. ARTC PM and SDM are to agree with the outcome of the decision.

Each PCF is to be appended to the SFOS once signed and approved. Updates to the SFOS will then be carried out based on each PCF and the SFOS re-issued as a revised version.

All design inputs will require reviewing based on the newly updated SFOS. Any design input changes shall follow change control procedures e.g. revision of the DMP.

3.9.5 Design Modifications

The SDM is responsible for setting up and maintaining a register of all:

- design modifications made to design documents issued to site for construction, testing and commissioning purposes
- Design Data Reports for data design modifications

3.10 Document Configuration Management

The SDM is responsible for the management of all requested documentation and data.

3.10.1 Project Closeout

On completion of the project, all documentation and data shall be issued to ARTC in accordance with standard EGP-04-01 and EGP-04-02.

4 DESIGN PRODUCTION

4.1 Final Specification Phase

The start of the design production process is the final specification phase of the project. Unless it is a minor works project covered by a Design Brief, this phase builds on the key documents carried over from the requirements development process, refer sections 2.2 and 3.1.

During this phase, the design team:

- Starts both the outstanding CCCs update process (If source record as-builts are not available) and the correlation process. Please refer to ESP2501F-09.
- Completes the ‘initial design’ as per project delivery model which may include the final SP (+any stagework SPs), SFOS and initial designs concerning the constructability of the signalling etc.

4.2 Produce Initial Design

The initial design provides all of the important source information required to commence the detailed design (refer Appendix A**Error! Reference source not found.**).

4.2.1 Source Records and Desk Top Correlation

Poor correlation between source records and the in-service existing signalling apparatus circuits and data may lead to:

1. Safety incidents, or
2. disruption to the project identifying and remedying any deficiencies

Poor correlation may be attributed to:

- inadequate record control when the original works were installed.
- site equipment or wiring that has been altered without the corresponding master records being updated.
- multiple schemes at the same location that have been installed in a different order to that for which they were designed.
- works installed but never commissioned

Prior to any alterations being made to the design of a signalling system, a check shall be made to confirm that the source records correlate accurately with what is installed on site.

The assurance and correlation process steps are as follows. These are to be documented and detailed on form ESP2502F-09:

a) Obtain Master Source Records (drawings and data)

(i) Book out all the nominated source records from ARTC's DMS or other approved DMS (refer section 3.4)

b) Desk Top Correlation

(i) A correlation copy set of documents shall be produced from the nominated source records

(ii) Check that all recent jobs have been completed and are reflected on the source records Amendment Sheet (AS1) and

(iii) check if there are any outstanding As Commissioned copies not incorporated in the source drawings

(iv) Check if other works are proposed or currently being designed or installed

(v) Check with signalling maintenance representative for the nominated location if additional works have been completed or are to be undertaken

(vi) Check with signalling maintenance representative if there are any known discrepancies between the source drawings and the installed equipment

(vii) Resolve any discrepancies, update outstanding source drawings and mark up the correlation copy accordingly

(viii) The SDM and design team shall determine whether the site correlation is required or not. If required, the level of site correlation to be performed to address the discrepancies identified and confirm the accuracy of the correlation copies.

(ix) The above are recorded on Form ESP2502F-09 sections 2 to 8.

At this stage, a site correlation of the updated correlation copies of the SP and DSSs shall be performed as the basis for finalising the initial design documents as per sections 4.2.2 to 4.2.4 below.

4.2.2 Final Signal Plan

The final SP is a more detailed version of the outline SP from the requirements development phase. If relevant, civil and track design shall be issued as defined in the interface documentation owned by the ARTC Project Manager.

The following associated design deliverables will also be produced alongside the final SP:

- Final braking analysis
- Aspect sequence charts
- Signal sighting
- Equipment room and location case sitting
- Final power calculations
- Final SFOS

- Detailed Site Surveys (DSSs)

SPs are to be divided at interlocking boundaries (where practicable) and signal box boundaries. (An overlap between signal boxes may be necessary to ensure that each plan shows all functions controlled from its respective signal box, up to the approach side of the first caution signal).

In non-track circuit block areas there may be gaps between SPs for adjacent signal boxes. In this case, separate SPs may be provided for any in-section ground frames or level crossings. These shall be cross referenced on the SP of the main signal box.

The stagework SP for each stagework is normally a copy of the final SP showing the functions to be altered at that commissioning and omitting the functions for the future commissioning.

For multi-points and crossings turnouts, which have staggered clearance point track circuit joints on converging adjacent lines, the SP shall clearly show the Clearance Points (CPs) with a note describing the clearance point arrangements. The CPs are shown to ensure the positioning of the track circuit joints or axle counter heads are sufficiently distant from the fouling point beyond which trains could collide. For further instructions on clearance points between converging tracks, refer to Appendix D.

4.2.2.1 Final Braking Analysis

The development of the final SP can, in some circumstances, involve the modification of the signalling equipment positions in the outline SP. If this happens, the braking analysis performed during requirements development will need to be modified accordingly.

If there has been no change to the signalling equipment positions or layout, there will be no reason for change to the braking analysis and the outline braking analysis is to be re-issued as the final braking analysis to accompany the final SP.

Braking analysis shall be recorded for the scheme using the latest version of ARTC's STOPDIST tool (refer to ESI-05-12).

4.2.2.2 Signal Sighting

A desktop or similar signal sighting exercise will have been carried out as part of the requirements development process.

Draft signal sighting forms (ESS0401F-01) are to be produced by the design team showing dimensioned details of the full signal profile including offsets from the nearest rail, along with the expected sighting distance and any obscuration to the visibility of the signal, particularly in the critical final seconds before the signal is passed.

The final signal sighting forms are to be completed by a competent person along with the Signal Sighting Working Group as per ESS-04-01.

The locations of signals and their offsets are provided to the ARTC Project Manager responsible for the interface management between disciplines by the Signal Design Manager.

In some cases, where there is no railway, or the existing railway is to be changed significantly so as to make a site based signal sighting committee impossible, 3D computer modelling may be used in this scenario to create a virtual signal sighting working group.

4.2.2.3 Equipment Room and Location Case Siting

The physical positioning of signalling location cases, equipment rooms and trackside and on-track equipment shall be cross-checked with the physical environment, terrain, clearances, maintainability and risks such as flooding.

The SDM shall provide the positioning information of all signalling locations to the ARTC Project Manager responsible for the interface management between disciplines.

4.2.2.4 Final Power Calculations

Once the final siting arrangements of location cases and equipment rooms positions are agreed, the final power calculations are to be completed with the knowledge of what equipment is to be fed from each, taken from the final SP. Once these loadings are calculated, the power reticulation diagram is finalised and the power cables properly sized.

4.2.3 Final SFOS

The final SFOS is produced to define all the parameters needed to produce a detailed design for construction. This will detail all the signalling equipment selected for the project.

As a minimum, the SFOS should address the list of items in APPENDIX B – Signalling Functional & Operational Specification (SFOS).

4.2.4 Final DSSs

The final DSSs are produced to provide scaled field drawings showing the accurate location of all underground services. It includes all existing and new main and local cable routes, ULXs, signal positions, land contours and gradients, track and civil infrastructure, vegetation and boundary lines. Please refer to EGP-04-01 for more information.

4.3 Determine Correlation Required

As stated in the section 4.2.1, it is vitally important that the signalling design is based on source records, which are a replica of the master as-built records and that these records accurately reflect the existing equipment configuration and installed wiring on site.

A site integrity assessment (refer to Appendix A) shall be carried out (refer to section 4.2.1 to ensure the signalling documentation reflects the current state of the infrastructure. If there is any doubt, then site correlation shall be carried out to ensure the integrity of the input documentation. The team responsible for the updating task will assist the SDM in determining the risk of inaccuracy of the records after updating. The design team will assist the SDM in reviewing any anomalies resulting from the correlation and the need for further investigation.

4.3.1 Signalling System Substitutions Design

Signalling System Substitutions (e.g. “interlocking heart transplant”, level crossing upgrade, etc) require the existing interlocking conditions to be exactly replicated in the substitute system. This is simplified if the existing interlocking has up to date control tables.

However, if control tables are not available, a set of control tables shall be created to accurately reflect the existing interlocking conditions. This usually means reverse engineering the control tables from existing relay circuits. The process for signalling system substitutions is covered in APPENDIX E – Signalling System Substitutions Design.

