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WESTRACE

System Overview Manual

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WESTRACE

System Overview Manual

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1. INTRODUCTION

1.1 WESTRACE System Overview

The WESTRACE Vital Signalling System is a modular, safety critical, programmable electronic signalling control system for Railway Signalling. WESTRACE is particularly suited to Signalling Interlockings.

WESTRACE is an acronym for **WES**tinghouse **T**rain **R**adio **A**dvanced **C**ontrol **E**quipment.

The WESTRACE system can be used for different safety critical applications, such as:

- interlockings;
- vital object controllers;
- vital telemetry;
- automatic train protection.

WESTRACE is extremely flexible to apply and to facilitate changes to existing applications. It uses plug in modules for compatibility with different types and quantities of inputs and outputs. Thus, only the hardware actually required for an application needs to be installed. Additional WESTRACE modules can be added later to extend the capability of the installation; new functionality being offered by newly designed modules.

Now with Ethernet vital and non-vital communications, WESTRACE is better than ever able to serve all applications from small to very large interlockings.

WESTRACE system designers use a graphical configuration system to define the modules and logical operation of the system. The logic can be changed or expanded as the needs of the system change and fully simulated before cutting into service.

The WESTRACE Signalling System described in this manual is one of a set of building blocks that may be used alone or in conjunction with other building blocks to develop state of the art train control systems.

Westinghouse Rail Systems Australia (WRSA) supports WESTRACE with state-of-the-art tools for simulating, testing, and diagnosing installations with little or no disruption of rail traffic.

This chapter introduces the WESTRACE system and the WESTRACE System Overview Manual. It includes references to other manuals for design and support information for WESTRACE.

1.2 Scope

To provide an appreciation of the WESTRACE Vital Signalling System; its capabilities, application, and maintenance; support tools, systems and training.

This is **not** a *how to* manual. It does not provide detailed information about any of those functions.

Readers must refer to the other applicable WESTRACE manual(s) for detailed information.

1.3 Manuals and Support

The manuals that describe and support WESTRACE are introduced in this section. Each manual has a specific purpose and is available from

. Figure 1.1 illustrates the relationship between these manuals. Higher level manuals are a prerequisite for the those below them.

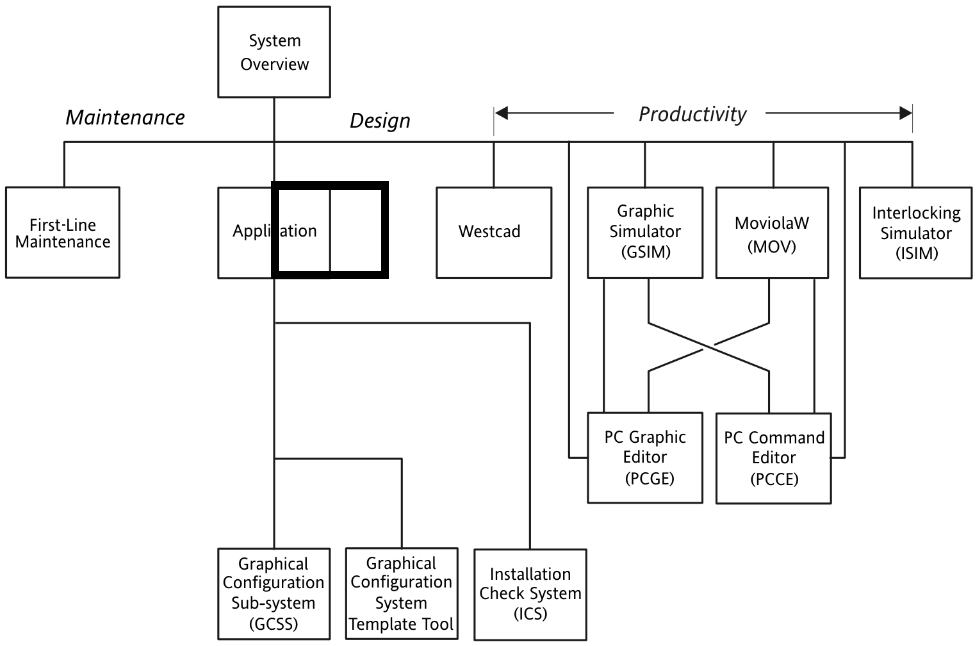


Figure 1.1: WESTRACE and Related Manuals

There are other manuals which describe the use of WESTRACE in larger systems, such as the WESTECT Automatic Train Protection System.

1.3.1 System Overview Manual

This manual provides an overall description of the WESTRACE system; what it is used for and what it consists of. The manual assumes a basic understanding of Railway Signalling but not specific product knowledge. It describes the system components (modules), support tools, and some applications for them. It will assist in deciding on the suitability of WESTRACE for a given application and will reference other manuals for system design, installation and maintenance.

This manual is pre-requisite reading before reading other manuals in the suite.

1.3.2 Application Manual

The WESTRACE Application Manual fully describes the design of a WESTRACE signalling system. It is the *how to* document that must be followed by the system designers and installers.

The Application Manual defines:

- system modules and their application;
- selection of system components;
- input and output interfaces to the system;
- system parameters;
- system operation;
- testing, commissioning and in service operation.

Refer to the GCSS manual for details of using GCS to prepare the Application logic.

SAFETY
WARNING

The Application Manual must be followed during system design to ensure that system safety is not compromised.

1.3.3 First Line Maintenance Manual

The WESTRACE First Line Maintenance Manual describes procedures for maintenance people to quickly and accurately diagnose system operational problems and restore correct operation.

The manual includes sections on:

- WESTRACE operating characteristics;
- maintaining and servicing WESTRACE equipment;
- instruction for fault evaluation and correction;
- descriptions of WESTRACE modules;
- descriptions of the use of the diagnostic tools.

First line maintenance generally involves module replacement to quickly return a faulty system to operation.

1.3.4 GCSS Manual

The WESTRACE Graphical Configuration Sub-System (GCSS) is a PC tool for designing and checking both vital and non-vital application logic for WESTRACE systems. The graphical user interface speeds system configuration with 'point and click' design of interlocking logic.

The WESTRACE Graphical Configuration Sub-System Manual describes the use and application of GCSS.

More details of the GCSS are in section 2.3.1.

1.3.5 GCS Templates Tool Manual

The WESTRACE GCS Templates Tool is a PC based application that Signal Engineers can use to develop standard geographical logic blocks applicable to a specific railway. A lesser skilled Signal Engineer apply these, with customised mnemonics and conditional logic, to prepare the bulk of the application logic for a specific signalling application.

The GCS Templates Tool manual describes how to use the Templates Tool.

1.3.6 ICS Manual

The WESTRACE Installation Check System (ICS) is a PC based tool for directly checking that the correct application logic is installed in the target HVLM-based WESTRACE system.

The WESTRACE Installation Check System Manual describes the use and application of ICS.

More details of the ICS are in section 2.3.3.

1.3.7 GSIM Manual

The WESTRACE Graphical Simulator (GSIM) is a PC application that

- simulates the operation of WESTRACE logic,
- simulates interfaces to control and maintenance systems
- simulates trackside equipment

to assist thorough, office-based testing of application data.

The WESTRACE Graphical Simulator User Manual describes how to configure GSIM to test WESTRACE Installation logic.

More details of GSIM are in section 2.4.

1.3.8 ISIM Manual

The WESTRACE Interlocking Simulator (ISIM) is a WESTRACE and S2 based tool that enables testing of railway signalling logic in the office prior to commissioning a system.

The WESTRACE Interlocking Simulator User Manual describes how to set up the simulator to test WESTRACE application data and optionally non-vital control (Interlogic data) for railway signal interlockings.

More details of ISIM are in section 2.5.

1.3.9 MoviolaW Manual

MoviolaW is a suite of PC diagnostic, logging and play-back tools for WESTRACE Vital Signalling Systems and other railway systems.

The MoviolaW User Manual describes how to set up and use MoviolaW to display and record the states of a WESTRACE system.

More details of MoviolaW are in section 2.6.

1.3.10 PCGE Manual

The PC Graphic Editor (PCGE) is a Microsoft Windows-based application for creating diagrams used with:

- GSIM;
- MoviolaW.

The PCGE manual describes how to set up and use the PC Graphic Editor to create station layout diagrams.

1.4 Organisation of this Manual

This manual includes chapters on the following subjects:

Chapter 1: **Introduction**—describes the purpose and perspective of the manual in relation to other manuals and the equipment.

Chapter 2: **WESTRACE System Description**—high level description of the WESTRACE system. It describes the basic purpose of the system and the function of each of the modules. It assists users to decide whether WESTRACE is suitable for their application. Further details of the modules are found in the Application Manual and the First Line Maintenance Manual.

Chapter 3: **System Design**—an overview of the process of system design of hardware and application logic for a WESTRACE interlocking. A full description of the methods and design process is included in the WESTRACE Application manual. Details of application logic design are included in the WESTRACE GCSS manuals.

Chapter 4:	**Maintenance and Training**—describes the WESTRACE maintenance philosophy and gives details of the training available. First Line Maintenance is fully described in the First Line Maintenance Manual.
Chapter 5:	**Safety Principles and Methods**—provides a background of the safety principles and methods used in the design of the WESTRACE system. Further information is in the Application Manual.
Appendix A:	**System Specification**—a brief specification of the WESTRACE system components.
Glossary:	Defines the acronyms and terms used in this manual.

2. WESTRACE System Description

This chapter describes the WESTRACE system and the functions it can perform. It describes each module and shows how these relate to railway signalling. It gives a specific application example. The system comprises the hardware (vital hardware is referred to as VLE in WESTRACE documents), configuration logic, support tools, and documentation.

Figure 2.1 depicts a typical WESTRACE system. The major components are:

Item 1 is the configuration system. GCSS (depicted) is a software package used for WESTRACE systems. The configuration system is used to generate the application data used by VLM and NVLM (the non vital logic module, either the NCDM or NVC/DM) that defines the modules used and unique operation of each particular interlocking.

The GCS Templates tool may be used to prepare much of the application logic to geographical rules as an input to GCSS.

Item 2 is the Graphic Simulator (GSIM), that provides graphical PC-based simulation of complete WESTRACE or multi-WESTRACE installations and the associated railway signalling objects. GSIM simulates Local Control Panels, the trackside equipment and graphical displays of the track. It also provides a networked connection to WESTCAD, MoviolaW, Small Control Centre and Interlocking Test Tool to enable efficient testing at a system level.

Item 3 is the configuration data generated by GCSS.

Item 4 is the hardware that comprises all the WESTRACE Vital and Non-Vital modules and the housings in which they are installed and operated. A system may use up to 4 housing and multiple systems can be interconnected.

Item 5 is the Installation Check System (ICS), PC package that is used to verify that the correct operational data is installed in an interlocking or system. A laptop PC running the ICS application is connected to the WESTRACE's serial ports.

Item 6 is the MoviolaW suite of diagnostic tools for WESTRACE Vital Signalling Systems and other railway systems. For local MoviolaW use, a dedicated PC running MoviolaW is connected to the WESTRACE. MoviolaW can be networked for remote access.

Item 7 is the set of manuals that are an integral part of a WESTRACE system. See section 1.3 for a list of the manuals required for a WESTRACE system.

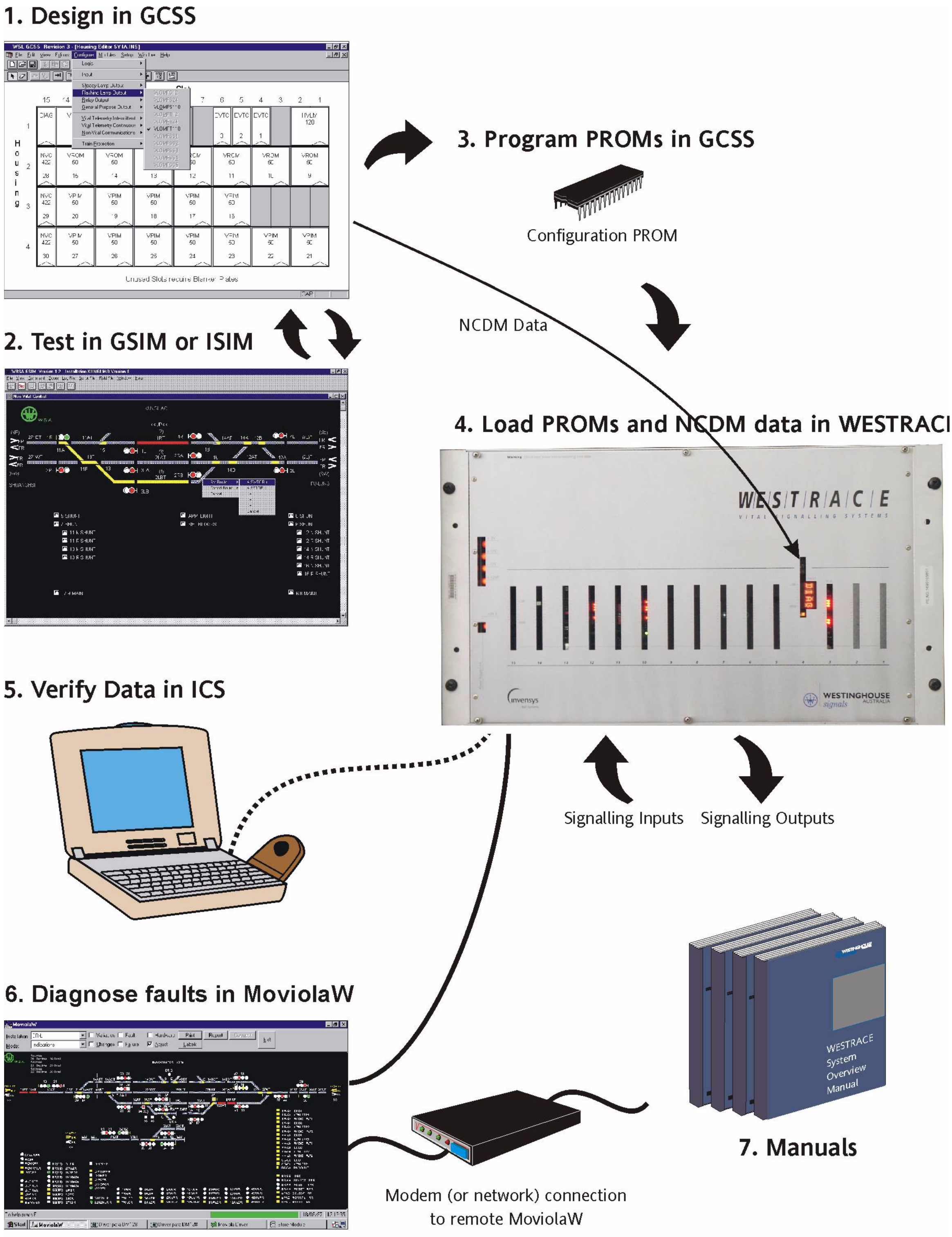


Figure 2.1: The WESTRACE System

2.1 System Operation

Signalling and Remote Control Inputs are processed in vital modules according to the application data to generate Signalling Outputs and remote control outputs as shown in figure 2.2. Remote control and indication, and non vital applications are processed according to non-vital application logic in a non vital module that communicates with the vital module. Communications interfaces with the non vital module (and occasionally the vital module) link to other WESTRACEs and associated systems.

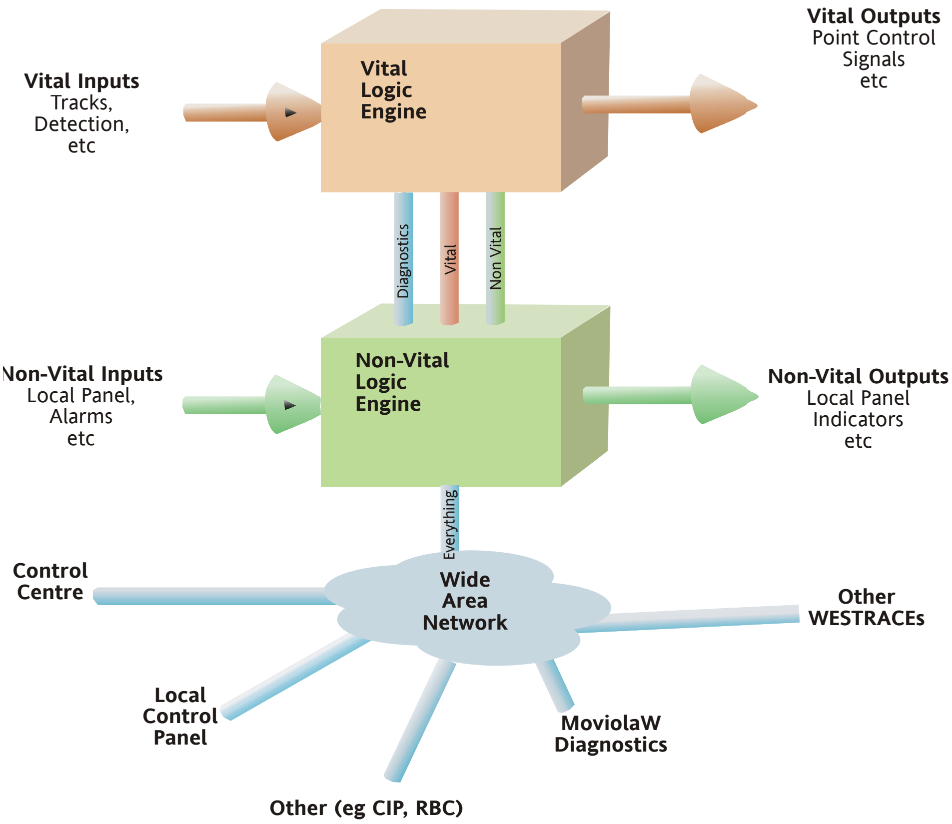


Figure 2.2: Overview of System Operation

The system will safely control signalling objects (points, signals etc.) based on:

- non vital remote control;
- non-vital logic relationships[1] (defined by relay equivalent circuits) of:
  - external control inputs;
  - internal vital and non-vital logic states;
  - internal timers;
  - time of day timers;
- vital inputs;

1. The non-vital relationships are for non-vital control such as route setting logic, panel processing and must never be used as part of the vital control.

- vital logical relationships (defined by relay equivalent circuits) of:
  - all these inputs;
  - internal vital and non-vital logic states;
  - internal timers.