4.3.2 Perform Site Correlation

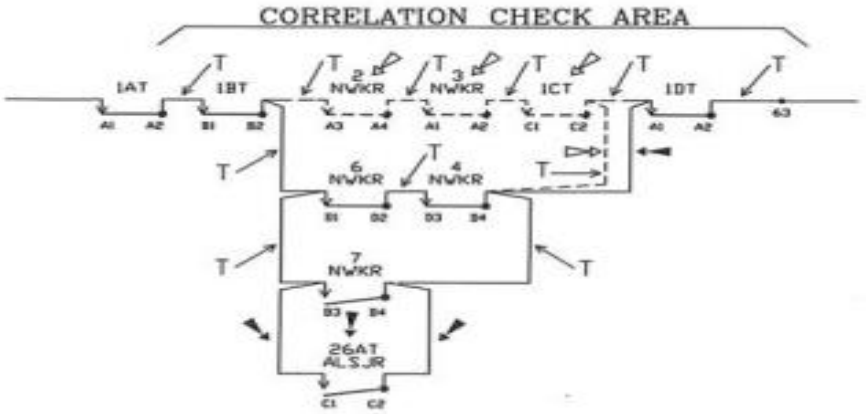
The files to be correlated are printed on white paper with the information to be correlated boxed with a blue highlighting pen. The sheet is stamped "correlation copy" and sent to the site team with the scope of correlation by the SDM.

The following process shall be followed in undertaking the Correlation check.

1. Before any alterations are carried out to existing wiring, a correlation check must be made between the circuit changes shown and the on-site wiring to ensure that they are the same.

2. The new circuit sheet is first compared to the existing Field Maintenance copy of the respective circuits. Ensure that there are no discrepancies before proceeding. If a discrepancy is found the design and existing maintenance circuit book to be referred back to the design engineer.

3. The existing circuits are physically checked by hand tracing the wiring and wire-counting at each termination point within the affected area. This check is to extend to one unaltered 'clean' termination point on each side of the alteration.



4. This correlation shall be performed prior to the removal of any wires. The same level of checking shall be performed after the new wiring has been installed.

5. All wires checked shall be recorded on the Testing Copy of the Signalling Circuits. Each wire checked is indicated by a tick or similar mark. The Testing Copy shall have a stamp indicating "Checked By", with the Tester's Name, Signature and Date.

   - Apply the following steps for site correlation using the correlation copy prepared by the design team, indicating what is to be correlated:
   - Equipment check, which is to include:
     - Equipment items and
     - Rack layout checks
   - Wire and Null Count
   - Wire Hand Trace (provided risks of interference are low)
   - Book out and Bell Test (high risk locations e.g. wiring degradation)
   - Check Clearance Points by measurement (unless checked in section 4.2.2)
   - Configuration of trackside equipment (e.g. point machines RHSNC or LHSNC, track circuits' polarities, etc.) Refer APPENDIX F – Correlating Point Motors and Detectors

   Site correlation shall be carried out by persons who have recognised competency in accordance with ARTC's competency management system.

   - Any deficiencies found shall be recorded and investigated
   - Resolve any discrepancies and mark up the correlation copy accordingly; the mark ups shall be independently verified (refer to APPENDIX G – Correlation Mark Up Example)

Once the correlation has been completed, the marked-up correlation copy is returned to the design team through the SDM. The design team update the master files to the results of the correlation.

The resultant fully updated master records and the completed and signed off form ESP2502F-09 are the baseline for detailed design to commence.

4.4 Final Specification Review – ARTC Acceptance

When all the initial design documents are complete, review (refer Appendix A) shall be conducted to ascertain the initial design is in accordance with original requirements from the requirements development process and is constructible.

Before detailed design can commence, the SDM shall submit a complete design package containing a copy of the final SFOS, SP, any stagework SPs along with a current copy of the DMP and other supporting documents to the ARTC Project Manager for final specification acceptance and sign off by ARTC business unit Signal Engineering representative.

Until acceptance has been signed off and the correlation is complete, detailed design should not commence.

4.5 Detailed Design Phase

During this phase, the design team produces the detailed design documentation (refer Appendix A above). Design proceeds as follows:

a) The designer on receipt of the endorsed DPB may start their works.

b) Any additional design notes, assumptions or additional design inputs shall be added to the 'Design Notes & Assumptions' section.

c) Only on completion of the design and production check shall the designer add their name, signature and date to the 'Design Progress Record' section of the DPB form. This signifies the design is complete to the best of the designer's ability and awaiting checking.

d) The SDM, on receipt of the designer's completed DPB, shall complete the DPB – Checking Record section of the form and ensure all scope details and design inputs are up to date. (This process will ensure the design checker checks the design against the documented inputs and any assumptions made during the design process).

e) The DPB **shall** accompany the design as it goes to the design checker.

f) Provided the design checker agrees that there are no design errors/omissions and the design meets the scope requirements, the design checker can complete, sign and date the DPB. If the design does not meet the DPB requirements, then the design checker shall follow the record and rework process for updating the design. *Reference the guidance note at the back of the form on how to detail the document.*

Note: All DPBs shall be archived for later referral/auditing

4.5.1 Produce Construction Designs

The DMP will specify whether the designs are to be issued using the full green/pink/yellow design process or a truncated version.

The key areas of signalling construction design delivery are:

- Initial Design (refer section 4.2)
- Control/Locking Tables (grouped by interlocking, ground frame, automatic level crossing)
- System schematics – network architecture, screen/panel layouts, power distribution (grouped to the power supply point), Track Insulation Plans (scaled), aspect sequence charts, I/O lists
- Equipment layout designs – racking/cubicle layouts, control desks, equipment room layouts, cable running and core allocation details

- Civil & Mechanical designs (equipment rooms and locations, LX layouts, signal structures, point mechanisms, equipment bases, mounting arrangements, cable access, etc)
- Data related to computer based interlockings, lineside modules, LX predictors, LX monitors, control systems
- Circuit books (grouped by interlocking, ground frame, automatic level crossing, etc)
- Stagework Drawings based on stagework SPs; each stagework commissioning shall be treated as a separate alteration with a complete separate suite of the above designs (including control tables, temporary patches for signal box panels, etc), irrespective of the timescale between the works

The designs will be produced following the general design process, refer to section 4.11

4.5.2 Issued for Construction (IFC) and ARTC Acceptance

As required for the ARTC Installation Work Package (ESC2104F-03), a complete package of IFC detailed design documents produced in accordance with the DMP shall be reviewed by SDM before submission to the ARTC Project Manager for acceptance and sign off by the ARTC as per EGP-04-01.

A copy will be made of the reviewed design along with the current DMP. This is called the ‘As Designed” copy. This copy is to be issued to the ARTC Project Manager for sign off as accepted:

- If the contract with ARTC is design only, the ‘As Designed” documents are to be issued to the ARTC DMS – refer to EGP-04-01.
- If the contract with ARTC is design and support construction, the ‘As Designed” documents are to be issued as IFC drawings to the construction site (refer section 4.6).

4.5.3 Data

Refer to ESD-05-11 – ‘Microlok Data Design Records’ (Addressing, File Control, checking, and FAT Testing) on the procedures describing the process management involved with the production of Microlok data. Similar process can be followed for other CBI data, axle counter data or any other signalling system data.

4.5.3.1 Design Data Report

When modifying existing data and on completion of the data design, a ‘Design Data Report’ shall be completed by the Designer. The report shall detail the actions taken by the Designer in response to the scope of works set. The report shall detail all design considerations and assumptions made by the Designer i.e. how the data change affected any approach locking, overlaps, timers, level crossing approach timers, etc. in the existing data.

The report shall be used by the Function Tester and Principles Tester as an input document for their checking/verification purposes. The report will enable them to understand what actions have been taken and why.

The ‘Design Data Report’ is an auditable document. Each report will have an individual report number assigned to it and shall be registered (refer section 3.9.5).

4.6 Construction, Testing and Commissioning Support

As required by the DMP, a copy is made of the approved design on green paper or white paper with green labels for long or non-standard sized drawings. This is the IFC copy and is issued to the construction team. Multiple copies may be provided on agreement with the ARTC Project Manager.

4.7 Design Changes during Implementation

Design changes may be issued as amendments during the construction and testing phases or the post-commissioning defect rectification phase, or there may be a new issue of design. In each case, the design office copy is updated to incorporate those changes and any comments from the construction team prior to issuing design for the next stage.

Authorisation shall be received for any design changes (refer section 3.9).