This operation is shown diagrammatically in figure 2.2.

Each WESTRACE system is custom integrated for its specific installation using the standard functional modules described later. Modules are specific for input and output types as well as for control, logic processing and other housekeeping functions. The designing Signal Engineer selects the type and quantity of each module required for each application and prepares the Application Data that defines the system and its operation.

The modules are plugged into one or more equipment housings that interconnect them, via a backplane, to the central processing functions. Each module with input or output capability is connected externally via a Protection and Filter Module (PFM) (protection only for (NVC/DM) that minimises electrical interference entering or leaving the housings. These PFMs are connected to the signalling equipment via plug couplers at the rear of the housing. We recommend external surge protection where cabling is subject to external transient voltages (e.g. where it is routed outside the relay room).

Figure 2.4 shows a typical application for WESTRACE. Many WESTRACEs may be controlled from a remote CTC office. Controls are sent, and indications returned, via serial communications or a Wide Area Network (WAN). The WAN only needs to be fast enough for the data transferred and can support diverse paths between the equipment. The WAN connects to the NCDM—all vital data is directly passed to the VLM6 without modification. Older systems used serial connections to the CTC, MoviolaW, Local Panel and adjacent WESTRACES and these can still be supported with the appropriate modules (NVC/DM, NVC, EVTC, DM etc.), or in most cases with the NCDM.

WESTRACE accepts inputs from trackside equipment such as track circuits and point machine detection, existing relay interlockings etc. This external equipment switches a signalling supply to the inputs on WESTRACE Vital Parallel Input Modules (VPIM) that are read by the application logic.

WESTRACE Vital Relay Output Modules (VROMs) are used to drive point machine contactors or signalling relays that may be necessary to connect to existing relay interlockings. These modules provide a 50 V supply to the external relay.

WESTRACE Vital Lamp Output Modules (VLOMs) are used to control trackside colour light signals directly. The modules can supply steady or flashing signal aspects. VLOMs switch a 110 V signalling supply to the signal lamps and LED signal modules.

Vital data must often be communicated between WESTRACE interlockings. This may be block information between adjacent interlockings, it may be used to expand the capacity of a system by combining two or more WESTRACE systems or it may be with logic in one WESTRACE interfacing to the field through several smaller WESTRACE *object controllers*. Vital data from the VLM is packetised without content modification into IP packets in the NCDM and passed over the network to other WESTRACEs. Enhanced Vital Telemetry Continuous (EVTC) modules can alternatively be used to talk with existing older systems over a dedicated data channel between each pair of EVTC modules. This could be a PCM channel, dedicated point-to-point radio link, direct cable for short distances or a pair of modems. We have an automatic external switch that can route the EVTC over one of a pair of channels to provide channel redundancy.

WESTECT Automatic Train Protection (ATP) may be incorporated into the interlocking. The special WESTECT data message is generated in the WESTECT Communications Module (WCM). The output is then modulated in a Radio Control Module (RCM) and broadcast over radios. The RCM module and radios are usually mounted in an external 19-inch 3U housing.

The WESTRACE system operates from a 24 V no-break power supply. This is connected to the WESTRACE Power Supply (PSU) to generate the other voltages required within the system.

The Vital Logic Module executes the vital application logic, controls the communication between all other modules and processes the application logic. It also monitors the safe operation of the system and will invoke a system shutdown to prevent unsafe operation. Current VLMs may be used in a hot standby system.

The NCDM or NVC/DM modules (older systems use the DM128 Diagnostic Module) log every change of state of every input, output, internal latch and internal timer and any system faults. MoviolaW, running on an external PC can record these logs indefinitely and display a mimic of the railway that shows current or played-back states. NCDM and NVC/DM can also execute large quantities of non-vital logic as may be required for route setting, panel processing or non-provocative control of the vital.

The new network features significantly simplify a WESTRACE installation and the single communication connection can minimise communication costs. Other equipment can easily be connected to the network at a later time. Networks can be designed with diverse, redundant routes to protect against single communication failures.

Figure 2.3: A typical 2 Housing WESTRACE System

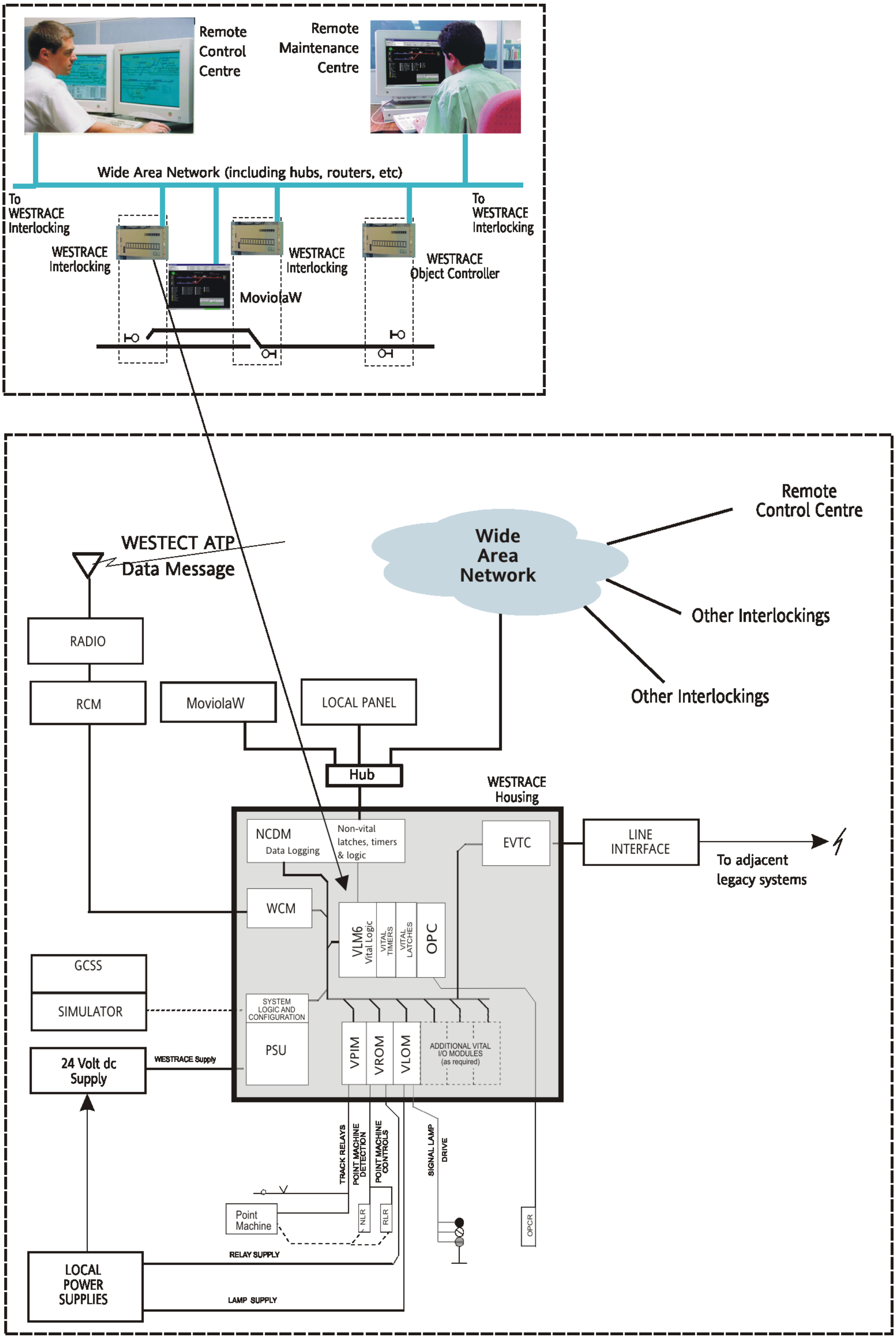


Figure 2.4: Typical WESTRACE System for CTC Installation

2.2 Vital Logic Equipment (VLE) Architecture

2.2.1 VLE Card Housing System and Backplane

Modules are installed in one or more WESTRACE housings. These housings provide the mounting for the modules, the interconnection between them, and shielding from electromagnetic interference. All external inputs and outputs are taken via plug couplers on the Protection and Filter Modules (PFM) (or Protection Module for NVC/DM) associated with the module.

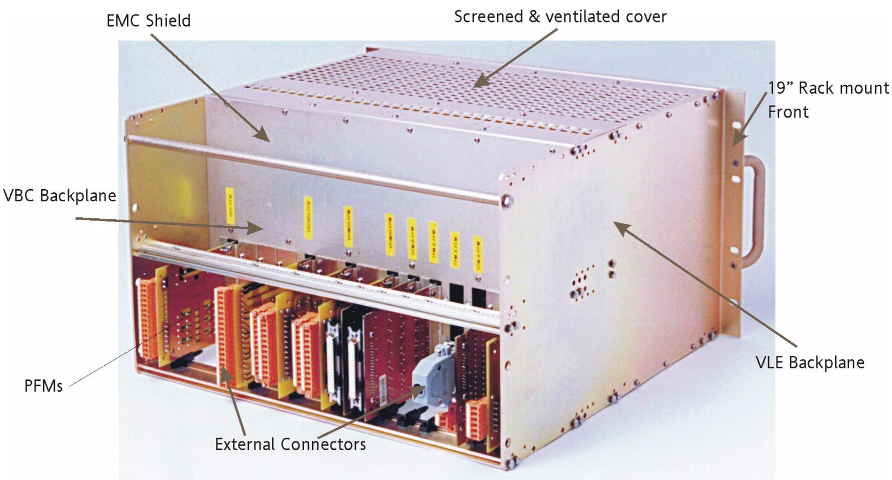


Figure 2.5: Typical WESTRACE housing (rear view)

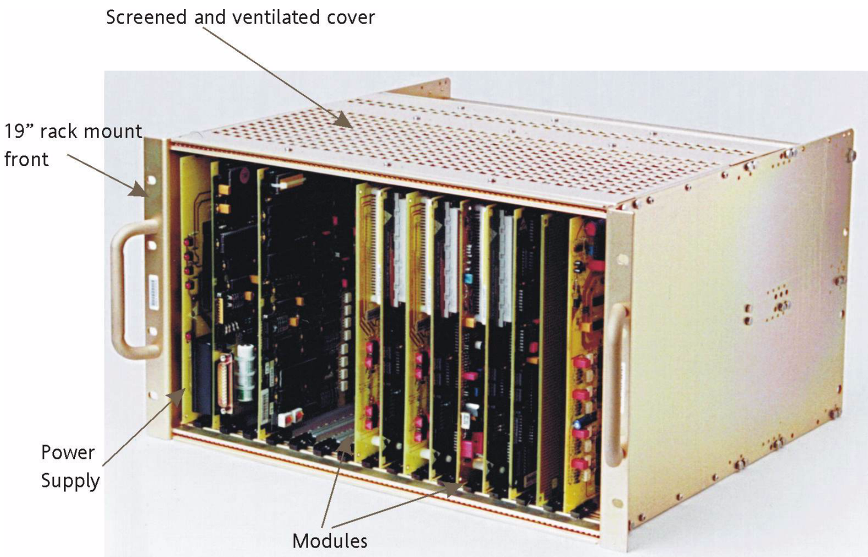


Figure 2.6: WESTRACE Housing Front (cover removed)

Each housing is a 19-inch 6RU extended Eurocard card frame. WESTRACE PFMs are installed at the rear of the housing. The housing is an efficient electromagnetic screen for the WESTRACE modules that minimises any electrical interference from entering or leaving the system. WESTRACE modules are plugged in from the front of the housing to connectors on the PFMs and back plane. There are 15 standard card slots in each housing plus an additional slot reserved for a PSU module. Some modules use more than one card slot. The VLE back-plane interconnects the upper module connectors for each card slot. A separate, short VBC backplane interconnects the lower connector for the VLM cards; two for HVLM and VLM5, three for VLM1.

A system may use between one and four housings as necessary for the number of modules required. Multiple housing systems are supplied from the factory with interconnecting cables between the backplanes.

Housings are numbered from 1 to 4, top to bottom. The backplane in each housing is strapped at assembly to set the housing number. Each card slot in a housing is numbered from 1 to 15. Slot 1 is on the right side looking from the front of the housing. Each system is given a unique address allocated by Westinghouse Rail Systems Australia.

There is an additional card slot in each housing for a Power Supply Module. At least one power supply is required in each system and normal practice is to use one power supply per housing.

2.2.2 Modules

The WESTRACE system hardware comprises functional modules as described in the following sections.

2.2.2.1 Vital Logic Module (VLM)

The Vital Logic Module has undergone continual improvement. The modules used by Westinghouse Rail Systems Australia are:

Module	Cards	Description
VLM1	VLC CEC OPC	Not used for new installations.
HVLM	HVLC OPC	Non-preferred module. Greater capacity than VLM1. Supports hot standby operation.
VLM5	VLC5 OPC	Non preferred module Approximately double capacity of HVLM. Supports hot standby operation.
VLM6	VLC6 OPC	Forms part of WESTRACE Network Communications in conjunction with NCDM module. Similar capacity to VLM5 and also supports hot standby and vital communic-tions over the network.

All variants also use a Vital Backplan Card (VBC) that is part of the top WESTRACE housing.

This manual discusses VLMs generically, except where it is necessary to refer to a specific variant; the nomenclature above will then be used.

The Vital Logic Module (VLM) is the intelligent core of a WESTRACE system. It controls the system operation, the interface to each of the other system modules, and performs the system logic processing. Every WESTRACE requires **one** VLM.

The VLM also plays a major role in system safety. It monitors system operation via two different paths and is capable of shutting the system down to a safe state to protect against any internal failures. The VLM does this by de-energising the Output Power Control Relay (OPCR) that positively inhibits the output of all parallel modules. It also removes the Vital Serial Enable Voltage (VSEV) to prevent transmission of serial data.

Each WESTRACE system has a unique address as part of the safety philosophy to protect against incorrect configuration data and communications with other systems. This address is set on links on the VBC so it is not affected by card or module change.

The VLMs must be installed in housing 1 of the system and are interconnected via the Vital BackPlane Card (HVBC) with the OPC.

All external connections are made via the HOPC PFM which plugs directly into the HVBC.

The VLM5 & VLM6 are similar mechanically and electrically to the HVLM but provides greater logic evaluation capacity. Only the VLM6 will communicate with the NCDM (non vital communication and diagnostic module) and then with the external network.

Two identical WESTRACE systems, except those using VLM1 modules, may be connected in a hot standby mode. Inputs and outputs of both systems are connected in parallel. One system is set on-line while the other monitors operation. A fibre optic link between the two systems updates the off-line system with the memory state of the on-line system every cycle. Automatic changeover, initiated by a failure, or manual changeover swaps between systems with no possible loss of data or conflicting system states.

Multiple WESTRACEs, each with a VLM may be interconnected as a large interlocking. These may be connected as a master-slave or as a peer-peer arrangement. Placing all the logic in one VLM and using other systems simply as Object Controllers is generally easier to design—provided of course, that there is sufficient capacity in the VLM. You need to take account of the timing between VLMs for either architecture as illustrated in figure 2.7.

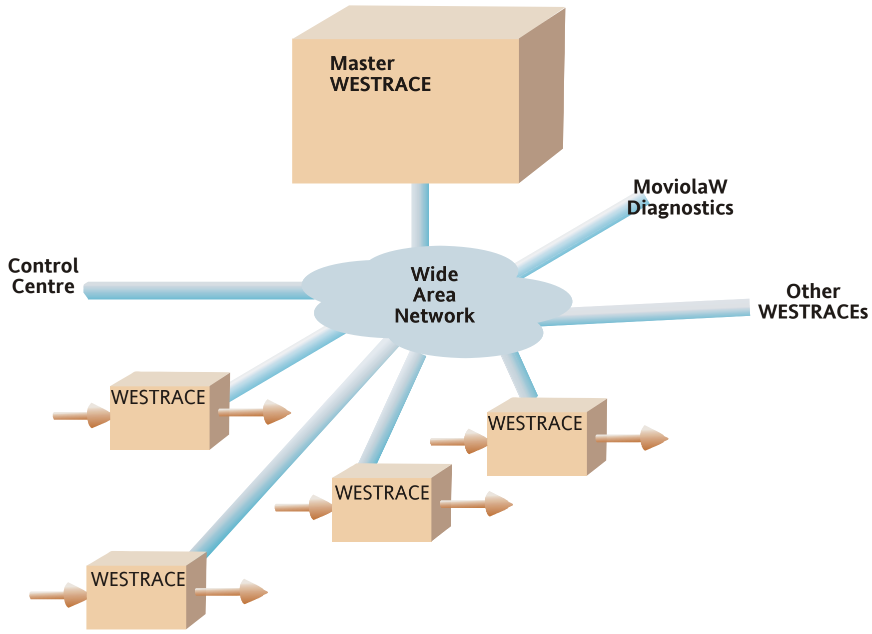


Figure 2.7: WESTRACE Master-Slave (or Object Controller) typical system

2.2.2.2 Vital Parallel Input Module (VPIM)

The Vital Parallel Input Module (VPIM) is used to accept signalling inputs into the WESTRACE system. The module will vitally detect the presence of externally supplied 50 Vdc that has been switched by signalling relays or other signalling equipment at each input.

Each module has 12 inputs that are isolated from the control supply and from each other. Inputs are polarity sensitive and two can be connected in anti-parallel so polar inputs can be used.

VPIM inputs are suitable for use in dc and ac electrified territory subject to the normal limitation of cable lengths to protect against unsafe voltages. Inputs are immune to the normal variations in the signalling supply voltage. A VPIM PFM must be used with each VPIM module and provides secondary transient protection.

A system can have several VPIMs to suit the number of inputs required.

A typical input connection is shown in figure 2.8.

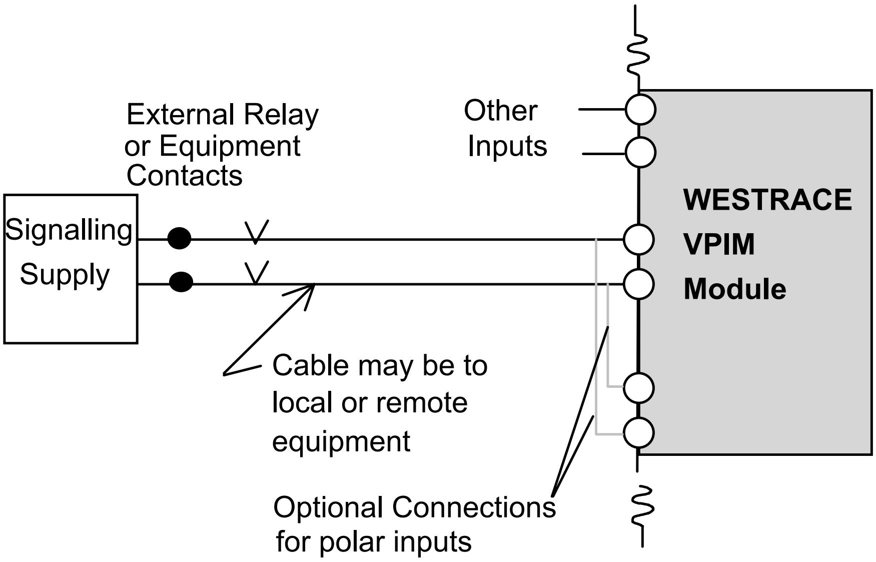


Figure 2.8: Typical VPIM Connection

2.2.2.3 Vital Relay Output Module (VROM)

The Vital Relay Output Module (VROM) is used to directly drive 50 Vdc signalling relays and similar loads. Each VROM has 8 individual outputs that will provide voltage to the relays.

VROM outputs are isolated from each other, from the control logic and from the 50 Vdc signalling supply. Two isolated outputs may be connected in anti-parallel to drive a pair of biased relays over a single wire pair.

VROM modules are suitable for use in dc or ac electrified territory, subject to the normal rules of maximum cable lengths to prevent false energising. Outputs are immune to the normal variations caused by remote relay loads wired in signalling cable. A VROM PFM must be used with each VROM module and provides secondary transient protection.

Multiple VROMs may be used in an interlocking to fulfil the number of outputs required.

A typical connection is shown in figure 2.9.

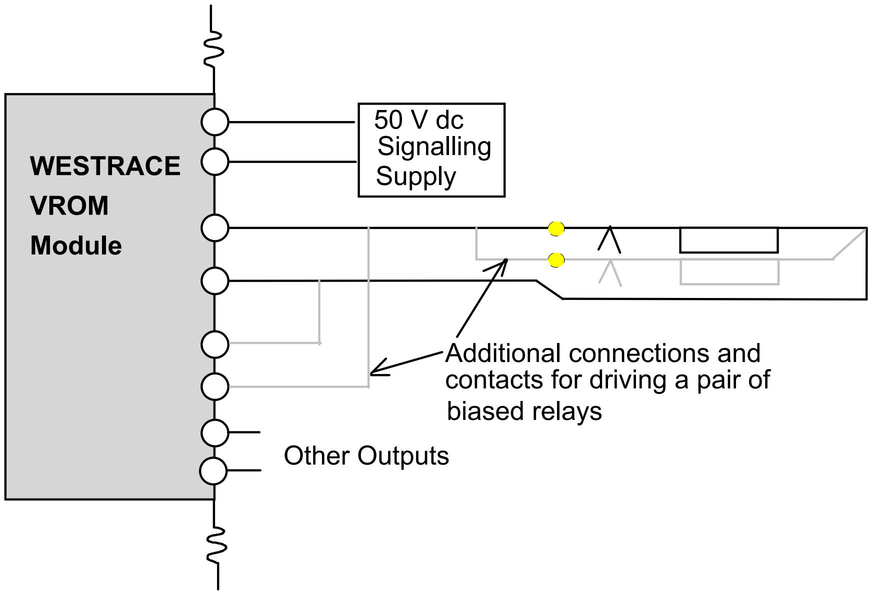


Figure 2.9: Connections to WESTRACE VROM Module

2.2.2.4 Vital Lamp Output Module (VLOM)

The Vital Lamp Output Module (VLOM) is used to drive 110 Vac transformer coupled signalling lamps or 110 Vac LED lamps directly under the control of the interlocking logic. It is suitable for driving 24W signalling lamps including twin filament types.

There are versions of this module but we have consolidated requirements to a 12 output module that can drive either a steady or flashing aspect, controlled by the interlocking logic. Each lamp can be controlled individually. All flashing lamp aspects in one system are synchronised.

VLOM outputs are isolated from the control supply but not each other.

The VLOM incorporates vital hot filament proving and cold filament checking. Lamp failures will be detected and made available to the application logic for direct use or to raise a remote alarm. There is an application note on the WRSA Web site that discusses current proving for LED signals.

VLOM modules are suitable for use in dc or ac electrified territories subject to the normal rules of maximum cable lengths to prevent false illumination and personnel protection.

Multiple VLOMs may be used in an interlocking.

Two VLOM PFMs are required for each 12 output VLOM to isolate any interference.

A typical connection to a signalling lamp is shown in figure 2.10.

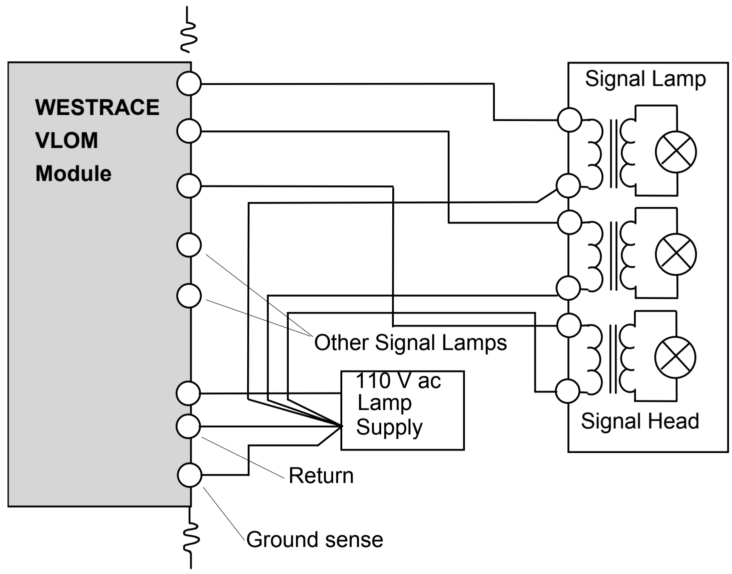


Figure 2.10: Typical VLOM Connection

2.2.2.5 Vital Telemetry Continuous Module (VTC & EVTC)

The Enhanced Vital Telemetry Continuous (EVTC) module has replaced the VTC module and is used to transfer data in both directions with WESTRACE systems. Networked connections are generally used for new systems.

Data transfer should take place over a dedicated link such as a PCM channel, wire pair or point to point radio link. The module interface is at RS232-C levels and external equipment can be used where necessary to provide extended cable runs. Full modem control lines are provided.

There are two variants of this module; VTC and EVTC. The VTC will transfer 17 logic states in each direction and the EVTC, 66 states. You cannot mix VTCs and EVTCs on a single channel.

Several EVTC modules may be used in a WESTRACE system. These may connect to one or more other WESTRACE systems.

An SIO232 PFM is required for each VTC module to isolate any interference.

Figure 2.11 illustrates a typical connection between adjacent installations.

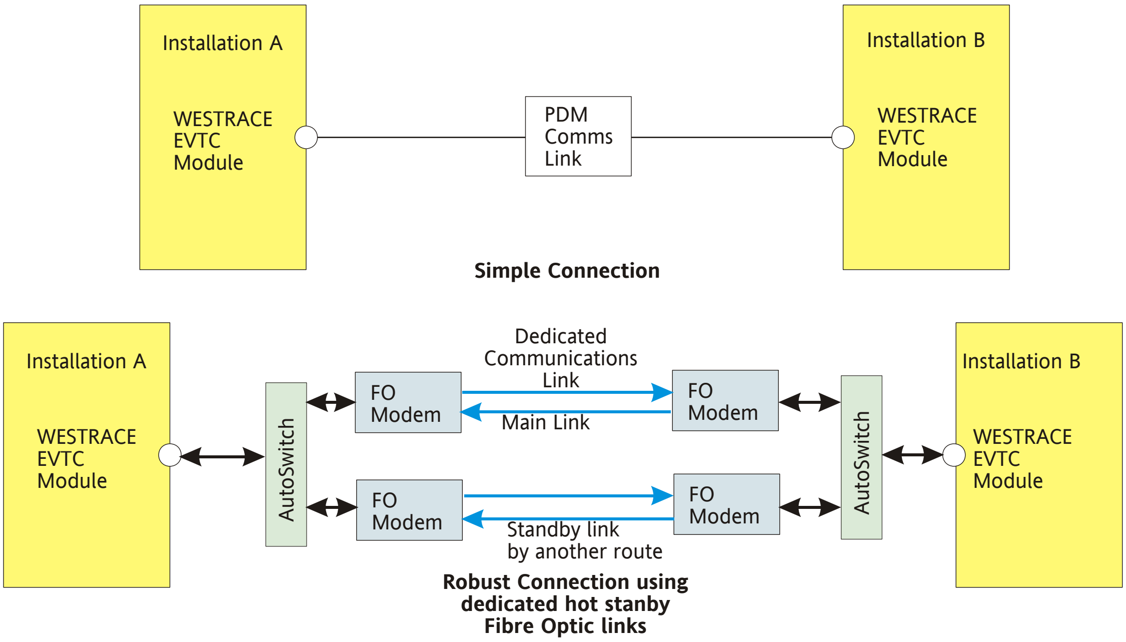


Figure 2.11: Typical EVTC Connection

2.2.2.6 Network Communication Diagnostic Module (NCDM)

One NCDM is used in a VLM6 based WESTRACE system. DM, NVC/DM modules are not used and NVC and EVTC modules are not used where their functions are replaced by the network communications .

The NCDM is used to:

- interface to the VLM6, including transfer to vital protocols;
- interface to adjacent WESTRACE systems (vital protocol);
- interface to remote control centres (e.g. CTC);
- interface to local control or indication PCs (e.g. WESTCAD);
- interface to MoviolaW;
- interface to a local PC running other diagnostic programs;
- execute non vital logic.

A typical application is shown in figure 2.2.

Only one NCDM is used in a system and this should be installed adjacent to the VLM6.

Each module consists of:

- Main Circuit board ((NCDC)
- Network Communication Diagnostic Protection and Filter module (NCD PFM)

Communications

Each NCDM has one 10BaseT Ethernet and 2 serial interfaces. The NCDM supports up to 16 vital communications sessions of up to 182 bits and at least 16 non vital communications sessions. Each port or session can connect to

- another WESTRACE vital sesson (network sessions only)
- another WESTRACE non vital session (network sessions only)
- control centre(s)
- local control computer
- S2 field stations (serial ports only)
- a maintenance computer;

All communication ports are programmed as part of the application data.

Serial communication ports operate at up to 64 kbps and can appear as multiple S2 addresses so there is no longer the restriction 48 and 64 bits per channel. Multiple communication ports can be used to support standby bearers. You will have to manage the source of control in either the external control system or application logic where multiple ports may be used to control input states.

Diagnostics

Each diagnostic port or session may be configured as:

- a permanent direct connection (e.g. for MoviolaW);
- a temporary connection (e.g. for diagnostic PC);
- a dial in connection connected to a modem (serial only);
- a dial out connection (serial only);
- a dial in, dial out connection (serial only).

All changes of state of all inputs, outputs logic states (vital and non-vital) are recorded in a circular buffer with a 250,000 event capacity. System faults and operations are recorded in separate, smaller buffers. Every record is time stamped. All data is accessible via the diagnostic ports.

There are also 10 time-of-day timers that may be used to initiate events.

Logic Evaluation

The NCDM supports:

- 40,000 logic states;
- 15,000 internal latches (and therfore logic rungs)
- 2,000 Set-reset latches;
- 3,000 timers;
- 10 time of day timers.

The logic is prepared using GCS and has functionality and preparation similar to the vital logic. Set-reset latches with one input to set the output and a second input to reset the output can simplify the design. Timers may be slow to pick or slow to drop.

NCDMs are suitable for full hot standby.

2.2.2.7 Non-Vital Communication, Logic and Diagnostic Module (NVC/DM)

One NVC/DM module is used in preference to the DM and all the NVC modules in HVLM, VLM5 or VLM6 WESTRACE Systems.

The NVC/DM is used to:

- interface to remote control centres (e.g. CTC);
- interface to local control or indication PCs (e.g. WESTCAD);
- interface to MoviolaW;
- interface to a local PC running other diagnostic programs;
- executing non vital logic.

One one NVC/DM is used in a system and this should be installed adjacent to the VLM.

Each module consists of:

- a Logic Evaluation Card (LEC);
- Communications Interface Module Protection Module (CIMFIM);
- up to 6 communication daughter boards (one for each used communication channel;
- a Communications Interface Module Protection Module (CIMPM) that is similar to a PFM but uses DB9 connectors

Communications

Each NVC/DM has 6 serial interfaces:

- all support the WSL S2 or WSA S2 protocol and emulate multiple addresses and may be used for remote or local control or indication communication;
- three of the six also support a diagnostic protocol and can be used for either diagnostic or control purposes.

All ports are programmed as part of the application data.

Communication ports operate at up to 64 kbps and can appear as multiple S2 addresses so there is no longer the restriction 48 and 64 bits per channel. Multiple communication ports can be used to support standby bearers. You will have to manage the source of control in either the external control system or application logic where multiple ports may be used to control input states.

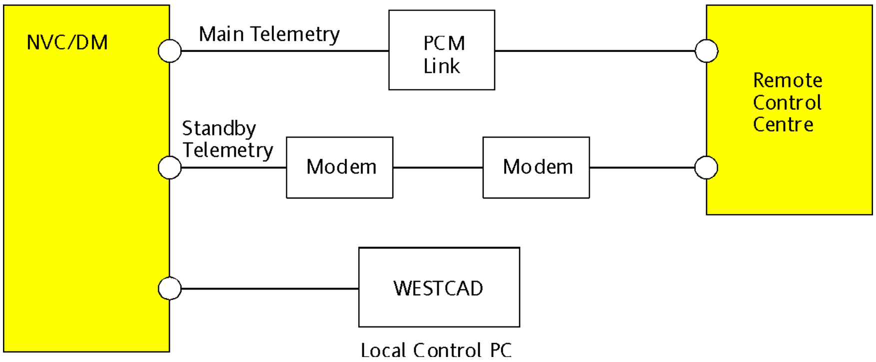


Figure 2.12: Typical Telemetry Connections

Diagnostics

Each diagnostic port may be configured as:

- a permanent direct connection (e.g. for MoviolaW);
- a temporary connection (e.g. for diagnostic PC);
- a dial in connection connected to a modem;
- a dial out connection;
- a dial in, dial out connection.

All changes of state of all inputs, outputs logic states (vital and non-vital) are recorded in a circular buffer with a 250,000 event capacity. System faults and operations are recorded in separate, smaller buffers. Every record is times tamped. All data is accessible via the diagnostic ports.

There are also 10 time-of-day timers that may be used to initiate events.

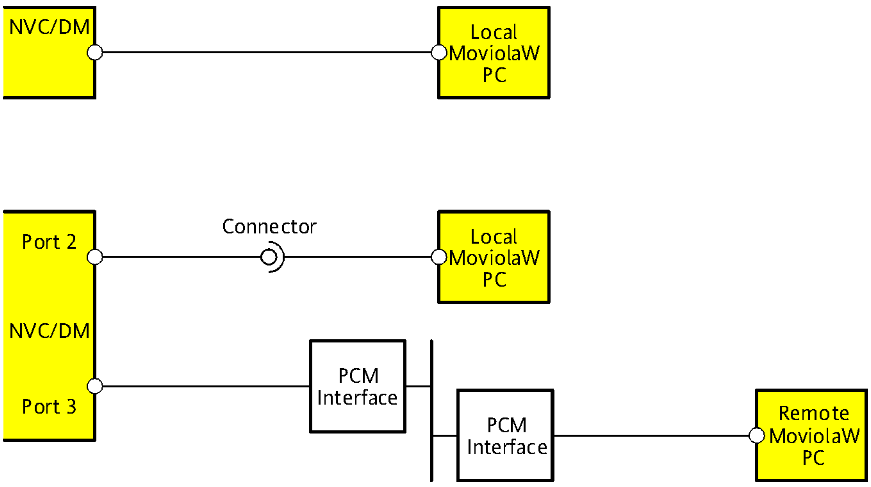


Figure 2.13: Typical Diagnostic Connections

Logic Evaluation

The NVC/DM supports:

- 40,000 logic states;
- 15,000 internal latches;
- 2,000 Set-reset latches;

- 3,000 times;
- 10 time of day timers.

The logic is prepared using GCS V5 and has functionality and preparation similar to the vital logic. Set-reset latches with one input to set the output and a second input to reset the output can simplify the design.

NVC/DMs may be used in a hot standby system although there is no specific communication between the main and off-line systems that enforce consistency on a cycle by cycle basis.

2.2.2.8 Non-Vital Communications Module (NVC)

The Non-Vital Communication (NVC) module is used to transfer non-vital data between a WESTRACE system and an external control system. Typically, control data would be sent to the WESTRACE and indications would be returned from the WESTRACE.

The NVC module is not used in a system using an NVC/DM or NCDM.

The NVC module can receive 48 logic states and transmit 64 logic states. The modules use the standard S2 Protocol and may co-exist on a multi-drop telemetry link with other WESTRACE and S2 systems.

The NVC module supports point to point, multi-drop and regenerative telemetry systems.

There may be several NVC modules in a system. It is possible to define two of these as a changeover pair to enable remote or local control. Each module will transmit the designated data but inputs will only be accepted from one of the pair as set by an internal logic state.

The interface may be at either RS232-C or RS422 levels. RS422 can be used directly for moderate cable runs (up to one km) provided that you can guarantee no differences in the common potential under transient (e.g. near lightning strike) conditions. An external bearer should be used for longer runs or for RS232-C levels. PCM data systems, modems and a communication cable or data radio can all be used for remote communications. A PFM is required for each NVC. A cost effective and very practical solution for moderate cable runs is to use an optic fibre modem and optical fibre cable.

A SIO232 or SIO422 PFM is required for each NVC module to isolate any interference.

Figure 2.14 depicts a typical example of remote control.