4.7.1 Amendments Produced using Modification Books

Modification books are used for commissioning or where a minor change is required and it is not appropriate to issue formal control sheets.

A register of modification books is to be kept by the SDM detailing the modification book numbers and who it is issued to. Completed modification books shall be returned for archiving to the SDM.

Modifications are to be drawn legibly and are to show as much of the existing circuitry as necessary to clearly show the changes required to install and test the modification. Whenever possible, contacts used in the original design should not be reused in the modification. Spare contacts should be used wherever possible.

Where a modification sheet is used but not issued, it is to be cancelled. Cancelled modification sheets shall have two diagonal lines with the word ‘Cancelled’ neatly printed between them.

Modification sheets shall be verified before issue. During commissioning where the design approver is not available on the shift requiring the modification, a copy of the modification may be issued if urgent. Approval shall be sought at the beginning of the approver's next shift and the approved original modification sheet issued to replace the unapproved copy of the modification sheet.

The coloured sheets of the modification book are for distribution as follows:

- Yellow - Certified Commissioning Copy
- Blue - Office Copy
- White - Site Copy
- Pink - Site Test Copy

The modification sheets are attached into the relevant circuit book as soon as practical, following issue. The commissioning engineer is responsible for ensuring the relevant circuit books on site have the modification sheet attached, and the designer is responsible for ensuring the design office copy has the modification sheet attached.

4.8 Issue of Design for Testing

As required for the ARTC Inspection & Testing Plan (ESC2104F-01), this complete package of testing documents shall pass through a “Test Readiness Review” for submission and acceptance by the ARTC Project Manager (refer Appendix A).

The revised design office copy incorporating all modifications and changes is to be re-issued on pink paper or white paper with pink stamp/label for testing as required by the DMP.

4.9 Commissioning Readiness Review and Issue of Design for Commissioning

A Commissioning Readiness review (refer Appendix A) of the new signalling works is required to be undertaken before the commissioning can proceed. This is detailed in the standards covering Commissioning and Commissioning Work Packages ESC-21-04.

A principal purpose of the review is to ensure that any construction feedback and/or amendments to the design found during site installation have been fully incorporated in the design and have undergone the full verification process.

Any signal design modifications shall be in accordance with current engineering standards. Where the situation is such that updating to current standards is unwarranted, it shall be covered by an engineering waiver.

This review also provides a final check that all the design documents and data have undergone the full design processes and that all configuration management documentation is in place and signed off ready for commissioning. Where the design was for a Signalling System Substitution, the final check shall include the minutes of the close out meeting (refer APPENDIX E – Signalling System Substitutions Design).

Form ESP2502F-10 is to be completed and signed off by the SDM. Until this review is signed off as complete, the commissioning shall not proceed.

The revised design office copy will be issued on yellow paper as per Section 4.11 for commissioning.

4.10 Post Commissioning - Final As-Built Drawings and Documentation

Following the commissioning, the CCC is returned to the design team to update the files to As-Built status. All documentation (refer Appendix A) shall be issued to ARTC as detailed below:

4.10.1 Post Commissioning

After the commissioning (or each stagework commissioning), a copy of the Certified Commissioning Copy (CCC) and Intermediate Maintenance Copy (IMC) shall be issued to the ARTC Maintenance Engineer. The As Commissioned drawings shall include:

- the As-Designed drawings together with all the amended drawings and Mod sheets to be scanned as a complete copy of the design
- a copy of the final marked-up CCC

The Design Group shall issue As Commissioned drawings, the final As-builts and data to the DMS in accordance with the requirements outlined within EGP-04-01.

4.10.1.1 Final As–Built Drawings

The issue of As-Built drawings to the ARTC DMS shall ensure:

- The documents shall have all company identification logos removed and the proper ARTC logos incorporated.
- The CCC that has been signed by the Design Group and the approver of each drawing and document to certify that the final documentation has been updated and is accurate to the approved design and commissioned installation.
- Signed Masters that verifies the documentation is to the CCC.

4.11 General Design Processes

4.11.1 Design Guidelines

Signalling design guidelines covering procedures/standards, work instructions, forms and guidelines can be referenced from the ARTC extranet;

All detailed design works produced for ARTC Infrastructure shall take into account the considerations listed in APPENDIX C – Design Considerations as a minimum.

4.11.2 Documentation and Control

General requirements for format and symbols are given in ESP-25-01 ‘CAD & Drafting Manual for Signalling Drawings’ as are special requirements for conformity of presentation when existing drawings are altered.

4.11.2.1 Forms of Signalling Documentation

Signalling documentation may be provided in various forms such as:

- Paper Copies
- PDF files
- CAD files
- Vital and Non-vital Data

4.11.2.2 Control

CAD file status can be checked against the version date embedded in the file and identified on signed Control Sheets.

- Designs shall be produced such that: Every page of the Circuit Book shall include the NAN number/Project Number/Cost Code, and version date showing the date the design was last altered.
- Circuit Books shall have a unique number and every page of the book shall include the Circuit Book number and page number.
- A control sheet (CP1) shall be produced for each Job listing all pages of all signalling design documents (i.e. Signal Plan, Track Insulation Plan etc). The Control Sheet shall be kept current and record the version date of each sheet or document and version date of the Control sheet.
- The amendment sheet (AS1) shall be updated at the end of each project. The amendment sheet shall be kept current with all new, removed, amended and replaced pages clearly shown, with the NAN number/Project Number/Cost Code, date and modification work details completed.
- All changes to documents shall be highlighted and version dating recorded on the document. Subsequent changes shall be highlighted using clouds with the version date shown. Clouds are only used for that version date (i.e. when a further update occurs, previous clouds are to be removed).

4.11.2.3 Coloured Documentation

Signalling documentation and drawings are designated as follows:

- Design Master (SOFT COPY ONLY)
- Construction copy (GREEN)
- Test copy (PINK)
- Commissioning Copy (YELLOW)
- Certified Commissioning Copy (CCC, Marked up YELLOW)
- Interim Maintenance Copy (IMC, Marked up YELLOW)
- As-built (WHITE)

The use of coloured documentation for the various submissions is intended to assist in document control. White paper with the above coloured stamp/label may be used instead of coloured paper. When updating a design from GREEN to PINK to YELLOW the sheet version date shall not change unless the design has been amended. The adding of detail by field personnel to clarify or further detail is not a change to the design. Where wiring is physically altered it represents a design change and the amendment shall be given a new version date, the control sheet updated, checked, independently verified and approved.

When updating between different colour issues, the signature block of the circuit book shall be signed by the Design Group to indicate the status and that it is ready for release.

4.11.3 Design/Check/Verify Process

For each design deliverable there is a basic design/check/verify process (refer Figure 3 – Design Check Verify Process). The configuration management of the design process is very important and is to be handled using the DPB form ESP2502F-04.

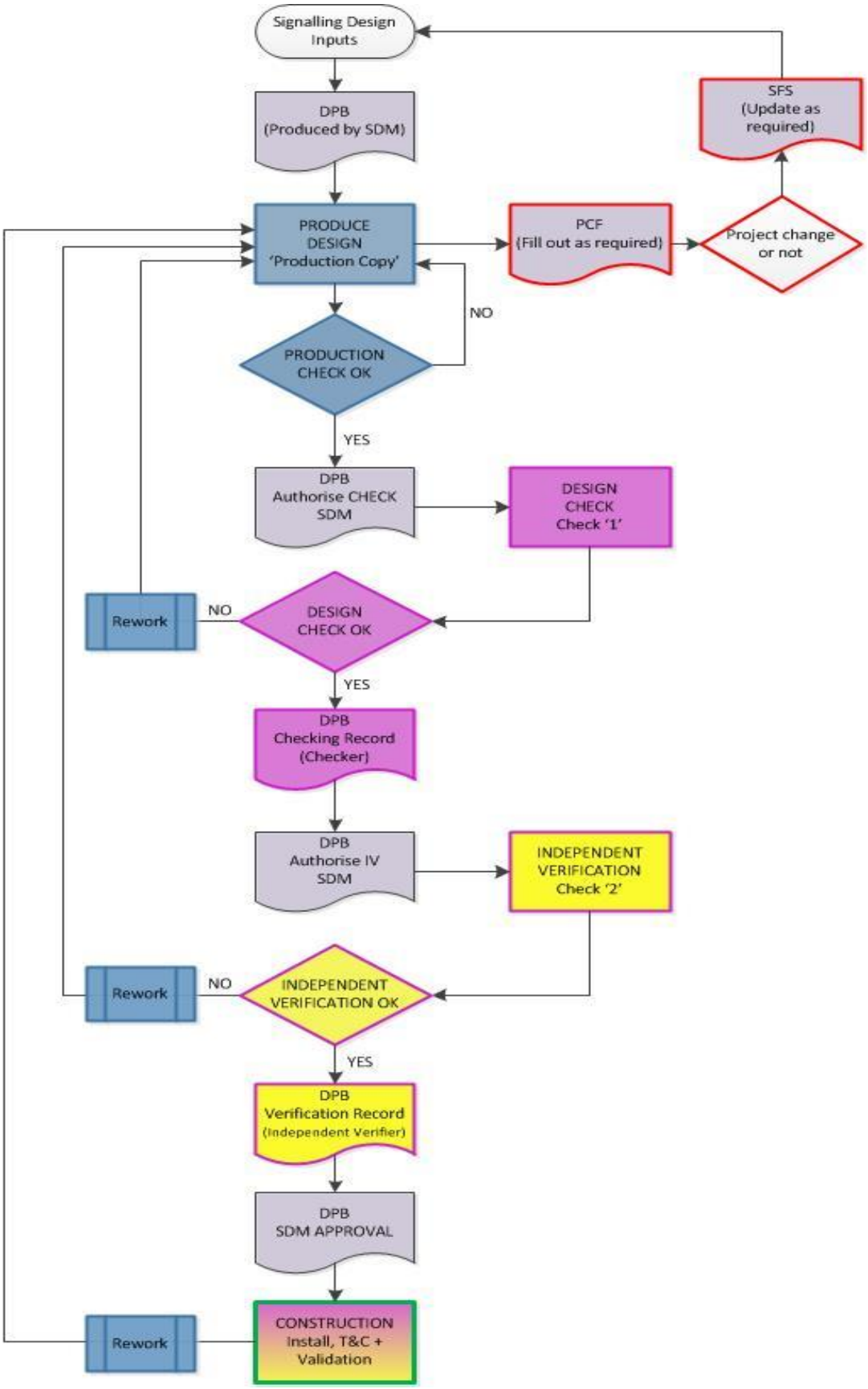


Figure 3 – Design Check Verify Process

Review Design Inputs: The design inputs are reviewed to ensure they match those specified in the relevant DPB and that they are suitable for commencing design.

Produce Design: The requirements for producing the design are dependent on the particular deliverable, which is described in the DMP and associated DPB.

Designs shall be in accordance with the accompanying DPB and shall always follow ARTC standards; on occasions where a design innovation is possible then consultation shall be sought with the ARTC. Written consent and agreement shall be received prior to any variation from ARTC and this shall be appended to the DMP.

The designer shall conduct a full production check prior to handing over of the design to the design checker. Only when the design is complete and all necessary corrections incorporated shall the designer sign and date the production copy.

Design Check (Check 1): The design check is the most detailed check performed on the design. It is essential that this check is carried out rigorously as later checks may not check the same level of detail (e.g. relay and terminal analysis cross-checks).

A check copy (copy of master design file) shall be issued to the design checker by the designer for checking purposes, along with all the relevant documentation, including the DPB.

The design check is a to be performed by a competent design checker who is independent of the design.

Independent Verification (Check 2): The independent verification of a design concentrates on safety, functionality, operational requirements and compliance with applicable signalling principles and standards. The independent verifier will check the requirements allocation and traceability matrix (RATM) produced by the SDM and the designers to ensure the elements of the design attributed to the functional and performance requirements are correct.

A verification copy shall be issued to the independent verifier by the designer when the design check and all rework have been completed and the DPB is signed off by the design checker. This verification copy is to go to the independent verifier along with all the relevant documentation, including the DPB.

The independent verification is to be performed by a competent verifier who is independent of the design.

Where multiple independent verifiers are being utilised across a design, then a singular independent verifier shall take responsibility for the overall design verification for that design and that it conforms to all design, safety and project requirements. This ensures that all designs have been completed to a consistent approach.

Approval: This is the sign-off by the SDM on the DPB that the proper process has been followed in producing/checking/verifying the design of each deliverable.

Rework: All errors found by the design checkers and independent verifiers are to be logged on the Check/Verification Defect Log (CVDL) ESP2502F-05 and are required to be addressed by the designer.

4.11.4 Design Checking and Independent Verification guides

Design Checking and Independent Verification shall be undertaken in accordance with this standard and ARTC signalling principles, which include (where applicable):

a) Ensuring all relevant source plans and drawings required for the design have been supplied.

b) A check of the SP conformance with the SFOS, and PMP; for a guide, use Form ESP2502F-08 – Design Check List - SP Design.

c) A check of the Track Insulation Plan (TIP) for conformance with the SP.

d) A check of the Control Tables to ensure operational and safety requirements are included.

e) A check of the locking diagram where applicable for agreement with the Control Tables and conformance with mechanical locking principles.

f) A check of the signalling circuits for:

- Conformance with signalling shown on the SP
- Inclusion of all required interlocking and track circuit controls including a check against the Control Tables,
- Inclusion of all train operating safety requirements,
- Conformance with applicable ARTC circuit design standards,
- for a guide to circuit book checking, use Form ESP2502F-07 – Design Check List - CBI Design

g) A check of computer interlocking data conformance with Control Tables; for a guide, use Form ESP2502F-07 – Design Check List - CBI Design

h) A check of the power supply design for:-

- Required power loading and supplies at each location,
- Adequate protection requirements,

i) A check of the mechanical design

j) A check of interfaces with existing signalling to ensure completeness and continuity of operation.

k) A check of other documents that are part of the design for the project e.g. indicator diagram, control panels and Train Control system.

4.11.5 Validation

The first validation process the design shall pass through is Functional Testing. This forms part of the Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT).

The second validation process the design shall pass through is the Principles Test. This forms part of the simulation testing when CBIs are used.

4.11.6 Design Independence

During the design process, the designer and design checker can liaise with each other regarding procedural and technical detailing but this shall be minimised as much as possible to help maintain a level of independence.

The independent verifier shall remain 100% independent from the design process. At **no** time shall the verifier be consulted on any technical or procedural aspect of the works.

4.11.7 Drawing Methods

There are two methods of presenting the design to distinguish between new equipment, existing equipment and equipment to be removed. These are the “one drawing” method and the “two drawing” method. The method to be used shall be specified in the DMP.

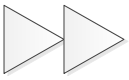
- One drawing method: The existing equipment, the new equipment and the equipment to be removed are shown on the same drawing. It is essential in the one drawing method that good CAD design practice is used so that the drawing can be easily manipulated to only show the final configuration without the risk of accidentally deleting parts of the design file.

- Two drawing method: This method comprises two copies of each sheet: one showing the new equipment with what will remain of the existing equipment; the other showing the existing equipment and what will be removed.

The new and removed equipment can be distinguished by two possible means:

Full arrows (new work) and hollow arrows (redundant work) can be used on production copies of design details to indicate changes as follows.


= New equipment to be installed or commissioned


= Redundant equipment to be recovered

The use of Red and Green or Yellow colouring schemes can be used. Red is to be used for new equipment to be installed or commissioned. Green or Yellow is to be used to show redundant equipment to be recovered.

Where practical, two-colour methods can be used to achieve consistency across the network in consultation with the ARTC Project manager and ARTC signal engineer.

*The combination of both design presentation techniques (arrows and colours) is not permitted within a works package***.**

Both drawing conventions may be applied to individual drawing elements by either:

- CAD (AutoCAD or MicroStation (if agreed by ARTC)) plotting is preferred
- Hand drafting on paper (to existing designs)

The style of presentation shall be consistent on any one sheet, in either “one drawing” or “two drawing” methods respectively.

Where a new drawing or discrete parts of a drawing depict all new work to be installed, the drawing, or the discrete parts bounded by a clouded border, shall be endorsed in ‘ALL NEW WORK’ with a full arrow. Alternatively, all the new circuits can be coloured red and endorsed with ‘ALL NEW WORK’.

Where recoveries are such that a complete drawing or discrete parts of a drawing become redundant, the drawing shall have a large cross through that sheet, or through the discrete parts bounded by a clouded border, shall be endorsed ‘REMOVE ALL’ with a hollow arrow. Alternatively, all the circuit sheet wiring can be coloured green and endorsed with ‘REMOVE ALL’.