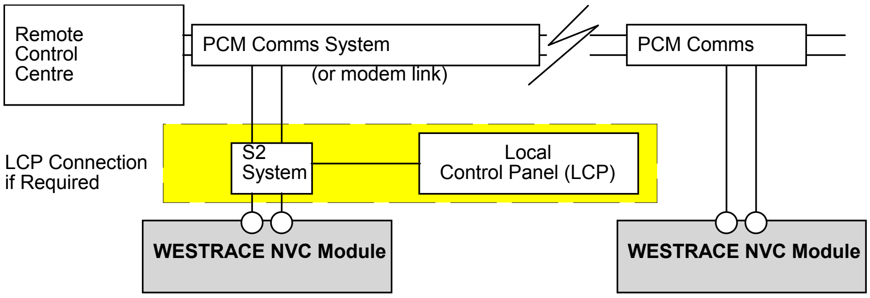


Figure 2.14: Typical Remote Control Connection

2.2.2.9 WESTECT Communications Module (WCM)

The WESTECT Communication Module (WCM) is used to send data to the radio system associated with the WESTECT ATP system.

The data is specially formatted to suit the application. Control signals are provided for the RCM and for radio control. Refer to the WESTECT manuals for further information.

An SIO232 PFM is required for each WCM module to isolate any interference.

Figure 2.15 depicts a typical connection to broadcast ATP status.

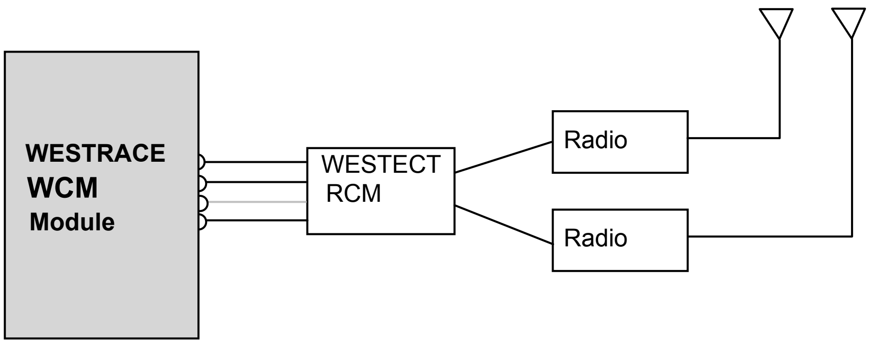


Figure 2.15: Typical WCM Connection

2.2.2.10 Diagnostic Module (DM64 or DM128)

WESTRACE systems using VLM or HVLM (not VLM5 or 6)have one Diagnostic Module:

- VLM1 systems are typically fitted with a DM64;
- HVLM systems are typically fitted with a DM128.

The Diagnostic Module aids set up, commissioning, and fault finding. Its purpose is to:

- record fault data for later analysis;
- record recent operation for later analysis;
- dump system operation to an external display or data logger;

- assist in checking the application software installation;
- allow real time logging of operation using external logger.

The DM may be used during testing, commissioning, and fault finding on an installation. The data logging and dump of system operation include changes of state of all inputs, outputs and internal logic states.

The DM has two independent serial data ports. The Technician Interface, on the front of the module, is normally accessed by a laptop computer. Fault data and internal logic states can be examined from this port. The Event Recorder Interface on the rear of the module can be used to dump logic state changes or to dump a recent history of operation to either the laptop computer or a separate data logger. Laptop and Event Recorder interfaces are RS232-C levels. The connector on the rear of the module actually has pins that allow both serial ports to be accessed via a special cable.

WESTRACE systems with the DM128 will preferably use MoviolaW to record events and diagnose faults. A PC running the MoviolaW suite of applications connects to the DM128's Technician and Event ports. MoviolaW permits fault diagnosis from remote locations via modem.

WESTRACE ICS (Installation Check System) connects to the DM to read the application data.

A SIO232 PFM is required for the data logging port to isolate any interference.

2.2.2.11 Blanker Card (BLANKER)

These cards are required to maintain continuity of chained signals around the system, must be fitted in all unused module slots in the system motherboard.

The blanker is a small PCB and attached to a connector that provides continuity for the backplane signals.

2.2.2.12 Power Supply Unit (PSU)

The Power Supply Unit converts the external nominal 24 Vdc power supply to the internal voltages required by the modules, and generates the system reset signal required by the other modules. The PSU will normally be fed from a 24 V battery to ensure the system is held up during any power fluctuations.

At least one PSU is required in each system. Larger systems may require multiple PSUs.

2.2.2.13 Protection and Filter Modules (PFM)

These modules are required to protect Input and Output Modules and the Power Supply Unit from the effects of excessive external electrical disturbances generated by traction supplies, radios, relays, neon lamps, etc. They also ensure that any internally generated radio frequency interference is prevented from leaving the housing by the conductors. There are different styles of PFMs according to the module functions. The full list of PFMs is included in the Application Manual.

The PFMs have a plug coupler for the external connections.

PFMs must be used for all Input and Output modules, the OPC and the DM. They are intended to provide a secondary level of transient protection such as voltage transients from switching relays or interference between cables in a wiring loom. Primary protection from high level faults is provided by surge arresters (see the next section).

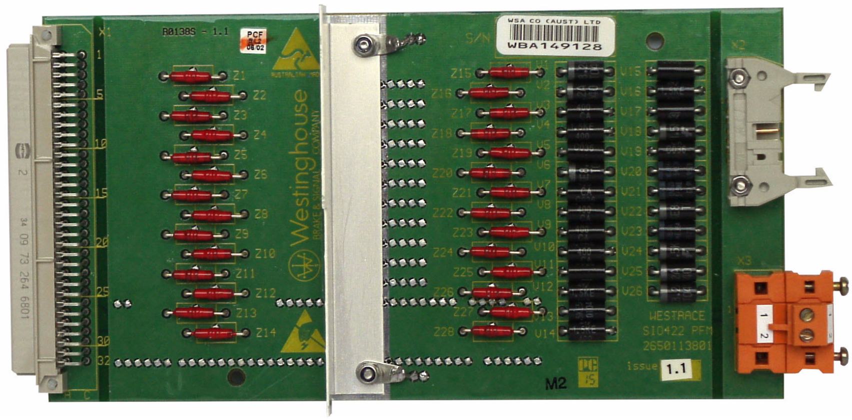


Figure 2.16: Typical Protection and Filter Modules (PFM)

2.2.2.14 Surge Arresters

Surge Arresters are used external to the parallel input modules (VPIM) and output modules (VLOM and VROM) when there is a danger of damage from voltages induced in the cable runs. Typically, surge arresters are used whenever cable leaves the relay room or location case.

The surge arresters are designed to prevent the possibility of cross feeds between similar functions in the event of failure to short circuit of multiple components. Commercial arresters such as three terminal gas discharge tubes are unsuitable and their use could lead to a wrong side failure. **Such arresters must not be used with WESTRACE.**

The surge arresters provide two levels of primary protection from external transient voltages using gas discharge tubes and Metal Oxide Varisters (MOVs).

Surge arresters are available in voltage ranges to suit the standard input and output voltages. Versions are available for left and right cable entry.

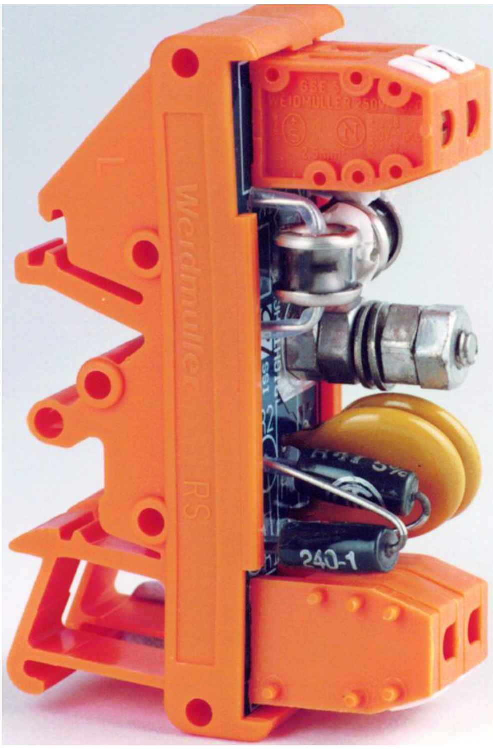


Figure 2.17: Surge Arresters

2.3 Graphical Configuration System (GCS)

Signal Engineers use WESTRACE GCS to design, modify and validate a WESTRACE installation.

GCS comprises two sub-systems:

- Graphical Configuration Sub-System (GCSS);
- Installation Check System (ICS).

GCSS and ICS are described in the following sections.

2.3.1 Graphical Configuration Sub-System (GCSS)

WESTRACE GCSS is used by Signal Engineers to design a WESTRACE installation, program the Configuration Data PROMs and download configuration data to NVC/DM and NCDM modules.

GCSS must be used with Vital Logic Modules (other than VLM1) and all non-vital Logic Modules.

Signal Engineers enter data to define the modules, mnemonics and functionality of the WESTRACE system.

The data is entered through edit windows and relay equivalent Ladder Logic windows. GCSS enables the Signal Engineer to use familiar, functional mnemonics and relay equivalent circuits to specify the logic operation. It supplies comprehensive print outs.

A second Signal Engineer is expected to check these print-outs against the control tables or other source data and use simulators such as GSIM or ISIM to validate the correct operation of the system. An authorised Signal Engineer must approve the design for use in an interlocking.

GCSS is used by Signal Engineers to:

- define the modules used in the installation and their locations in the housing(s);
- assign mnemonics to inputs, outputs, latches and timers;
- assign values to timers;
- enter the vital and non vital application logic that defines the logical relationships between the inputs, outputs, latches and timers;
- define the NVC/DM and NCDM serial ports, protocols and addresses;
- define NVC/DM and NCDM telephone numbers, passwords, time-of-day events etc.;
- define the NCDM network sessions.

The outputs from GCSS are:

- print-outs that allow the checking of the data entered by the Signal Engineer (source files);
- records of the approval of Source Files;
- records of programming of the CED PROMs;
- print outs specifying how the VLE for an installation must be assembled in order for it to be consistent with the data within the CED PROMs;
- print outs that help with the interpretation of the Diagnostic outputs;
- CED PROMs and NVLM application data

GCSS also performs housekeeping functions including:

- file maintenance;
- version control;
- display and port setup.

Figure 2.18 depicts the GCSS Housing Editor Window. Modules are placed in the housing by selecting a module from the tool bar and clicking on a slot in the housing diagram.

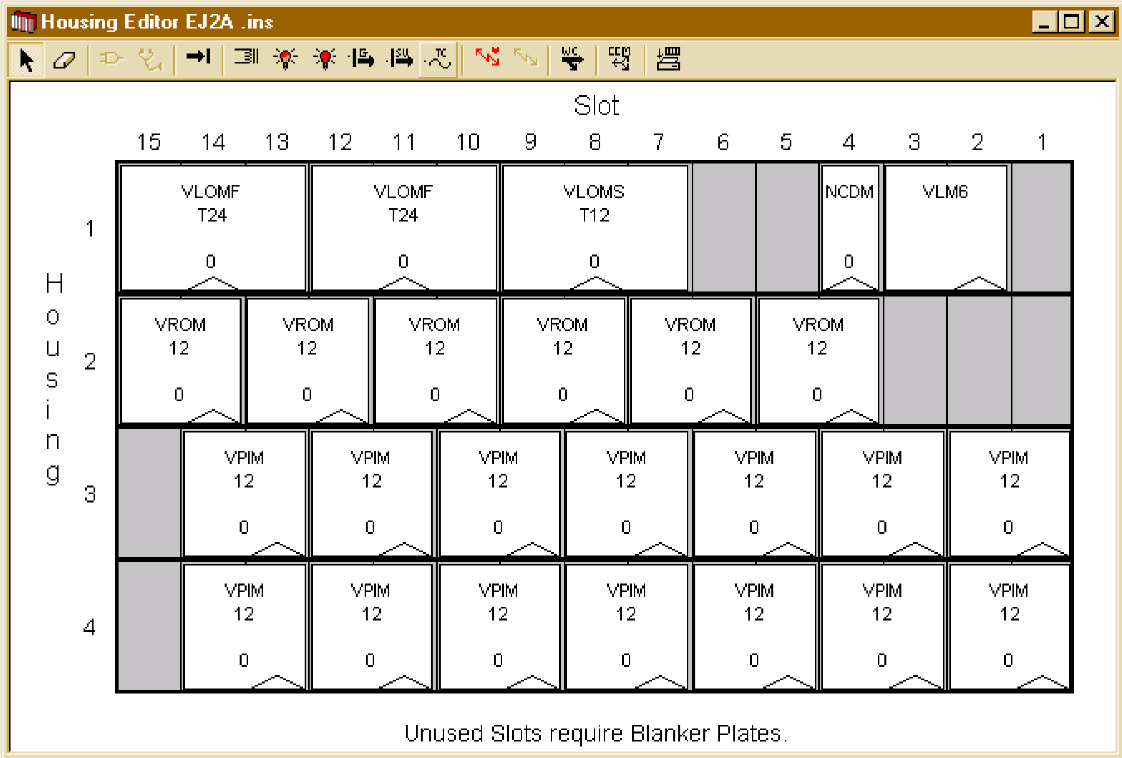


Figure 2.18: GCSS Housing Editor Window

Figure 2.19 depicts the GCSS Rung Viewer Window displaying a portion of the ladder logic for the Installation.

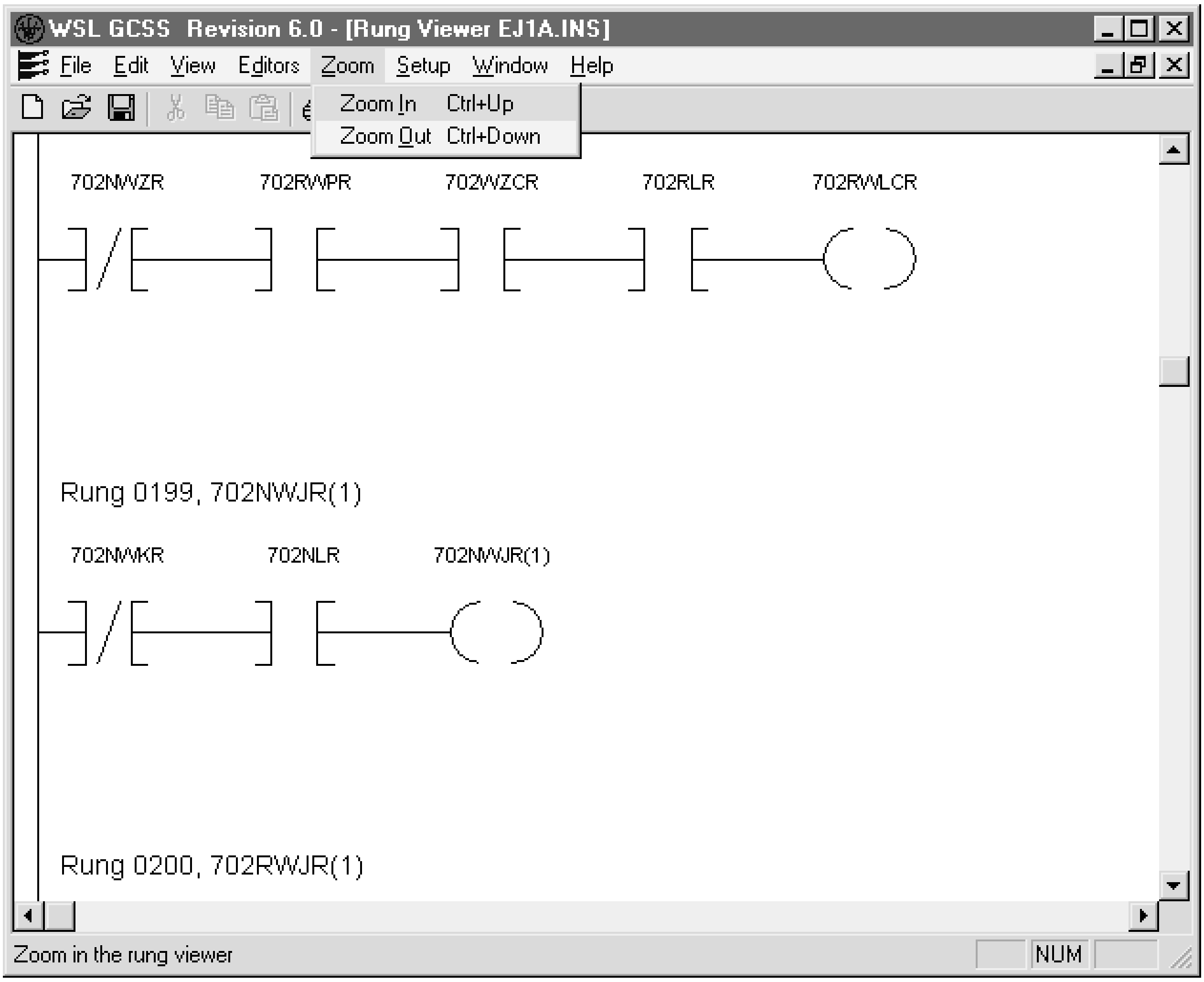


Figure 2.19: GCSS Rung Viewer Window

2.3.2 GCSS Templates Tool

The GCSS Templates tool is a front end to the GCS system. Templates—standard WESTRACE application logic with conditional contacts—are prepared by experienced Signal Engineers according to each Railway's practices.

Less experienced Signal Engineers can then place multiple instances of these logic templates in the correct order, change mnemonic prefixes and select the conditional contacts required according the track layout. The tool can then generate application logic that GCS can read and add any final customisation to suit the railway application. The Template Tool can substantially improve the efficiency of design where there are several systems to the one set of practices.

2.3.3 Installation Check System (ICS)

WESTRACE ICS is software used by the Signal Engineer to verify that the Configuration Data PROMs fitted to an installation are valid and are consistent with the approved design.

ICS must be used with the all Vital and Non-Vital logic modules (except VLM-1).

2.4 Graphical Simulator (GSIM)

WESTRACE GSIM is a PC application that simulates the operation of WESTRACE logic and trackside equipment to test application data.

GSIM now supports multiple interconnected WESTRACE (Vital and Non-Vital) systems

Newly-designed or modified railway signal logic must be tested before it can be used in service. This has previously been achieved by testing the logic on a target system connected to switch inputs and lamp outputs. This process is time-consuming and expensive, especially when it cannot be done at the design location.

GSIM enables Railway Signal Engineers to validate the railway signal logic and perform principles testing before programming PROMs and using them on the target hardware at the target site.

GSIM may be viewed on a single PC screen, or on a multi-screen display (with a suitable graphics card). Figure 2.20 depicts a GSIM session on a multi-screen display.

Figure 2.20: GSIM Enables Multi-Screen Viewing of Interlockings

Figure 2.21 depicts the relationship of GSIM windows to the design elements they represent.

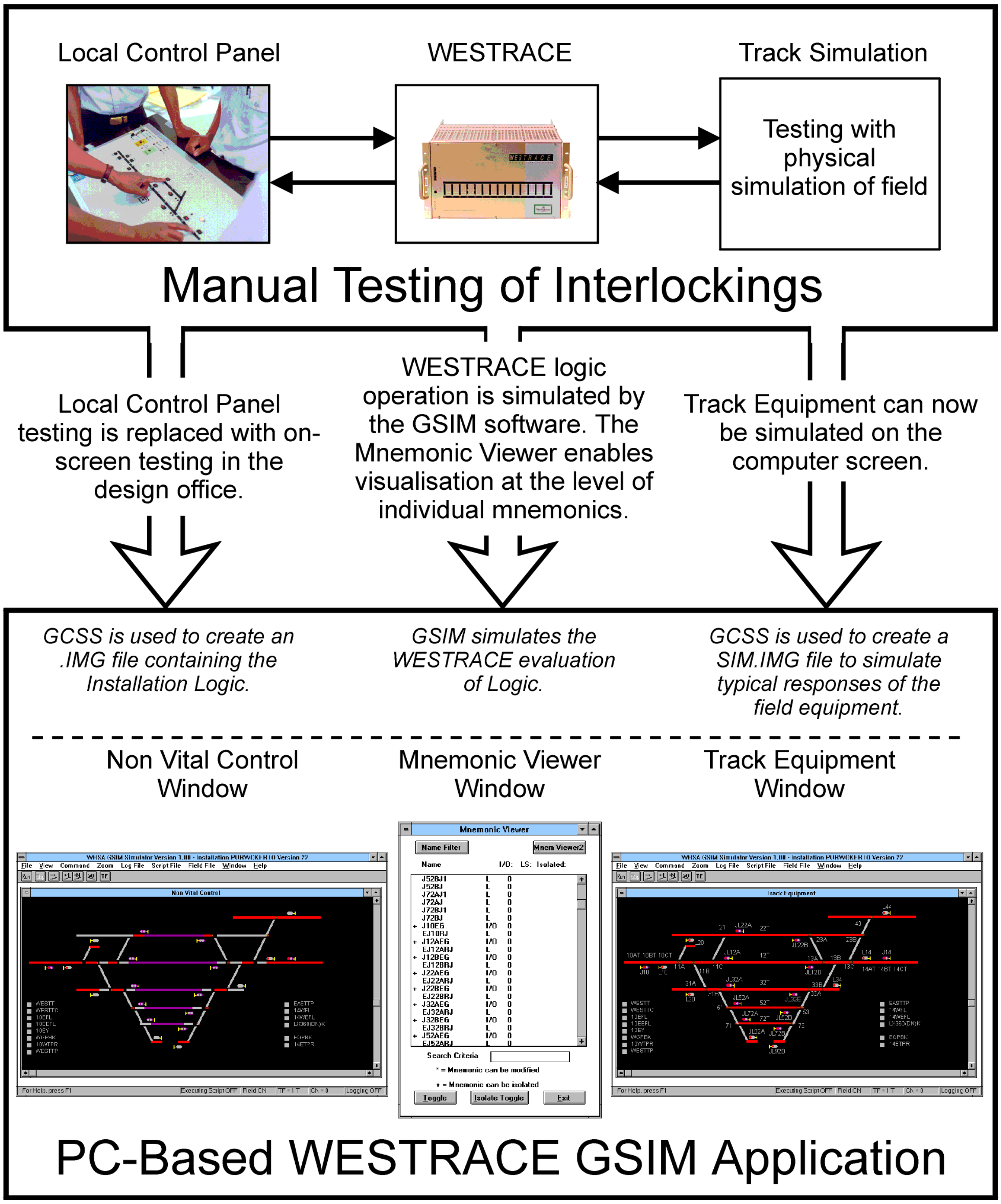


Figure 2.21: Functional Relationship of GSIM Windows

The multi-WESTRACE capability is particularly important when testing larger WESTRACE systems with cross-WESTRACE communications. The complete system can now be simulated rather than resorting to simulating separate WESTRACEs.

GSIM screen layouts can be created or modified using the PC Graphics Editor.

2.5 Interlocking Simulator (ISIM)

WESTRACE ISIM is a WESTRACE and S2 based tool that enables testing of railway signalling logic and optionally non-vital control (Interlogic data) for railway signal interlockings in the office prior to commissioning a system.

The purpose of testing application data on ISIM is:

- reduced costs of testing by reducing site costs;
- reduced interruption of railway operations.

ISIM consists of a pair of equipment cubicles containing:

- two WESTRACE systems,
- two trackside simulators;
- two sets of connections for simulated trackside equipment inputs and outputs;
- two sets of connections for remote control;
- one panel processor for an optional LCP or MP;
- power supplies and cabling.

ISIM is used to test WESTRACE application data by replacing the actual vital parallel input and output modules and field equipment with simulated field equipment (switch and LED boxes) connected via non-vital serial links.

Tests can therefore be performed using actual WESTRACE hardware and application data to ensure the logic evaluation and timing is identical to an actual installation. Differences between the WESTRACE Interlocking Simulator and the actual WESTRACE system installed are minimal.

ISIM is often used with MoviolaW as its diagnostic interface.

The configuration depicted in figure 2.22 uses either of the two Simulator Cubicles A or B to test two individual WESTRACE Interlockings, one of which has a local control panel or maintenance panel.

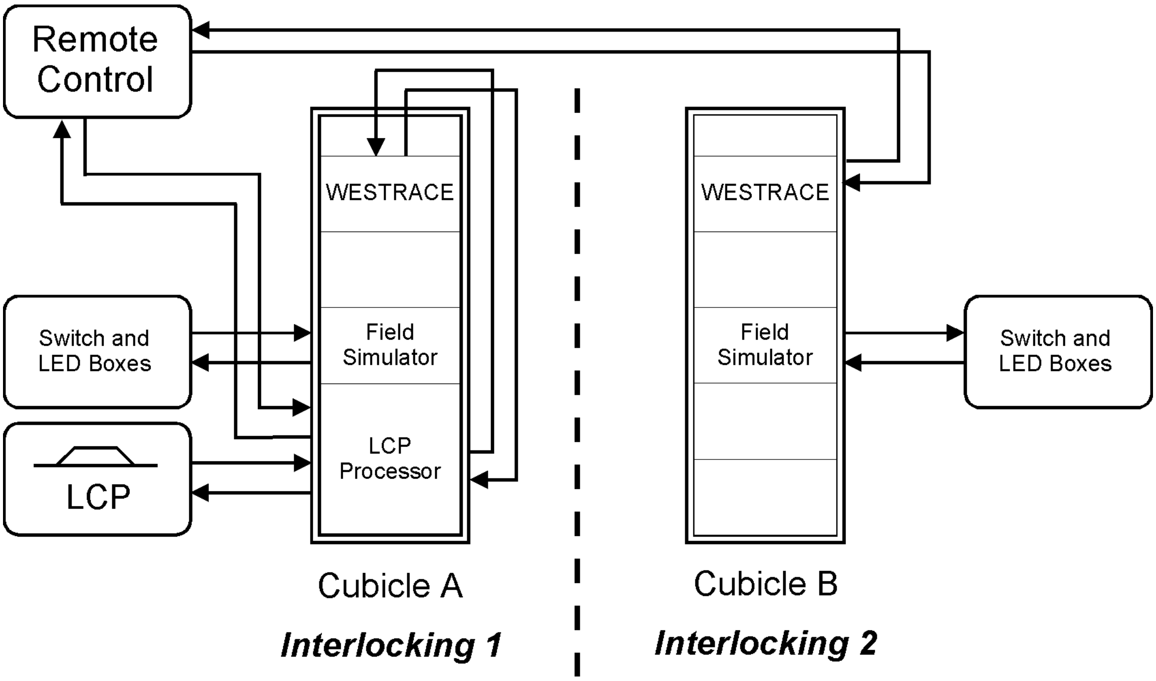


Figure 2.22: Typical Interlocking Simulator Arrangement

ISIM can be configured to simulate:

- two adjacent WESTRACE Interlockings, neither of which has a local control panel or maintenance panel;
- two adjacent WESTRACE Interlockings served by a local control panel or maintenance panel;
- two individual WESTRACE Interlockings, neither of which has a local control panel or maintenance panel;
- individual WESTRACE Interlockings, one of which has a local control panel or maintenance panel.

2.6 MoviolaW

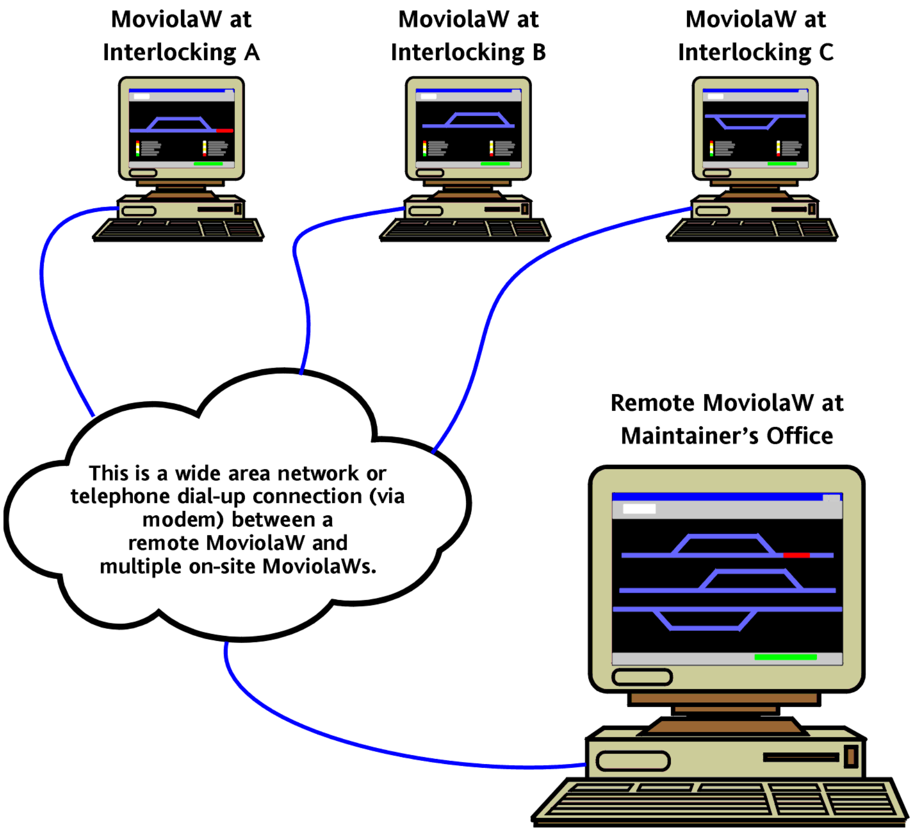
MoviolaW provides real-time monitoring and graphic display of WESTRACE operation, both local (on-site) and from remote locations.

MoviolaW is a suite diagnostic tools used to monitor, record, and playback Interlocking events for WESTRACE Vital Signalling Systems and other railway systems. Signal Engineers at remote locations can use PCs to connect via WAN or modem to local MoviolaW systems.

MoviolaW:

- enables technicians to solve problems without the need for on-site visits;
- provides a high-capacity log of Interlocking events (limited only by the local PC's hard disk size).

Figure 2.23 depicts a typical example of MoviolaW use.



MoviolaW offers remote monitoring and fault diagnosis of any number of interlockings.

A maintainer can monitor conditions in the field and quickly focus on individual areas of concern.

The maintainer's remote MoviolaW makes a connection and displays in real-time, or in replay mode, information provided by the on-site MoviolaW.

Figure 2.23: Relationship of remote MoviolaW to local MoviolaW

Faults at distant locations can be diagnosed by viewing and replaying the events on the remote PC. MoviolaW has the ability to replay events at various user-defined rates to assist in diagnosing problems in WESTRACE operation.

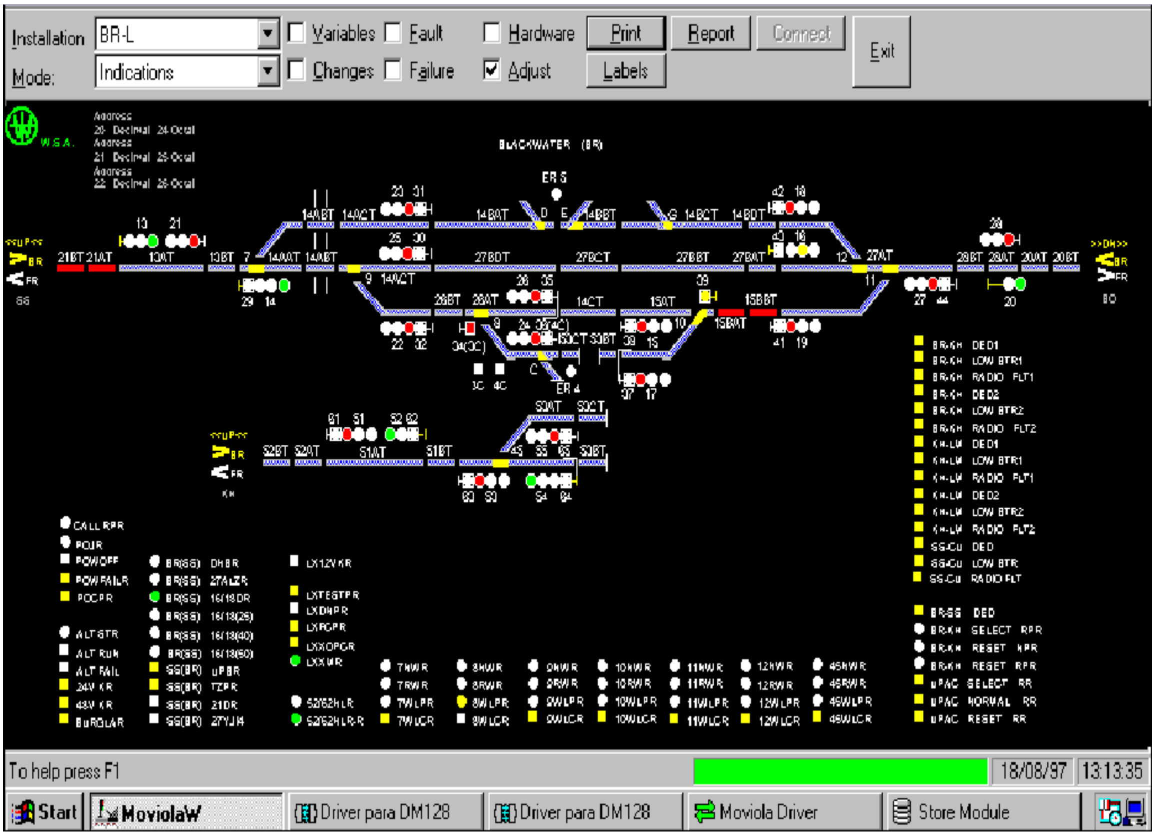


Figure 2.24: Typical MoviolaW Window

MoviolaW screen layouts can be created or modified using the PC Graphics Editor.

2.7 PCGE and PCCE

PC Graphic Editor is a graphical tool operating on a PC and is used to prepare the diagrams used in MoviolaW and GSIM.

PC Command editor is a graphical tool operating on a PC and is used to prepare the command entry for GSIM.

2.8 Automatic Test Tool

The Automatic Test Tool (ATT) operates in conjunction with GSIM3 and assists Signal Engineers to pre-test interlockings.

The intention of this tool is to eliminate the majority of errors prior to formal Principles testing.

The ATT does not have a safety validation and **must not** be used as a substitute for Principles testing.

3. SYSTEM DESIGN

3.1 Introduction

This chapter gives an outline of the design requirements and design process for a WESTRACE system. It is not intended to be a complete design description, it provides an overview of the design process. See the WESTRACE Application Manual and the WESTRACE GCSS (or CS) Manual for a full description.

The hardware design defines of the number and type of modules required and the number of housings required. The configuration design specifies all inputs, outputs, initial variables and timers, and the application logic that acts between then.

3.2 Safety

WESTRACE will execute application logic correctly.
The Signal Engineer is always responsible for ensuring that the application is safe at both the logic and system levels

The integrity of any WESTRACE installation is only as great as the integrity of the logic. The WESTRACE system will always faithfully execute the logic prepared and installed by the Signal Engineer. If this logic is unsafe, then the total system may consequently be unsafe. Signal Engineers must design and check each installation thoroughly to ensure the safety of the system.

The Configuration System GCSS provides tools to assist with the entry and validation of the logic. The GCSS Manual describes the process of system and logic design and clearly identifies procedures that must by followed to achieve a safe system. The ultimate responsibility for entry of correct logic must remain with the Signal Engineers who design and check the logic for each installation.

3.3 Design Requirements

3.3.1 Configuration System

GCS (comprising GCSS and ICS) are computer based tools for assisting in the design of system logic. GCSS is described in Chapter 2. (CS is only used to maintain legacy systems and will not be described further here.)

3.3.1.1 Hardware for GCSS and ICS

GCS runs under Microsoft Windows NT4 SP5 or SP6 on a P3 or P4 PC. A serial port for PROM programming and a connected printer is essential. Multiple users are best served with a networked installation, including a strong backup regime.

ICS requires a P3 or P4 PC with Microsoft Windows NT4 SP5 or SP6. A portable PC is easier to use for site work. One serial port is essential for connection to the WESTRACE and a second port is useful for monitoring the Diagnostic Module. A network port is valuable for VLM6 systems. A printer is required to print reports for checking and approval (although you can print to file on site and print a hard copy later for signing).

An PROM Programmer is required to program the CED PROMs. The Dataman S4 PROM Programmer is the only one supported by GCSS and ICS and is available through RS Components Pty Ltd.