This avoids putting multiple arrows on design elements which could lead to confusion of the design.

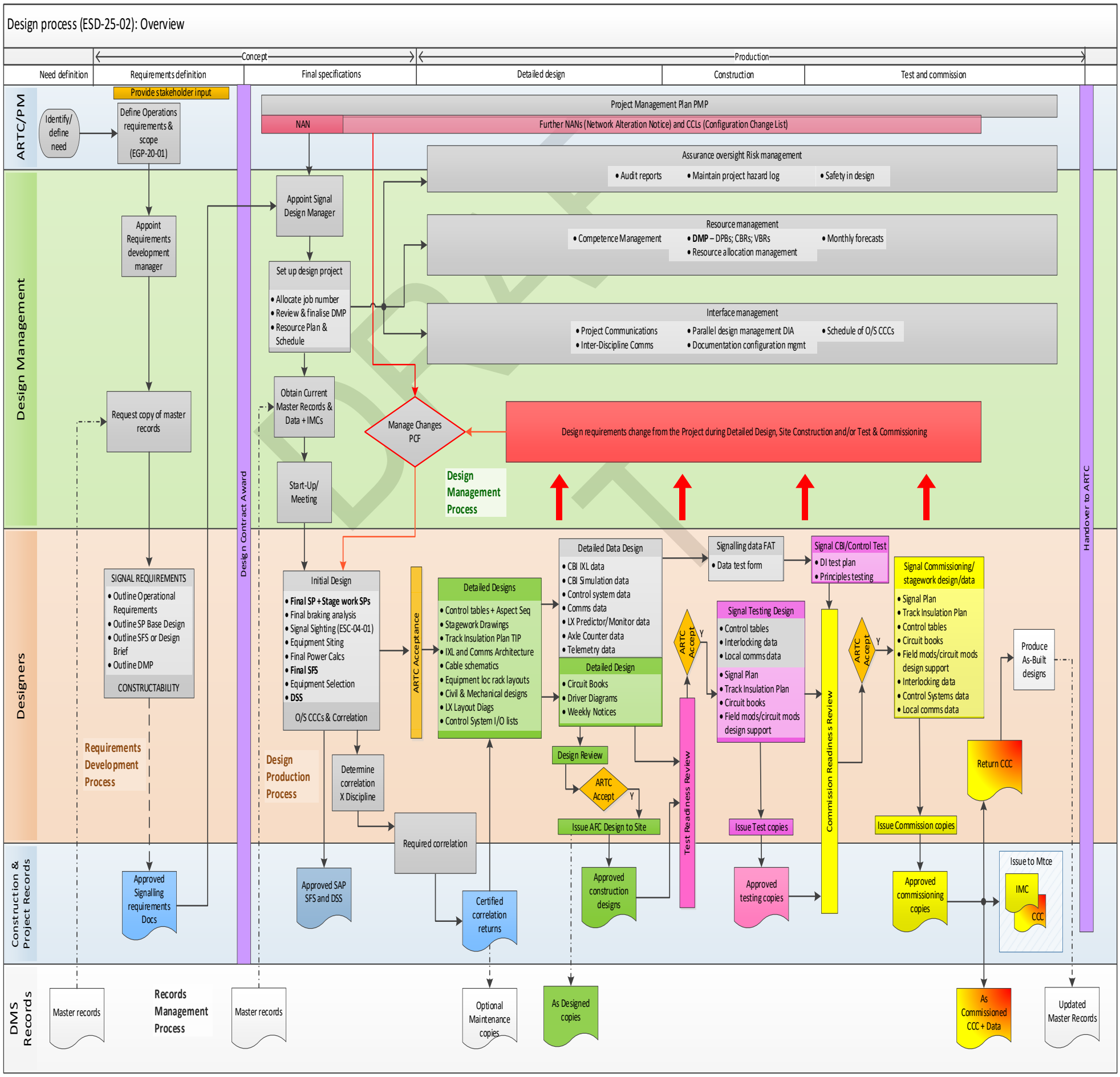
4.11.8 CAD Files and PDFs Copies

All circuit sheets shall be mandatorily updated to CAD prior to issue back to ARTC DMS, unless special dispensation is granted by the delegated asset management representative from ARTC.

After completion of the works, as-built CAD files of all circuit sheets and plans shall be returned to ARTC including hard copies in **PDF** format.

5 APPENDICES

5.1 APPENDIX A – Signal Design Production Process Flowchart



Definitions: – **AFC** – Approved for Construction; **CBI** – Computer Based Interlocking; **CCC** – Certified Commissioning Copy; **DIA** – Design Interface Agreement; **DMP** – Design Management Plan; **DMS** – Document Management System; **DSS** – Detailed Site Survey; **IXL** – Interlocking; **IMC** – Interim Maintenance Copy; **PCF** – Project Change Form; **LX** – Level Crossing; **SP** – Signal Plan; **O/S** – Outstanding; **SFS** – Signal Functional Specification; **TIP** – Track Insulation Plan

5.2 APPENDIX B – Signalling Functional & Operational Specification (SFOS)

Any special requirements governed by the ARTC shall be detailed within the SFOS.

The following are proposed items to be detailed within the Signalling Functional & Operational Specification for a project which undertakes signalling infrastructure works.

5.2.1 Applicable standards

1. State and network specific
    - Review of 'Commentary' and 'Issues Register' to ensure conformity to the latest standards.
1. Non-standard project requirements
    - Agreement by ARTC standards

5.2.2 Existing Signalling Arrangements

1. Existing SP
2. Description of signalling system

5.2.3 Proposed Signalling Arrangements

1. New SP
2. New and Altered Signal Routes and Points
    - New Signal Routes
    - Altered Signal Routes
    - New Points
    - Altered Points
3. Stageworks
4. Interface requirements/Interface agreements with other overlapping projects
5. Unique arrangements if any

5.2.4 Train Operations

1. Any stabling or yard requirements
2. Permissible train movements
3. Catchpoints and derailers
4. Track speeds
5. Fallback Operation Modes
6. Locking arrangements

5.2.5 Signalling Equipment Configuration & Standards

1. Design Criteria
    - Braking tables,
    - Overlaps requirements
    - Headway
    - Crossover line speeds

2. Interlocking Principles
    - Yard working
    - Shunt signals
    - Approach locking
    - Automatic normalising
    - Automatic re-clearing
    - Conditional clearing of Signals
    - Route releasing

5.2.6 Signalling Field Equipment

1. Field locations e.g. location case types, bungalow construction, cooling requirements (A/C or other cooling types)
2. Field location positioning e.g. kms and which side of track
3. Field location approx. sizes
4. Interlocking Configuration
5. Line side signals
    - Proposed positioning
    - Signal Sighting requirements/issues
    - Main running signals, Shunt Signals, Turnout Indicators, Signal Repeaters etc
        - Size
        - Aspects
        - Type LED or Incandescent
        - Positioning on signal post
6. Track Circuits
    - New Track Circuits
    - Altered Track Circuits
    - Types of track circuits to be used
7. Points
    - New Points
    - Altered Points
    - Types of points to be used
    - Detection requirements
    - Back drive requirements and detection
8. Vital Relays
    - New vital relays to be used
    - Special relay requirements
9. Communication
    - Communication type
        - 3G/4G, Fibre Optic, Copper based, Line Wire, other
    - Diversity

- Equipment requirements

5.2.7 Level Crossing

1. New crossing
2. Altered crossing
    - Line speed changes
    - Crossing type changes

5.2.8 Signalling Power Supply

1. Power supply arrangement/distribution
2. Power supply calculations
3. Power supply feeder
4. Power supply backup
    - UPS
    - Generator
    - Battery
5. Earth leakage detector positions

5.2.9 Signalling Interlocking Equipment

1. Interlocking Configuration schematic
2. Redundancy
3. Data Link Configuration
4. Diagnostic/Replay Facilities
5. Control system Interface

5.2.10 Train Control System

1. Proposed Modifications

5.2.11 Cable Route

1. Existing cable routes
2. New cable routes
    - Type of cable route
        - GST, GLT Pit and Pipe, other
3. ULX and local cable routes positions
4. Spare cable routes/conduits

5.2.12 Testing and Commissioning

1. Factory Acceptance Testing
    - Simulator testing
    - Test Plans
    - Hot standby testing
    - Design Integrity Testing

2. Commissioning
    - Full correspondence testing
    - Function testing
    - Weekly notice updates
    - Staging requirements

5.2.13 Construction Staging

1. Enabling Works
2. Support Works

5.2.14 Competency Requirements

1. Competencies required for the project

5.2.15 Signalling Equipment

1. Equipment type approvals (compliance to ESA-00-01 ‘Approved Signalling Items for the ARTC Network’
    - New approvals
    - Existing approvals

5.2.16 Appendices of relevant signalling documentation

Use this section to add tables and any reference material such as forms.