3.3.2 Designers

WESTRACE is designed by suitably trained Signal Engineers:

- One (or more) engineers designs the system.
- A second engineer checks the design. This engineer may use tools such as the Graphical Simulator (GSIM), Interlocking Simulator (ISIM) or Automatic Test Tool (ATT) to assist. However, the engineer is ultimately responsible for the voracity of all testing.
- A third engineer (authorised for this purpose) approves the design.

3.3.3 Specification Data

The operational specifications or requirements may be supplied in different forms from the rail authority. These represent the base level requirements of the system operation. Typically, they will be track plans and control tables.

3.4 Design Process

The design process is described in the WESTRACE Application Manual, the WESTRACE CS Manual, and the WESTRACE GCSS Manual. This section gives an overview of that process.

Figure 3.1 depicts a typical WESTRACE design process.

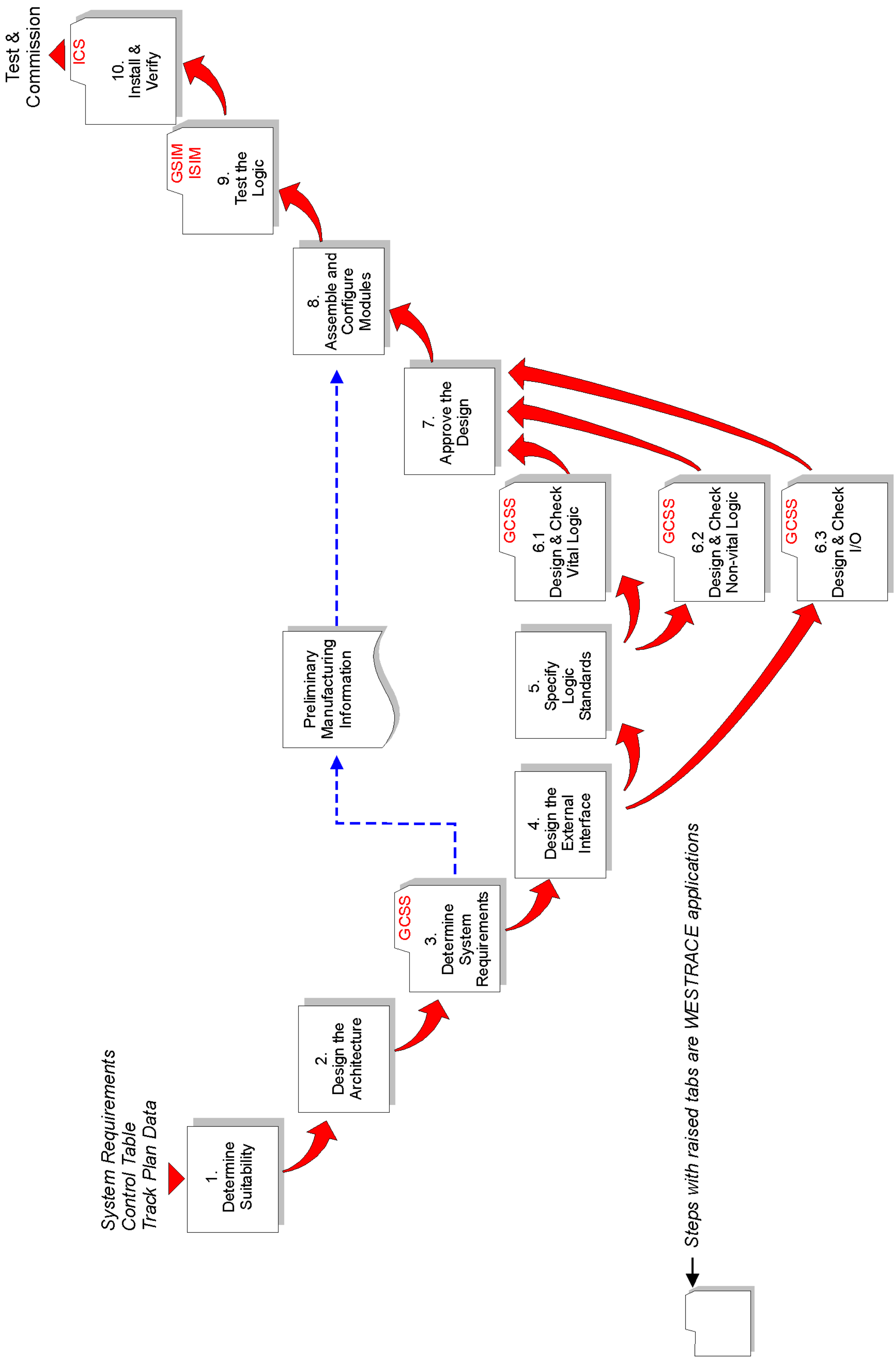


Figure 3.1: WESTRACE Design Process Flowchart

3.4.1 Determine Suitability

Determine the suitability of WESTRACE to the interlocking, with regard to:

- size and layout of interlockings;
- lamp controls;
- operating voltages;
- communications protocols.

3.4.2 Design the Architecture

Determine the appropriate architecture for the WESTRACE system:

- Is the system stand alone or stand-by?
- Are multiple WESTRACEs required?
- Is non-vital logic required?
- What are the interfaces to external systems?

3.4.3 Determine Hardware Requirements

Determine the number and type of each module that will make up the system.

Determine whether any capacity constraints are exceeded and divide into multiple systems if necessary.

Define the power requirements.

Determine whether non-vital logic in an NVC/DM is required.

3.4.4 Design the External Interface

Design external interfaces to power supply, field inputs, field outputs, vital and non-vital serial communication and lightning surge protection.

3.4.5 Specify Logic Standards

Determine in advance of designing the application logic, any standards and configurations for logic that will affect the design.

Create and thoroughly check and test templates for the Template Tool where this will be used in logic design

3.4.6 Design and Check the Vital Logic

Design the vital signalling logic in GCS to implement the requirements from the control tables, track plan etc. The Template Tool can assist where multiple installations following the same Rail Authority rules are to be designed.

Check the GCS printouts against system requirements.

3.4.7 Design and Check the Non-Vital Logic

Design the non-vital logic in GCS to implement route setting, panel processing and other non-vital. The Template Tool can assist where multiple installations following the same Rail Authority rules are to be designed.

Check the GCS printouts against system requirements.

3.4.8 Design and Check the Communications

Design all communication interfaces—ports, data, protocols, etc.—and the overall communication network (you will probably need to call in appropriate expertise for network communications).

3.4.9 Approve the Design

The complete design must be checked and approved by an authorised, independent Signal Engineer before the design is tested.

3.4.10 Assemble and Configure Modules

Assemble all the WESTRACE modules in the housing.

Configure the modules for site specific conditions.

3.4.11 Test the Logic

Test the application logic by Simulation or on the target system. We recommend testing with GSIM or ISIM. The Automatic Test Tool may also be used for pre-testing the interlocking to eliminate most errors before formal Principle's testing.

Application data proved via testing can be approved for commissioning by the Principles Test Engineer.

3.4.12 Install and Verify

Load the approved vital logic onto the modules and verify that it is correct with the diverse check provided by ICS.

3.4.13 Test and Commission

Check correspondence of the input and outputs on the installed system. Test and verify correct operation of any functions that could not be verified during simulation or previous testing.

there is something wrong with the order of design, check, test and approve. in the overall section 3.4

4. Maintenance and Training

The successful safe installation and operation of a WESTRACE system requires it to be designed and maintained by qualified personnel. The WESTRACE system is designed to revert to a safe condition during failures but non adherence to design or maintenance requirements could override these safety features.

SAFETY WARNING

WESTRACE must be maintained by qualified personnel in accordance with the manuals to ensure continued safe operation.

The WESTRACE Application Manual and the WESTRACE GCSS manuals describe the procedures for system design. These must be followed.

The WESTRACE First Line Maintenance Manual describes first line maintenance requirements of the system.

Westinghouse Rail Systems Australia can provide training courses to assist in familiarising people in the design and use of the WESTRACE system.

4.1 Maintenance

The WESTRACE system does not require any routine maintenance except for replacement of the lithium battery on the Diagnostic Module or NVC/DM. The fully electronic design using reliable components will give many years of operation without the need for intervention.

First line system maintenance is limited to module replacement and checking of the input and output circuitry. WESTRACE modules must not be repaired or modified in any way in other than a fully equipped workshop with comprehensive test capabilities that meet the relevant test requirements. All faulty modules should be returned to Westinghouse Rail Systems Australia for repair where they will subjected to the same automatic tests that are applied to new modules. Unauthorised repair will invalidate the safety certification.

Each WESTRACE module includes a set of LEDs that are visible through the front panel. Modules that are working correctly display a flashing green LED. Modules that have shut down display a fault code on 8 red LEDs. The WESTRACE First Line Maintenance Manual lists all module fault codes. The repair technician only need read the fault codes to determine the faulty module and replace it with a known working module. Modules may continue to operate with a fault that is not safety related.

WESTRACE keeps a log of the recent history as well as any fault conditions in the DM, NVC/DM or NCDM as appropriate. A technician can use a portable PC to interrogate the system to read this information. This provides an alternative means of determining faulty modules.

We recommend MoviolaW as the preferred diagnostic tool for all currentWESTRACE systems.

MoviolaW's main benefits to the Signal Engineer or maintainer are:

- real-time display of system status on track plan displays;
- capable of displaying multiple interlockings on a single interface;
- high capacity logging of system events;
- graphical replay of logged data (at various rates of speed) with forward, reverse, and pause controls;
- easy to read system fault messages, configurable by user;
- remote diagnostics may be performed from a suitably-equipped PC anywhere in the world connected via phone line or WAN (Wide Area Network).

4.2 Training

Complete system safety can only be guaranteed when all staff:

- understand how WESTRACE and associated equipment operate;
- are aware of the procedures detailed in the manuals;
- always comply with those procedures.

Westinghouse Rail Systems Australia recommend that the user's Quality Systems maintain a registry of staff who have been trained in the design and maintenance of the system.

Westinghouse Rail Systems Australia offers on-site or off-site (as required) training courses that can be tailored to suite specific needs of a railway, designer or maintainer.

Please contact WRSA at:

Phone +61 3 9233 8840 Fax +61 3 9233 8702
Email wsra-training@wrsa.com.au

4.2.1 General and Introductory Courses

Signalling Systems Courses—provide underpinning knowledge and skills to railway personnel. These courses belong to a professional development training program in signalling systems. Signalling systems courses cover the appreciation, design, installation, testing and maintenance of most types of railway signalling systems.

All of the following WESTRACE courses provide credit towards the qualifications possible from the Signalling Systems course.

WESTRACE Appreciation—provides a background into the use of WESTRACE for all personnel associated with WESTRACE. This course is appropriate for staff who require a basic understanding of the operation and use of the WESTRACE Vital Signalling System.

Duration: four hours for up to ten people.

4.2.2 WESTRACE System Design Courses

WESTRACE System Design—a hands-on course that provides Signal Engineers with skills to design WESTRACE systems. This course explains the concepts of WESTRACE operation and leads the Signal Engineers through all the steps required to design WESTRACE Vital Signalling Systems using the graphical Microsoft Windows environment. Attendees should understand Railway Signalling and should be familiar with PCs and Microsoft Windows.

Duration: four to five days for up to six people.

PC Graphics Editor, WESTRACE Graphic Simulator, and MoviolaW for Designers—a hands-on course that provides Signal Engineers with skills to design graphical simulators and MoviolaW diagnostic tools (including screen layout) for WESTRACE. These three courses may be integrated into the WESTRACE System Design course, extending the course duration by four days. The courses are available separately for Signal Engineers who have completed the WESTRACE System Design course.

Duration: four days for up to six people.

Interlocking Simulator for Designers—a hands-on course that provides Signal Engineers with skills to use the WESTRACE Interlocking Simulator (ISIM) to test WESTRACE application data for railway signal interlockings.

Duration: four days for up to six people.

Automatic Test Tool for Testers—a hands on course that provides testing Signal Engineers with skills to use the WESTRACE Automatic Test Tool in conjunction with GSIM to pre-test WESTRACE application data. This course may be combined with a GSIM course.

Details on application.

4.2.3 WESTRACE Maintenance Courses

WESTRACE First Line Maintenance—a hands-on course that provides Signal Maintainers and Field Service Engineers with an overview of the WESTRACE system, explains the safety procedures, and describes first line maintenance and commissioning procedures. The course also includes the use of the WESTRACE diagnostic tools including MoviolaW. Attendees should be familiar with the use of PCs and Microsoft Windows.

Duration: four days for up to six people.

WESTRACE First Line Maintenance Refresher—provides personnel who have completed the WESTRACE First Line Maintenance course with a review of the WESTRACE system, safety procedures, and the first line maintenance and commissioning procedures. The course focuses on in-field activities and site-specific issues. This course is not suitable as an alternative to the WESTRACE First Line Maintenance course.

Duration: one day for up to six people.

MoviolaW for Maintainers—develops competency in the use of the MoviolaW graphical interface and diagnostic tool. This course is integrated into the WESTRACE First Line Maintenance course and is only offered separately for personnel who have previously completed the WESTRACE First Line Maintenance (prior to MoviolaW being added).

Duration: four hours for up to six people.

Figure 4.1: Typical hands-on training session

5. Safety Principles and Methods

Each WESTRACE system comprises vital and non-vital functionality. The levels of safety assurance and types of design processes differ between them. The non-vital meets EN50128 Safety Integrity Level 2 and the Vital, Safety Integrity Level 4—as applicable to its use in controlling trains. The subsection of this chapter describe system level and vital or SIL4 parts of the system—non vital description is not necessary to understand or support the operation.

Safety was designed into the system from the design concept stage. It is applied by the way the system was designed, is manufactured and is used. It is also applied in the design and installation of the configuration logic.

5.1 System Safety Principles and Methods

The WESTRACE Vital Signalling System is designed to the highest safety integrity levels and is therefore suitable for the controlling of a railway. It is generally compliant with the Safety Integrity level 4 standards applicable to this type of equipment including consultative document RIA 23, IEC 61508 and Cenelec EN50128. These standards require high level safety analysis, specific design methodology and implementation techniques.

The WESTRACE System is intended to control safety critical applications. The general principle applied to WESTRACE is the use of two diverse methods of assuring the correct operation of vital functions—at least one, and whenever possible, both methods being inherently fail safe. This diversity is applied both at system level and at functional block levels.

Each vital module uses a single microprocessor. The diversity principle is applied in each module in many different ways, including:

- storing all data as true and complement in two diverse forms;
- utilising diverse true and complement data processing that is based on differently structured code;
- checking hardware against software and vice versa;
- continually testing hardware;
- proving the correct operation of the microprocessor by checking against other modules in the system.

5.2 Application Safety Principles

Figure 5.1 and the following paragraphs show how this principle is applied at the system design level to the WESTRACE system. Similar processes are used throughout the modules.

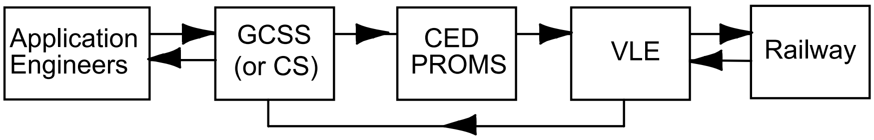


Figure 5.1: WESTRACE Safety Critical System

Main Process	Diverse Process
The installation is designed and the Configuration Data entered into the GCS by an Application Engineer.	A second Application Engineer checks the data entry and design and approves the GCS source file.
The GCS produces CED PROMs for use in the VLE from the approved source file.	Diversity is applied to the data within the CED PROMs by having two copies of the data used by the VLE within the PROMs. This data is also protected by several checksums.
The CED PROMs are installed into the VLE	The CED PROM Data is uploaded from the VLE to the GCS where it is checked against the approved source file.
Overall design process.	The correctness of the interfacing between the configured VLE and the railway is verified by on-site testing.

5.3 VLE Safety Principles and Methods

5.3.1 VLE Safety Objective

The VLE is designed to protect against 2 hazards:

a) a parallel output incorrectly energised for excessive time (longer than the fleeting output time);

b) a complete, incorrect vital serial message.

Several techniques are used to ensure that these hazards cannot occur. Detection of input states, all logic processing, data storage within the VLE and the communication between modules have all been designed to stringent requirements and are protected against undetected error conditions by diverse processes. The major techniques are described in following paragraphs. Ultimately, diverse checking paths monitor the system operation and will inhibit any incorrect outputs by removing the power to both parallel and serial outputs.

5.3.2 CED PROMs

The VLE checks that the format of the data in the CED PROMs is as expected, that the two copies of the data are in agreement and that the data is consistent with the modules present in the installation. If any of these checks fail, then the VLE will not start. Although the VLE continues to check for corruption of the data, the VLE is reliant on the correctness of the data provided by the Signal Engineer, within the CED PROMs.

5.3.3 VLE Design Considerations

Some techniques that are used to provide protection within the VLE include:

- Each vital module contains a single microprocessor. The operation of the microprocessor is checked by internal tests and external checks against a microprocessor in an adjacent module.
- The modules and their software and hardware, have been verified using the top down approach. Each stage of the design life cycle is subject to review. Comprehensive analysis and testing have been performed.
- The design of modules requires the software to test any parts of the hardware that are not inherently fail-safe and which perform vital functions. All such hardware is tested or otherwise assured in two diverse ways.
- All vital data is stored in two diverse representations. Vital logical data is also stored redundantly within one of these representations. During operation, the system checks that the two copies of all logic states passed over the Inter Module Bus (IMB) are consistent. If they are not consistent, the system shuts down. When logical data is transmitted either within an installation, or between installations, additional redundancy is applied.
- All vital processing is performed by two different paths of different software.
- The VLE internal circuitry is fully isolated from external connections (parallel inputs and outputs, serial ports and power supply).
- Each system installed uses a unique installation address allocated by Westinghouse Rail Systems Australia. This is to prevent unintended communication between different WESTRACE systems.
- The Configuration System defines the module placement in card housings. This information is included in the Configuration firmware and the system checks for correct module fit.

5.3.4 System Negation

WESTRACE safety design ensures that

- all vital outputs are forced OFF
- complete vital messages cannot be transmitted

should any failures be occur. This is termed *System Negation*. Signalling logic must be designed with these as the safe states.