5.3 APPENDIX C – Design Considerations

Any detailed design works produced for ARTC Infrastructure shall take into account the below considerations as a minimum.

5.3.1 Site Specific Considerations

Consideration shall always be given to the site that is proposed to be altered; consideration shall be given to gradient, locality, environmental issues (see 5.3.8 below), geology, access as well as what the new system will transport i.e. passengers, freight or minerals and how this affects the design of the system.

5.3.2 Site Integrity Assessment

A site integrity assessment shall be carried out to ensure the signalling documentation reflects the current state of the infrastructure. If there is any doubt then correlation shall be carried out to ensure the integrity of the input documentation.

5.3.3 Specific Safety Considerations

Consideration shall be given to hazards likely to be experienced by installers, maintainers, or operators and the necessary protective measures required.

5.3.4 Maintenance Considerations

Consideration shall be given to how maintainers are to interact with the equipment over the life of the installation and the life cycle of equipment proposed for use.

Maintenance facilities shall be provided as required to meet the specified maintainability and availability performance.

5.3.5 Future Proofing Considerations

Consideration shall be given to the equipment type, the maintenance requirements they have, and the availability of ‘spares’ with regard to providing a design that can be supported throughout the life of the installation.

Consideration shall also be given to future works that are proposed for the area and what can be done to aid these installations i.e. use of double width location huts as opposed to single width locations, for use of future equipment.

5.3.6 Site Condition Assessment

An assessment shall be made to the current state of the infrastructure proposed to be altered. As a minimum this shall include suitability to re-use equipment (e.g. location cases, relays, power supplies etc), special precautions (e.g. asbestos) and any interfacing needs that shall be made. A ‘Condition Assessment Survey’ shall be used to document the assessment made.

5.3.7 Communications Addressing

Any addressing for communications systems, non-vital and vital signalling systems (e.g. IP addressing between comms equipment rooms) shall be requested from ARTC.

5.3.8 Environmental Considerations

The operating environment shall include electromagnetic compatibility (EMC) considerations, equipment proximity, climatic, corrosive and explosive conditions. Consideration to the likelihood

and impact of hazards, such as flooding or sea water spray and the degree of dust and water protection required. Protection against vermin shall also be considered.

5.3.9 Noise Considerations

Noise nuisance shall be considered, especially when in close proximity to urban areas.

5.3.10 Vandalism Considerations

Consideration to vandalism prone areas shall be given to ensure the safety of the systems in place.

5.4 APPENDIX D – Clearance Points between converging tracks

The signalling system uses track sections from track circuits or axle counter sections to check that a train path is clear for the passage of a train. Where tracks converge or diverge then there needs to be a defined clearance point that all other trains or rollingstock is clear off for the signal to show a proceed aspect.
The clearance point shall be determined by the track design engineer in accordance with the ARTC track standards. Please refer to ETS-07-00 for more information. The signalling insulated rail joint for track circuits or the position of an axle counter head shall be 3.5 metres minimum from the clearance point. This allows for a 3.5 metre overhang of the headstock of a wagon or rolling stock past the last axle.

The designer shall indicate on the ***Track Insulation Plan*** and Signalling Plan, every location of a clearance point that is used within the signalling design. The signal plan because of it is non-scale in the lateral direction may be deceptive as to clearance between tracks.

The designer shall include a table in the Control Tables detailing every clearance point and the signal routes or locking that is dependent on the clearance point.

The Commissioning Work Package shall include a specific Work Instruction to check and measure and record the clearance available at each clearance point listed in the control tables.

In the example at Figure 4 below, clearance is required between the block joint at signal 33 and the adjacent road.

In the example at Figure 5 below, there is no clearance point between 157A turnout and 159A turnout. Thus 13BT track section shall be unoccupied for a signalled route through 157A reverse. This requirement would apply for a shunt route.

In example at Figure 6 below the insulated rail joint between 7AT and 23AT is not clear of 24AT track for a train traversing 107 points reverse. Routes across 107 points reverse would require 7AT track section to be unoccupied.

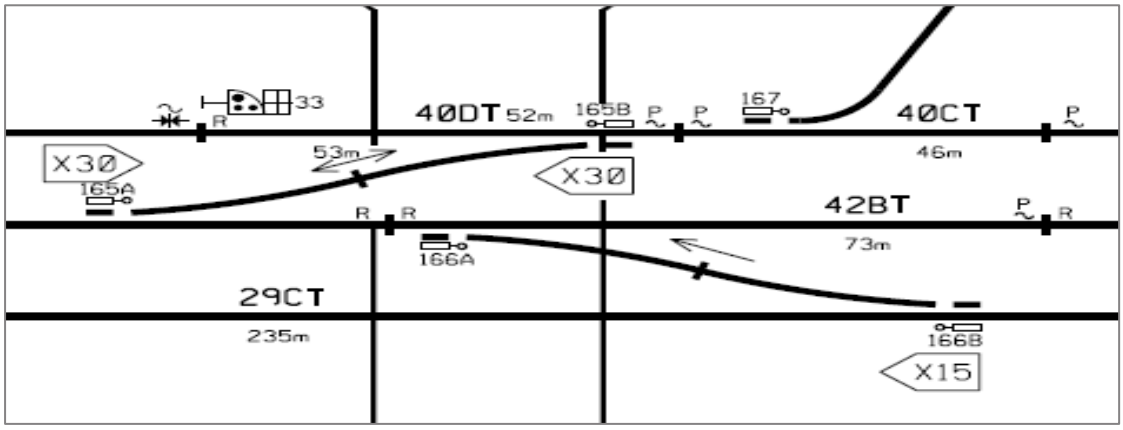


Figure 4 - Clearance Point for 33 signal

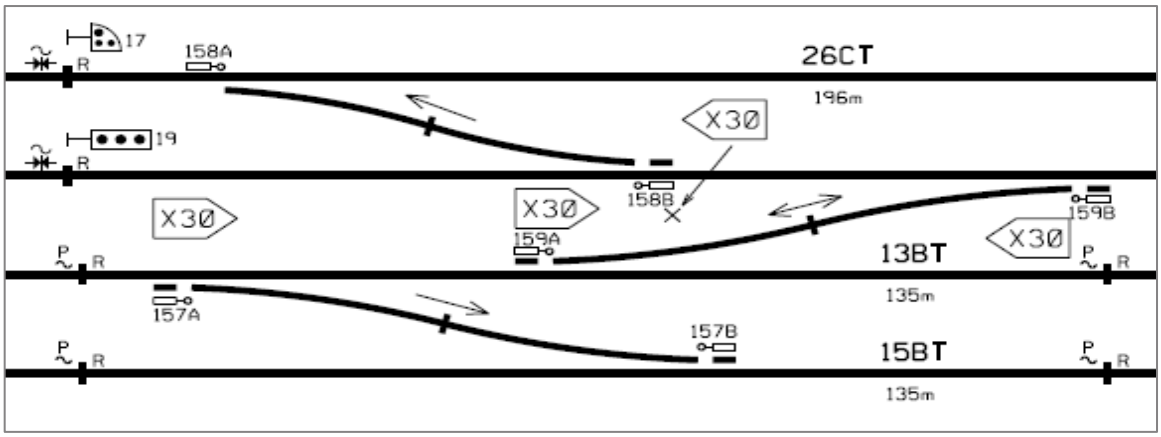


Figure 5 - No Clearance Point between 157A points and 159A points

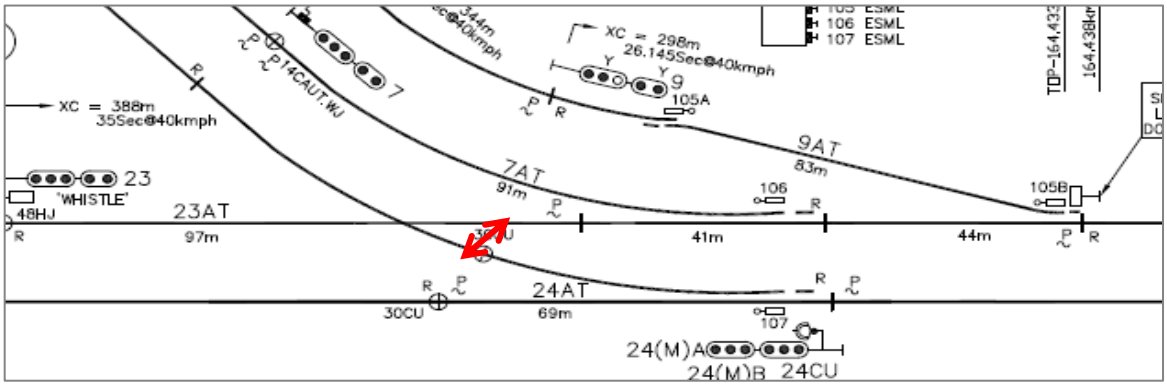


Figure 6 - The Signal Plan is deceptive as there is not sufficient clearance at this insulated rail joint between 7AT track section and 24AT track section

Measurement of Clearance Point and related Train Detection

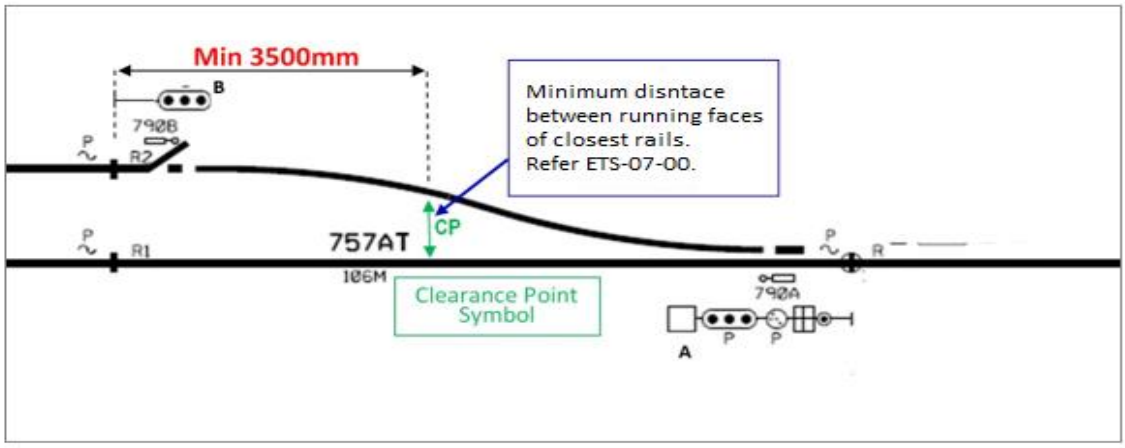


Figure 7 - Example layout

For each turnout, the CP is to be shown on new and newly amended ARTC Track Insulation Plan. This is to show where the train detection limit has to be located beyond the CP such that a train on one route will not collide with a train on the other route at the fouling point. The diagram above shows the minimum distances for the clearing point and the associated track circuit joint or axle counter head. This ensures a "passing clearance" for a minimum space between vehicles and an allowance for vehicle overhangs.

It is not always possible to place train detection limits on the "correct" side of the CP. If this is the case, the interlocking design shall treat it as being foul to prevent conflicting moves.

Note the CP distance from the point ends will depend on the speed of the turnout. Higher speed turnouts diverge much more gradually and this will lead to the CP distance to the point ends being greater than for lower speed turnouts.

Using the example layout above (refer Figure 7), if a train signalled past signal A via 790 points normal stops just beyond track circuit 757A joint R1, it will allow 790 points to be free to move reverse for routing a train from signal B. If the track circuit joint R1, was located inside the CP nearer the points, then a train signalled from signal B through 790 points reverse could potentially strike the stopped train.

5.5 APPENDIX E – Signalling System Substitutions Design

Signalling System Substitutions (sometimes referred to as “interlocking heart transplants”) require the existing interlocking conditions to be exactly replicated in the substitute system. This is fairly straightforward if the existing interlocking has up-to-date control tables.

However, if control tables are not available, a set of control tables shall be created to accurately reflect the existing interlocking conditions. This usually means reverse engineering the control tables from existing relay circuits. The following shall be addressed:

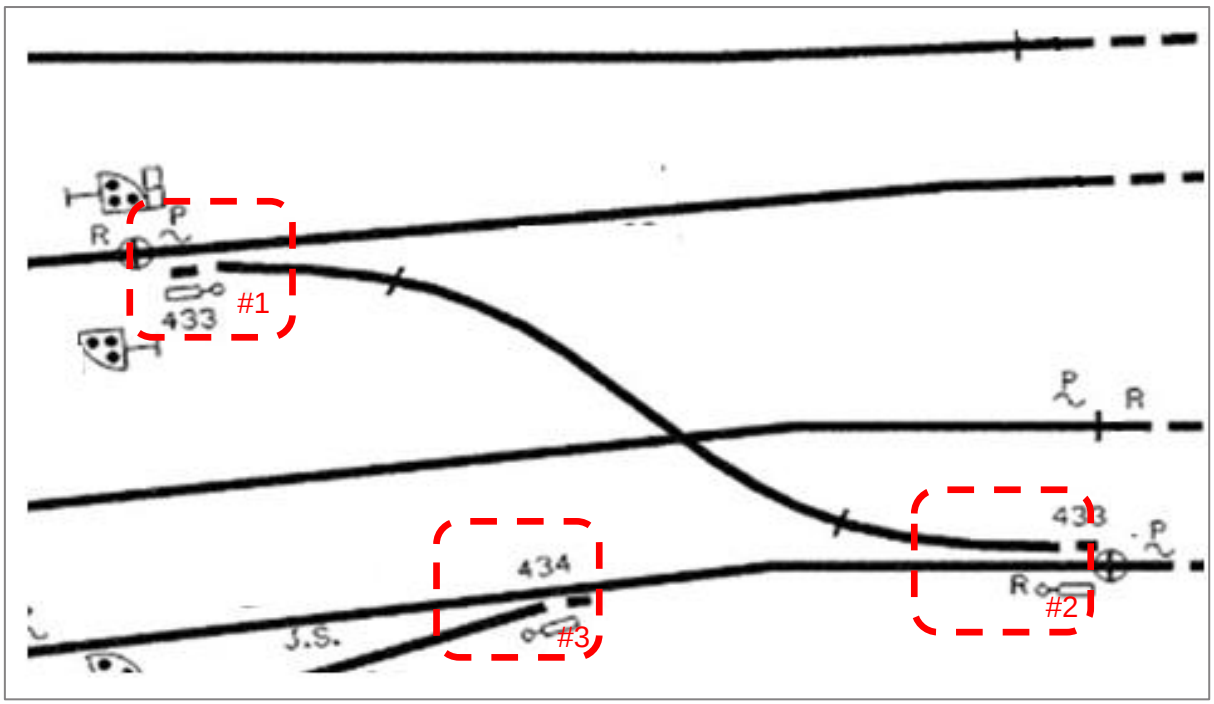
- Any special/novel locking requirements, that are not covered in ARTC’s Common Signal Design Principles ESD-05-01, shall be clearly included in the “Remarks” section of the appropriate control table.
- The SFOS (Signalling Functional & Operational Specification) shall also be updated to include any special/novel requirements (under Special Design Requirements).
- There shall be an Operations Requirements Specification detailing all train operations in the area affected by the signalling works. The Principles Tester and Design Verifiers shall ensure that the new design is suitable for the intended train operations.
- Control tables shall be designed/checked/verified by persons with the appropriate minimum level 2 competency. Principle testing of the control tables produced from reverse engineering shall be performed as per ESC-21-03. This also includes associated data, circuits and track insulation plans. Persons under mentorship are specifically excluded from this task for Signalling System Substitution Designs.
- Any existing design features not consistent with the current standards shall be reviewed and covered by an Engineering Waiver.
- NOTE: the requirements of ESI-05-13 - Signal Design and Standards Applicability apply to these works and the default is for the design to be upgraded to current standards.
- For the Checking/Verification/Validation process
    - Care shall be taken with review/verification logs that the meaning is clear and not easily misinterpreted by the designer amending the design
    - As part of the independent verification process, a final cross-check shall be performed to ensure any pre-existing novel requirements in the existing relay interlocking circuits/SP have been replicated in the data before the data is released for design integrity testing.
    - Design integrity test logs that require no further action shall go through the same process as if these logs required modification. That is, they shall be reviewed and signed off by the designer, checker and independent verifier.
    - Before the Commissioning Readiness Review, a minuted close out meeting shall be held between the Principles Tester, Independent Verifier, Design Checker and Designer to ascertain all special/novel locking requirements have been addressed,

The above process also applies to any upgrades to level crossings.