The safe state is achieved by isolating the outputs of the VLE from the railway. Parallel outputs are isolated external to the VLE by using front contacts of a safety signalling relay, the Output Power Control Relay (OPCR). Serial outputs and VLC-NCDC communication are isolated by removing the Vital Serial Enable Voltage (VSEV). The drive to the OPCR and the VSEV are both removed when the VLE shuts down.

Two independent means of detecting the failure of a vital module and achieving System Negation are provided within the VLE. The first is by internal self tests of the microprocessor and other hardware within a module and requesting the VLM shut the system down. This is called *Primary Negation*. The second is by testing of the microprocessors, by other microprocessors, via the Health Monitoring Link and using this link to cause the OPC card of the VLM to initiate a system shutdown. This is called *Secondary Negation*. In practice, one method of shutdown causes the second.

Non-vital VLE modules do not take part in any system shutdown and will generally continue to operate.

5.3.5 Self Tests and Primary Negation

Primary negation is described with reference to the following diagram.

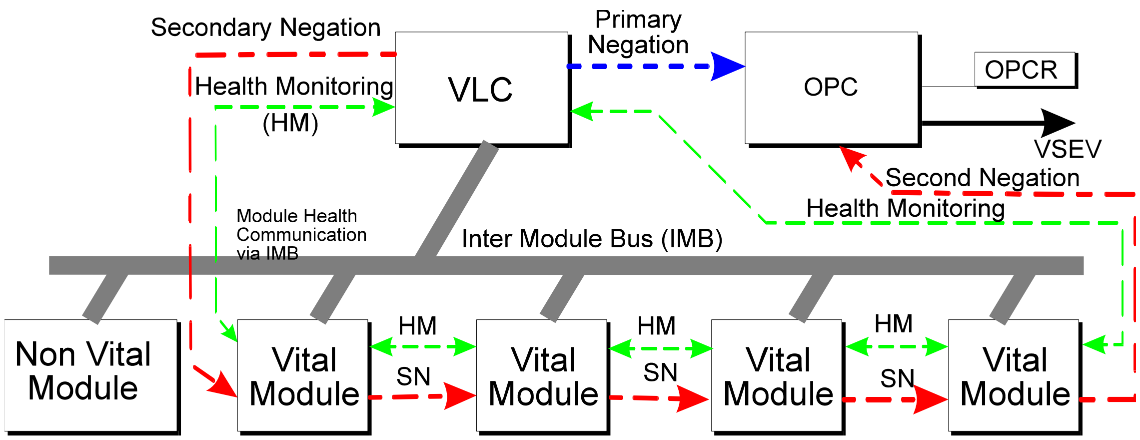


Figure 5.2: Primary and Secondary Negation

Primary negation uses the IMB (the normal communication between the VLM and other modules) and involves all vital modules in an installation.

The OPC uses fail-safe circuitry and only energises the Output Power Control Relay (OPCR) drive and Vital Serial Enable Voltage (VSEV) if both the primary and secondary negation signals are present.

The VLC will remove the primary negation signal and the OPC will remove the OPCR drive and VSEV if:

- the VLC ceases to operate, (the primary negation signal is not produced);
- the VLC detects a failure within itself by means of its internal self tests;
- the VLC fails to perform a transaction on the IMB with any vital module;
- any other vital module fails and therefore does not communicate with the VLC;

- any other vital module shuts down because it detects:
  - a failure within itself by means of its internal self tests;
  - a communication timeout with the VLC.

If any vital module instigates primary negation, all other vital modules also shut down.

5.3.6 Health Monitoring and Secondary Negation

Health Monitoring and Secondary Negation are described with reference to figure 5.2.

All vital modules use the bi directional Health Monitoring links to test adjacent vital modules, to ensure that the microprocessor and timing reference of the adjacent vital modules are working correctly. The Health Monitoring Loop and the Secondary Negation signal are carried between backplanes in a multiple backplane installation.

If a vital module detects a fault with an adjacent module, it will disable the Secondary Negation signal and will also cease communicating with its adjacent modules via the Health monitoring links. Removal of the Secondary Negation signal will cause the OPC to remove the OPCR drive and the VSEV.

If any one vital module instigates Secondary Negation, then the neighbouring vital modules will also shutdown and disable the Secondary Negation signal when they detect the Health Monitoring communication failure. This means that the Secondary negation is not reliant on a single module disabling the Secondary Negation signal.

5.3.7 System Shutdown Time

Detection and negation of failures take a finite time to isolate an incorrectly energised parallel output. An incorrectly energised parallel output that persists until the system shuts down is called a Fleeting Output. External protection against the effects of fleeting outputs may be required for some installations. A more detailed description of Fleeting Outputs and application guidance may be found in the WESTRACE Application Manual.

5.3.8 Graceful Degradation

Graceful Degradation is the isolation of a single input or output to ensure safe operation without enforcing a total system shutdown.

a) Vital parallel input modules, VPIMs, check the input detection circuits. If a fault is detected, the module first attempts to isolate the faulty input. If this is not effective, then the VLE is shut down.

b) Vital parallel output modules, VROMs and VLOMs, check the states of the outputs and of the detection circuits. If these outputs are perceived by the module to be in an incorrect state, or if a failure of the output detection circuits is detected, then the module first attempts to isolate the faulty output. The VLE is shut down if this is not effective.

5.4 Application Data Safety Validation

The safety objective of the GCS is to ensure correct configuration of the VLE for a particular installation. The combination of the GCSS and ICS achieves the total safety integrity. The GCSS is used for diverse data entry and checking by the Signal Engineers and for creation of CED PROMs. The ICS verifies that the CED PROMs in the configured VLE are consistent with the data entered and approved by the Signal Engineers.

The GCSS uses a combination of hardware checks, self tests and manual procedures to ensure that data is entered, stored and used on commercial hardware and operating systems in a manner that prevents incorrect or unintended data from being incorporated into a WESTRACE installation. The same principle of diverse techniques used within the VLE is applied to the GCSS.

Appendix A – System Specification

A.1 System Capacity

Number of Housings: 1 to 4

Card Slots Per Housing: 15

11 slots are available in Housing 1 after allowing for the VLM and DM (or HVLM and DM128).

10 slots are available with VLM6 & NCDM

10 slots are available with HVLM128 or VLM5 and an NVC/DM.

A maximum of 56 usable slots is available in a 4 housing system.

FUNCTION	HVLM128	VLM5	VLM6
Maximum number of Logic States	2,500	4,000	4,000
Maximum total module communication time	200 ms	333 ms	333 ms
Maximum logic execution time	570 ms	870	870
Maximum Cycle time	1 second	1.3 second	1.3 second
Minimum Cycle time	500 ms	500 ms[a] 750 ms[b]	550 ms[c] 750 ms[d]
Typical maximum number of logic rungs[e]	750 to 1,000	1,800 to 2,600	1,800 to 2,600
User Defined Mnemonics	2,500	4,000	4,000
Internal Latches	2,057	3,357	3,357
Internal Timers	200	300	300

a. Stand alone mode.
b. Hot-stand-by mode.
c. Stand alone mode.
d. Hot-stand-by mode.
e. Depends upon complexity.

A.2 Power Supply

System Supply Voltage:	24 Vdc nominal; 20 V minimum trough; 30 V maximum peak (including ripple and noise).
Input/Output Isolation:	500 Vdc
Consumption:	Dependant on module fit.
Efficiency:	66% Minimum.

Module	Power Consumption (Watts) from 24 V
VLM1	63.75 (includes up to 60 W for OPCR & VSEV drive).
HVLM	64 (includes up to 60 W for OPCR & VSEV drive).
VLM5	64 (includes up to 60 W for OPCR & VSEV drive).
VLM6	64 (includes up to 60 W for OPCR & VSEV drive).
NVC	3.63
VTC	2.63
EVTC	2.63
VROM[a]	6.67
VLOM 12[a]	11.18
VPIM[a]	4.05
DM	4.50
NCDM	2.5
NVC/DM	8
WCM	2.63

a. Separate power supplies are required for VLOM, and VROM modules. An external supply may also be required to source voltage for VPIM inputs. Refer module specifications for further detail.

A.3 Size and Weight

A system comprises one main 19-inch 6 U housing and up to three similar expansion housings.

Width:	486 mm overall.
Height:	265 mm per housing (1060 mm for four housings).
Depth:	425 mm for housing (approximately 50 mm rear clearance is required for connectors).
Mass:	Dependent on Module Fit (maximum total mass of any single housing less than 18kg).

A.4 Temperature and Humidity

Operational Temperature:	40 °C to +70 °C ambient (around housing).
Humidity:	0 to 95% non condensing.

A.5 Vibration and Shock

Vibration 0 - 12 Hz:	0.4 g or 6.35 mm maximum displacement in 3 axes.
Vibration 12 - 100 Hz:	1.4 g in 3 axes.
Shock:	Undamaged by free drop of 250 mm maximum on solid surface.

A.6 Electromagnetic Interference

Compliant with European Directive for Electromagnetic Compatibility, BR6667 and BR967 when installed in compliance with the WESTRACE Application Manual and good practice.

A.7 Earthing

The equipment should be connected to an earth of less than 15 Ω (5 Ω preferred) for correct operation. Earth impedance should include ac and dc component.

A.8 Module Capacity

The system module capacity is defined in the WESTRACE Application Manual. The capacity is limited by the maximum for each module type, the maximum number of slots available and the total service time of each module. The GCSS or CSS provide a check to ensure the capacity is not exceeded.

The maximum quantity of each module is given in the WESTRACE Application Manual.

A system can have up to 56 module slots available.

A.9 Response Time

The system response time is dependent on the number of modules installed and the application logic used. The worst case time for input to output response is 2.9 seconds with a typical response time of 1.5 seconds.

A.10 Module Specifications

A.10.1 Vital Logic Card (VLC)

Power Consumption:	2 W from + 5 V (includes CEC card).
Maximum VSEV Off Voltage:	2.8 V.

A.10.2 Hot Stand-by Vital Logic Card (HVLC)

Power Consumption:	2 W from + 5 V.

A.10.3 Vital Logic Card 5 (VLC5)

Power Consumption:	2 W from + 5 V.

A.10.4 Vital Logic Card 6 (VLC6)

Power Consumption:	3.3 W from + 5 V.

A.10.5 Output Power Control (OPC)

The output power control card energises an external signalling relay (OPCR) while the system is healthy. Contacts of the OPCR are used to cut supply to other system outputs. The OPC has a nominal 50 V output for the OPCR.

Power Consumption: 0.5 W from + 5 V;
up to 60 W from +24 V external.

Item	Limits
Minimum Relay Resistance	833 Ohm
Minimum OPCR On Voltage	40 V
Maximum OPCR Off Voltage	2.8 V
Minimum VSEV On Voltage	20 V
Maximum VSEV Off Voltage	28 V
Maximum VSEV Output Power	8 W

A.10.6 Vital Relay Output Module (VROM)

Outputs per module: 8

Output Voltage: 50 V nominal.

Output Type: All outputs are full floating voltage sources. Outputs may be connected in anti-parallel for bipolar relay driving.

Isolation between outputs: > 1 M Ω @ 1 kVdc for 1 minute.

Isolation output to common: > 1 M Ω @ 2 kVdc for 1 minute.

Output load: 3W nominal per output;
18W maximum continuous output per module.

Signalling Supply: A smoothed signalling supply is converted to the required output. The total variation of the supply including ripple and noise, line and load variation must be within the specification given in the table below.

Output Voltage: Refer table below.

Item	Limit
Max Peak Supply Voltage	60 V
Min Trough Supply Voltage	42 V
Maximum Off Output Voltage	2.8V
Minimum On Voltage	40 V
Min Load Resistance	600Ω

Power Consumption:	1.25 W from +5 V; 0.6 W from + 12 V; 0.6 W from -12 V; 2 W from +12 VHD.

A maximum of 26 modules can be used in any system.

A.10.7 Vital Lamp Output Module (VLOM)

Outputs per Module:	6 for double width module; 12 for triple width module.
Output Type:	All outputs switch an external lamp supply to lamp outputs. The lamp supply is commoned at the module. Outputs can be (selected) flashing or steady. All flashing outputs for an installation are synchronised.
Isolation output to common:	> 1MΩ @ 2 kVdc for one minute.
Output Load:	Nominal 24 W; 0.4 A maximum continuous; turn on inrush current is acceptable.
On Voltage Drop:	1 Vac maximum @ 0.2 Aac.
Hot Filament Proving:	< 100 mA Off; > 160 mA On.
Lamp Supply:	Minimum 100 Vac; Maximum 130 Vac.
Power Consumption:	1.25 W from + 5 V; 0.6 W from +12 V; 0.6 W from - 12 V; 3 W from +12 HD for 6 Output module; 5 W from +12 HD for 12 Output module.

A maximum of 26 double width or 15 triple width modules can be used in any system.

A.10.8 Vital Parallel Input Module (VPIM)

Inputs per module:	12
Input Voltage:	50 V nominal; smoothed or full wave rectified.

Item	Limit
De-energised input Voltage (average)	-100 to + 10.5 V
Energised input Voltage (average) (Source impedance < 8Ω)	+30 to +100 V
AC immunity for energised or de-energised state (11 Hz to 45 Hz with input source impedance)	40 V rms <32Ω
Input Impedance (dc)	4k ±800Ω

Input Type:	All inputs are full floating voltage detectors. Inputs may be connected in anti-parallel for detection of bipolar line signals.
Isolation between inputs:	> 1 M Ω @ 1 kVdc for 1 minute.
Isolation output to common:	> 1 M Ω @ 2 kVdc for one minute.
Power Consumption:	1.5 W from + 5 V; 0.6 W from + 12 V; 0.6 W from -12 V.

A.10.9 Non-Vital Communications Module (NVC)

Data Rate:	600 to 4800 bit/s, full duplex
Protocol:	Westinghouse S2/ compatible (modified SDLC)
External Interface:	Compliant with RS232-C, RS422-A or open collector; dependent on the interface personality module used. May be multidropped with suitable line interface.
Signal Lines:	TxD, RxD, RTS, CTS, CD, DTR, Rx and Tx Signal Element Timing.
Send Data (Indications):	64 bits.

Receive Data (Control):	48 bits.
Isolation on Data Lines:	> 1 M Ω @ 500 V.
System Power Consumption:	1.75 W from + 5 V; 1 W from External 24 V or VSEV.

A maximum of 10 NVC modules can be fitted to one system. It is possible to use two of these as a mutually exclusive receive pair to enable a control changeover function based on an internal logic state.

A.10.10 Vital Telemetry Continuous Module (VTC)

Data Rate:	1200 bit/s, full duplex, 8 data bits.
Protocol:	Byte synchronous; proprietary data protocol.
External Interface:	Compliant with RS232-C.
Signal Lines:	TxD, RxD, RTS, CTS, CD, DTR, Rx and Tx Signal Element Timing.
Send Data:	17 bits.
Receive Data:	17 bits.
Isolation on Data Lines:	> 1 M Ω @ 500 V.
System Power Consumption:	1.75 W from +5 V; 1 W from VSEV.

A maximum of 8 VTC modules can be included in any system.

A.10.11 Enhanced Vital Telemetry Continuous Module (EVTC)

Data Rate:	1200 bit/s, full duplex, 8 data bits.
Protocol:	Byte synchronous; proprietary data protocol.
External Interface:	Compliant with RS232-C.
Signal Lines:	TxD, RxD, RTS, CTS, CD, DTR, Rx and Tx Signal Element Timing.
Send Data:	66 bits
Receive Data:	66 bits
Isolation on Data Lines:	> 1 M Ω @ 500 V.

System Power Consumption:	1.75 W from +5V; 1W from VSEV.

A maximum of 8 EVTC modules can be included in any system.

A.10.12 WESTECT Communications Module (WCM)

Data Rate:	1200 bit/s, full duplex, 8 data bits
Protocol:	Byte synchronous proprietary data protocol.
External Interface:	Compliant with RS232-C
Signal Lines:	TxD, RxD, RTS, CTS, CD, DTR, Rx and Tx Signal Element Timing
Send Data:	150 bit structured message specific for WESTECT ATP use.
Receive Data:	None
Isolation on Data Lines:	> 1 M Ω @ 500 V.
System Power Consumption:	1.75 W from +5 V; 1 W from VSEV.

A maximum of 1 WCM module can be included in a system.

A.10.13 Diagnostic Module (DM64 or DM128)

The DM64 is used with VLM-based WESTRACE systems and the DM128 is used with HVLM-based WESTRACE systems.

The diagnostic module has two external interface ports; a Technicians Interface for interrogation of the system and an Event Recorder Interface to enable all change of state and fault information to be recorded. All event and fault information is time and date stamped.

Technicians Interface

Data Rate:	1200 or 4800 bit/s, full duplex.
Protocol:	Asynchronous, 7 data bits, even parity, 1 stop bit
External Interface:	Compliant with RS232-C.
Signal Lines:	TxD

Functions:

- Status Inquiry on inputs, outputs, or internal variables.
- Dump all/selected events.
- Dump all/selected fault information.
- Display Faults.
- Display Status.
- Display events (mnemonics) for Change of States.
- Set date and time.

Isolation on Data Lines: >1M Ω @ 500V

Event Recorder Interface

Data Rate: 1200 or 4800 bit/s, full duplex.

Protocol: asynchronous;
7 data bits;
even parity;
1 stop bit.

External Interface: Compliant with RS232-C (dumb terminal interface).

Signal Lines " TxD, RxD

Functions:

- Print Faults.
- Print Status.
- Print Events mnemonics for change of state.
- End of Day.
- Dump stored logs

Isolation on Data Lines: > 1 M Ω @ 500 V.

Power consumption: 2 W from + 5 V;
1 W from +12 V.

A single Diagnostic Module is required in every system.

A.10.14 Non Vital Communication, Logic and Diagnostic Module (NVC/DM)

The NVC/DM is used with an HVLM or VLM5.