While doing the reverse engineering from circuit books, the below steps shall be considered.

- Site correlation of circuit books including signalling locations, equipment rack layout, etc.
- Correlation of circuit book with the signaling plan
- Drawing to be CAD and follow the design, check and approval process to produce the baseline for the project.

5.6 APPENDIX F – Correlating Point Motors and Detectors



When correlating points, it is important to check what hand the points are and that the drive and detection circuits are wired to the appropriate standard drawings for the particular points machine being used.

For example, in the layout shown above:

#1. Points are RHSNC (Right Switch Normally Closed) with the point machine mounted on the right

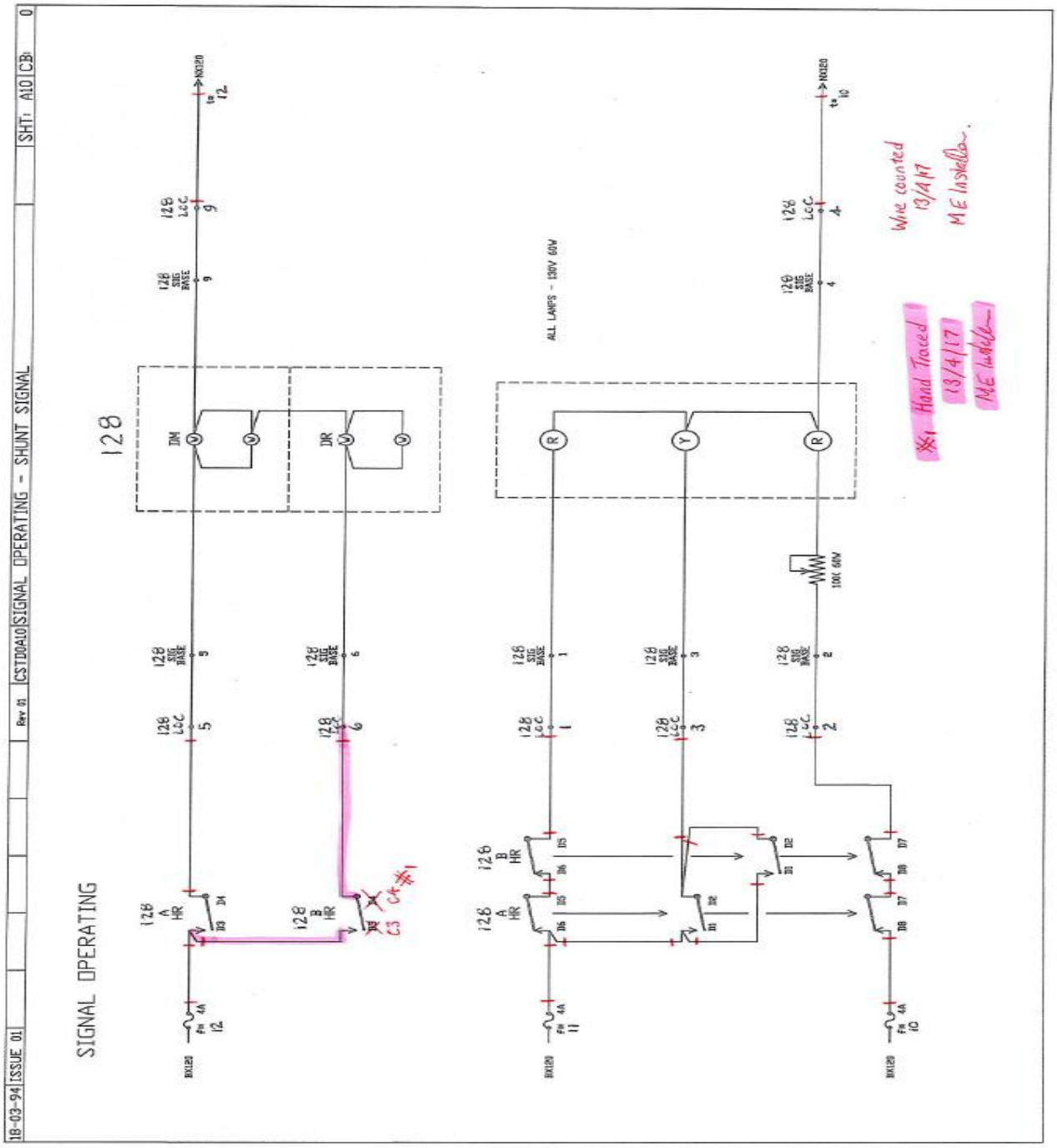
#2. Points are RHSNC with the point machine mounted on the left

#3. Points are LHSNC (Left Switch Normally Closed) with the point machine mounted on the left

If the points were Westinghouse 84M machines, the standard circuits for #1 and #2 would be SDS25 sheet W18 part 2/2 for detection and sheet W17 part 1/2 for points motor wiring.

The standard circuits for #3 would be SDS25 sheet W18 part 1/2 for detection and sheet W17 part 2/2 for points motor wiring

5.7 APPENDIX G – Correlation Mark Up Example



Appendix H: Design documentation for Signalling

The signalling equipment and systems should be designed in the following 3 design packages where applicable as below.

IFC Design Documentation of signalling equipment and systems package 1 should be completed before the design of packages 2 and 3 commences.

Signalling design package 1, includes:

A. signal functional and operational specification;

B. design of power supply loadings, reticulation power calculations and power schematic for HV and LV supplies;

C. braking calculations;

D. Microlok II or CBI system architecture

E. centralised train control system (Phoenix) and telemetry network architecture (Kingfisher, RS400);

F. telemetry data and input / output bit lists;

G. correlation circuit design (circuit books);

H. source design records assurance and correlation complete;

I. spare capacity analysis (local and main cables and signalling locations);

J. cable plan signalling and electrical;

K. signalling equipment room rack layout and floor plan;

L. structure gauge design assessment report on all new signals and modifications of existing signals;

M. signal sighting forms in accordance with ARTC Engineering Standard ESC-04-01 Signal Sighting;

N. signalling arrangement plan;

O. control tables / locking tables;

P. bill of materials;

Q. train modelling to ensure design complies with requirements of the TSWD;

Signalling design package 2, includes:

A. track insulation plan;

B. circuit design drawings (circuit books) including individual stage work design drawings as required (circuit books and plans to follow blue (correlation), green (construction), pink (testing), yellow (commissioning) and white (as built) process);

C. signalling power supply design (HV/LV) including High Voltage service provider design;

D. communications data plan / design;

E. signal civil design, including:

1. signal foundations;
2. signal post & ladder landings;
3. signalling equipment room foundations;
4. signalling equipment rooms and cases;
5. walkways and handrails;
6. shade structures;
7. track side equipment; and
8. integrated signal civil design solution to prevent clashes with existing asset constraints;

F. combined services route design, including:
    1. cable plan (including detailed site survey and conduit / cable detail drawing set);
    2. cable entry configurations / details;
    3. combined services route transition details;
    4. combined services route and under line crossing cross sections;
    5. pit schedules and pit layout (including drainage details);
    6. cable schedules including combined services route allocation;
    7. cable installation plan (cable types and pulling tensions);
    8. combined services route cable marker and signage drawings;

G. consolidated technical / shop drawing for each turnout or catch point arrangement, including:
    1. turnout / catchpoint technical drawings;
    2. point machines;
    3. point rodding;
    4. switch rollers;
    5. locking and associated equipment;
    6. bearers and base plate;
    7. insulated joint positions;
    8. Phoenix Train Control System design, including signalling configuration changes and installation stages;
    9. Kingfisher and telemetry design and data;
    10. thermal assessment report on signalling equipment rooms and location cases;

Signalling design package 3, includes:

A. drivers diagram ;

B. Design Integrity Test Plan and detailed program;

C. Microlok II or CBI Data includes completed:
    1. Microlok or CBI interlocking system simulation design and testing,
    2. principles testing;
    3. Phoenix integration testing;
    4. RS400 Data;
    5. Kingfisher telemetry data; and

D. Phoenix Train Control System, including signalling configuration changes.