Function	Parameter
User Defined Mnemonics (Inputs, outputs, latches, timers etc.)	40,000

Function	Parameter
Internal Latches	15,000
Set-Reset Latches	2,000
Timers	3,000
Time-of-Day Timers	10
Maximum Rungs of Logic	15,000
User serial ports (diagnostic+ communication)	Up to 6. Each needs a daughter board.
Serial Communication Ports	Up to 6.
Serial Communication Protocol (configured in application data)	WSL S2 (field) multiple addresses WSA S2 (field) multiple addresses WSA S2 (office) multiple addresses
Diagnostic Ports	Up to 3
Diagnostic Message Protocol	Proprietary
Serial Port Line levels	RS232-C or RS485 (configured with daughter board)
Serial Data Rate (all user ports)	Up to 64 kbps
Programming Port	9,600 or 112,000 bps RS232-C levels
Power Consumption	7 W from 5V 8 W from 24 V

A.10.15 Network Communication and Diagnostic Module (NCDM)

The NCDM is used with an VLM6.

Function	Parameter
User Defined Mnemonics (Inputs, outputs, latches, timers etc.)	40,000
Internal Latches	15,000
Set-Reset Latches	2,000
Timers	3,000
Time-of-Day Timers	10
Maximum Rungs of Logic	15,000
User serial ports (diagnostic+ communication)	2
Network Port	10BaseT Ethernet using RG45 connector
Serial Communication Protocol (configured in application data)	WSL S2 (field) multiple addresses WSA S2 (field) multiple addresses WSA S2 (office) multiple addresses
Diagnostic Message Protocol	Proprietary

Function	Parameter
Serial Port Line levels	RS232-C or RS485 (configured with daughter board)
Serial Data Rate (all user ports)	Up to 64 kbps
Programming Port	9,600 or 112,000 bps RS232-C levels
Power Consumption	3.3 W from 5V 2.5W from 24 V

Glossary

2nd Negation	Part of the *WESTRACE Backplane*. Provides a mechanism for vital WESTRACE modules to negate the system in the event of a fault being detected. See also *Negation*.
Application Logic	The logic that defines how the inputs and outputs for a particular installation are related.
Approach Locking	The locking which is applied after the signal has cleared to prevent the signal attempting to normalise a route in front of a train.
Aspect	The current state shown by a signal, eg Stop, Caution, Proceed, Reduce Speed etc.
ATP	Automatic Train Protection
AWS	Automatic Warning System
Backplane	Interconnects all *WESTRACE* modules, incorporates the Inter Module Bus, Fault Bus, Health Monitoring, 2nd Negation and various other interfaces.
BCC	Block Checksum Character. A method for validating the integrity of digital data.
Boolean Logic	A method to define and evaluate the logical relationship between digital inputs and outputs. An equation consists of terms which are combined using AND, OR and NOT operators.
bps	Bits per second
Buried Earth	A connection made to earth by means of driving, or burying one, or more earth rods or conductors.
CBI	Computer Based Interlocking—a generic term applied to interlockings using microprocessors.
CCSS	Configuration Check Sub-System—a *WESTRACE* software package that executes on an IBM compatible *PC*. It is used by Signal Engineers to verify that the *CED* fitted to an interlocking is the correct version and has not changed from the source data. Used for *VLM*-based systems.
CEC	Configuration Element Card—the CEC is part of the *VLM*. The *PROMs* containing the *CED* are fitted to the CEC on VLM1-based systems.
CED	Configuration Element Data—configuration data, application logic, module definitions and mnemonic names. The vital CED is stored in *PROMs* which are installed on the VLM1 or HVLM modules. 'Vital PROM Data' is the equivalent term when discussing later vital logic modules. 'Non-vital Configuration' is the term used when discussing non-vital data that is downloaded to the *NVC/DM* or *NCDM*.
CIM	Communications Interface Module—part of a *NVC/DM*, provides the serial interfaces.

CIMFIM Communications Interface Module Filter Interface Module—part of a *CIM*, contains level translation and filtering electronics.

CIMPM Communications Interface Module Protection Module—part of a *CIM*, contains transient protection electronics.

CNVC Configurable Non-Vital Communication Module

Coil An internal logic state which forms the output of a logic rung.

Compilation The process of creating the *CED* from the source file information.

Contact An internal logic state which is used as an input to a logic rung.

Control System The interface between the signaller and the railway signalling system. It may take the form of the rail authority's central control centre, or a local hard wired panel, or a control computer.

Control Tables A method of representing the interlocking functions in a form which is commonly used by Railway Industry.

CRC Cyclic Redundancy Check—a method for validating the integrity of digital data.

CS Configuration System—a set of *WESTRACE* software packages that executes on an IBM compatible *PC* and an associated manual. The CS comprises the *CSS* and *CCSS*. Used for *VLM*-based systems.

CSS Configuration Sub-System—a *WESTRACE* software package that executes on an IBM compatible *PC*. Used by Signal Engineers to design and simulate Application Data for WESTRACE Vital Signalling Systems. Used for *VLM*-based systems. Has been superseded by *GCSS*.

CTSS *WESTECT ATP* Transponder Configuration Sub-System

Cycle [WESTRACE] *WESTRACE* is designed to operate cyclically. Each cycle comprises the major phases of accepting input data, evaluating the logic once, delivering output the data and performing health checks.

Cycle Time The time taken to execute one complete *WESTRACE* cycle. This will vary, unless fixed for hot standby purposes, according to the number of *I/O* modules connected and the logic evaluated.

Diagnostic Module See *DM*.

Diagnostic System See *MoviolaW*.

DM Diagnostic Module— a *WESTRACE* module that monitors and records all changes of state and fault information in the WESTRACE system. The DM has external interface ports for interrogation the system and for transmitting data. A collective term which includes the original DM and the DM128. To be replaced by the *NVC/DM* or *NCDM*.

DTC Direct Traffic Control—a computer-based train control system used to electronically manage and validate train movements in non-signalled territory.

DWL Data Word Length—specific to the *WSA/S2* protocol and indicates the number of data bits in a message.

EPROM Blowing Form	A printed record of *EPROM* programming.
EPROM Programming	The process of storing data in *EPROMs*.
EPROM	Erasable Programmable Read-Only Memory—a type of *PROM*. Used to store the *CED* and module software on the *HVLM128*.
Equipment Room	Any building, fixed, or transportable, other than a control centre, housing *WESTRACE* equipment.
Event	A transition in the state of an *ILS*. All events are logged by *WESTRACE*.
Event Log	*MoviolaW* creates event logs of the *WESTRACE* operation and stores these logs for a defined period. Events recorded in the event log can be replayed.
External Diagnostic System	See *MoviolaW*.
EVTC	Enhanced Vital Telemetry Continuous Module—a *WESTRACE* module used for vital communication (66 bit) between two WESTRACE systems. For new installations, EVTC modules are recommended in place of *VTC* modules.
Fail-Safe	The attribute of a process or equipment that ensures that each and every failure or combination of failures results in the system attaining safe condition. Modern safety engineering prefers the term 'safety critical' and to define safety integrity levels.
Fatal Fault	A software or hardware fault which makes the continued operation of a module impossible. A fatal fault in a vital module will result in negation of the system before the safe operation of the railway is compromised. See also *Non-fatal Fault*.
Fault Bus	Part of the *WESTRACE Backplane*. Provides a mechanism for WESTRACE modules to report fault codes to the *DM* or *NVC/DM*.
Fault Code	An numerical code which a *WESTRACE* module displays on its front panel fault display and which is logged by the *DM* or *NVC/DM*. This code indicates a self-diagnosed fault in the module, or, in the case of the NVC/DM, an externally connected module. Phase 1 WESTRACE modules use 8 bit fault codes, while the NVC/DM use 16 bit codes.
Flash Memory	Non-volatile computer memory which can be written to as well as read from during operation.
GCS	Graphical Configuration System—a set of Windows-based *WESTRACE* applications and associated manuals. The GCS comprises the *GCSS* and the *ICS*. Used for all *WESTRACE* using *HVLM128* or later vital logic module based systems.
GCSS	Graphical Configuration Sub-System—a Windows-based *WESTRACE* application used by Signal Engineers to enter data to define the functionality of the WESTRACE system. Used for all *WESTRACE* using *HVLM128* or later vital logic module based systems.

GSIM	Graphic Simulator —a Windows-based *WESTRACE* application that provides graphic on-screen simulation of Local Control Panels and the status of tracks and trackside equipment of the railway under simulation.
HDLC	High-level Data Link Control protocol—a commonly used computer protocol for serial communication. The *WSA/S2* and protocol is based on HDLC.
Health Monitoring	Part of the *WESTRACE Backplane*. Provides a mechanism for vital WESTRACE modules to check the health of each other.
Hot Standby	The arrangement where two *WESTRACE* installations, a main and a standby, run in parallel. The standby system is able to automatically take over in the event of a fault.
Housing	The physical unit used to hold the *WESTRACE* modules in an installation. Up to four housings may be interconnected within the one installation.
HVBC	Hot Standby Vital Backplane Card—a small, half height, printed circuit board installed directly behind the lower connectors of the *HVLM128*.
HVLC	Hot Standby Vital Logic card—is the central processing module for an *HVLM128*.
HVLM128	Hot Standby Vital Logic Module—a *WESTRACE* that controls the operation of each WESTRACE system. It performs all logic processing and supervises communication between each WESTRACE module and itself. Two systems using these modules may be operated as main and standby with automatic changeover on most failure situations.
HVLM128a	Hot Standby Vital Logic Module—same as HVLM128 but with modified capacities.
HVLM PFM	Hot Standby Vital Logic Module Protection and Filter module.
I/O	Input and Output
I/O Assignments	The allocation of mnemonics to specify inputs and outputs.
ICS	Installation Check System—*WESTRACE* software used by the Signal Engineer to verify that the Configuration Data *PROMs* fitted to an installation are valid and are consistent with the approved design. Used for *HVLM128*-based systems.
IHCL	Inter-HVLM Communications Link—a fibre-optic connection used in a hot standby system to transfer data between the main and standby *VLM*s.
INCL	Inter NCDM Communications Link. A fibre-optic connection used in a Hot Standby system to transfer data between the main and standby NCDMs.
ILS	Internal Logic State—a one-bit storage element which is associated with a mnemonic name.
Image File	A copy of an installation's vital or non-vital *CED* stored on a *PC* for use by tools such as *MoviolaW*.
IMB	Inter Module Bus—part of the *WESTRACE Backplane*. Provides general purpose parallel data communication between the *VLM* and other WESTRACE modules.

Initialisation (System) This is a time prior to normal operation when the installation determines the current state of the external inputs.

Installation A single physical *WESTRACE* system, comprising up to four standard WESTRACE housings.

A set of railway signalling application data.

Input The input to the *VLE*.

ISIM Interlocking Simulator—a *WESTRACE* tool that enables testing of railway signalling logic in the office prior to commissioning a system.

Ladder Logic A form of boolean logic that is used to define the application data. It consists of relay equivalent logic and is input using the *GCSS* or *CSS*.

Latches These are internal logic states within the installation logic and are shown as relay coils in the ladder logic. They do not have a physical input or output.

LEC Logic Evaluation Card—part of an *NVC/DM*. Performs all (non-vital) logic and communications processing.

LED Light Emitting Diode

Location Case A metal cabinet housing *WESTRACE* equipment.

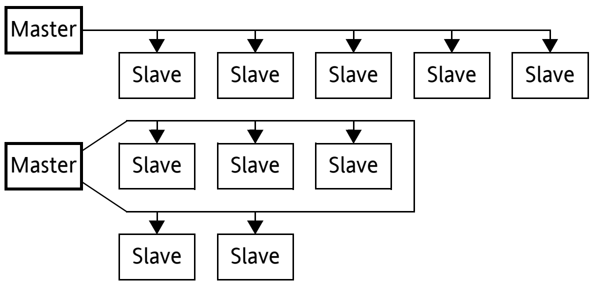
MB Megabyte

Mnemonic Abbreviated names that consists of numbers and letters to represent particular logic states or functions.

Module Bit Allocation This is the process of allocating mnemonics to *I/O* bits on a module.

MoviolaW MoviolaW is a suite of Microsoft Windows based diagnostic tools for *WESTRACE* Vital Signalling Systems and other railway systems.

Multidrop A serial cable configuration where multiple slave devices are connected to a single cable coming from a master device. The cable can be a single line or loop configuration. See also *Point-to-point*.



NCDC Network Communication Diagnostic Card—the NCDM's main circuit board.

NCD PFM or NCDC PFM Network Communication Diagnostic Protection and Filter Module

NCDM Network Communications Diagnostic Module—comprises an NCDC and an NCD PFM.

Negation	Shutting the system down to a safe state.
Non-fatal Fault	Faults such in software, hardware or other equipment that do not compromise the safe operation of the railway. See also *Fatal Fault*.
Non-Vital Telemetry	The means of communicating non-vital data from the *WESTRACE* to an external system such as a local control panel or control centre.
NVC	Non-Vital Communication Module—a *WESTRACE* serial data module used for communicating serially between WESTRACE Installations and a non-vital control system or similar.
NVC/DM	Non-vital Control and Diagnostic Module
NVLM	An acronym representing non-vital logic modules such as the *NVC/DM* or *NCDM*.
NVP	A non-vital protocol developed by Westinghouse Rail Systems Australia for network communications.
OPC	Output Power Card—part of *VLM* and *HVLM128*. A circuit board that controls the *OPCR* and *VSEV*.
OPC-PFM	Output Power Card Protection and Filter Module.
OPCC	Output Power Control Card
OPCM	Output Power Control Module—comprises an *OPCC*, a *VBC* and an *OPC-PFM*.
OPCR	Output Power Control Relay (or followed relay)—used to isolate parallel outputs when the *WESTRACE* system cannot be guaranteed to be operating safely. This relay is used as the final arbiter of system safety.
Output	The output of the VLE, such as a relay or lamp output.
PC	Abbreviation for Personal Computer (historically, an "IBM compatible" personal computer).
PCGE	Personal Computer Graphic Editor—a *PC* based application used to create graphical display files used by *MoviolaW*, WESTCAD and *GSIM*.
PCM	Pulse Code Modulation
PFM	Protection and Filtering Module—used to isolate the internal WESTRACE environment from the external electrical environment by providing screening, filtering and over-voltage protection.
PIOFLT	Parallel Input Output Fault—a vital mnemonic representing a parallel input or output fault.
PM	Protection Module
Point-to-point	A cable configuration where a separate cable is used to link two systems. See also *Multidrop*.
Printouts	Output from a computer driven printer.

PRM	Portable Radio Monitor
PROM	Programmable Read-Only Memory—a computer memory device which retains its contents without power.
PROM Program Form	The printed record of *PROM* programming having taken place.
PROM Programming	The process used to store data into *PROM*s.
PSU	Power Supply Unit
PTM	Portable Transponder Module
RAM	Random Access Memory
RS232-C	An electrical interface standard used for serial connection of one device to another (*Point-to-point*) for the purpose of data communications.
RS422	An electrical interface standard that uses differential signal levels allowing operation over longer distances.
RS485	Electrically similar to *RS422* but also supports *Multidrop* operation.
RSE	Railway Signalling Equipment
RTC	Real Time Clock
Rung	A part of Ladder Logic. A rung is the group of logic (relay equivalent contacts) that control a latch or output (relay equivalent coil).
SDLC	Synchronous Data-Link Protocol—see *HDLC*.
SIL	Safety (or sometimes Software) Integrity Level
Simulation	Testing of the *WESTRACE* Application Logic on a *PC* or other device rather than the actual system.
Slot	This is a space in a housing where *WESTRACE* modules can be inserted. WESTRACE modules occupy one or more slots.
Source File	A file that contains the data that has been entered into the *GCSS* or *CSS*.
Surge Arrester	Any device for controlling electrical surges on circuits entering a location, including gas discharge arresters, semiconductor arresters, or arresters combining both types.
Telemetry	Data communication system. The process of transmitting data between two points.
Temporary Approach Control	The process of forcing a timed approach control on a signal to minimise entrance speed. The total process or applying, retaining and removing the control must allow it to be vital.
Time-of-Day Timer	A timer whose output is set at a particular time of day.

Timer	A device or circuit that provides time signals at regular, specified intervals for purposes of controlling a sequence of events or synchronising events in separate operations. Ladder logic uses software timers.
Timestamp	Indicates the date and time at which a logged event, fault or operation occurred.
Transfer States	A set of logic states that will be able to be transferred from the *NVC/DM* to the *VLM* and vice versa.
UHVBC	Universal Hot Standby Vital Backplane Card—interconnects the *VLC*, the *OPCC* and the *OPC-PFM*. Also contains links for setting the installation address.
VBC	Vital Backplane Card—interconnects the *VLC*, the *OPCC*, the *CEC* (original-*VLC* only) and the *OPC-PFM*. Also contains links for setting the installation address.
Vital	Pertaining to system safety. Used an adjective to describe a process, function or equipment that, when not operating correctly, can adversely affect the safety of a system.
Vital Bar	Generic term to refer to Vital Blocking and Temporary Approach Control.
Vital Blocking	Process used to prevent the Signalling System to allow sections of track being allowed to be occupied. The total process or applying, retaining and removing the block must allow the blocking to be vital
Vital Communications	Communication of data that required for the safe operation of the *WESTRACE* system. Vital communication is between WESTRACE systems.
VLC	Vital Logic Card—a general term for the original VLC, the *HVLC,* the *VLC5* and the *VLC6*.
VLC5	Vital Logic Card for the *VLM5*.
VLC6	Vital Logic Card for the *VLM6*.
VLE	Vital Logic Equipment—is the physical *WESTRACE* equipment, both vital and non-vital.
VLM	Vital Logic Module—*WESTRACE* which controls the operation of each WESTRACE system. It performs all logic processing and supervises communication between each WESTRACE module and itself. This is a collective term for the original *VLM1*, the *HVLM128*, the *VLM5* and the *VLM6*.
VLM1	Vital Logic Module1—the name given in the WRSA WESTRACE manuals to the original and largely superseded vital logic module which was known as the VLM.
VLM128	See HVLM128.
VLM128a	See HVLM128a.
VLM5	Vital Logic Module—has essentially the same functionality as the *HVLM128* but has a greater capacity.

VLM6	Vital Logic Module—has essentially the same capacity as the *VLM5* but can also provide vital communications over a network to connected *WESTRACE* systems when used in conjuction with an *NCDM*.
VLOM	Vital Lamp Output Module—*WESTRACE* module used for driving relays or similar loads.
VPIM	Vital Parallel Input Module—*WESTRACE* module used for accepting vital parallel inputs into a WESTRACE installation.
VROM	Vital Relay Output Module—*WESTRACE* module used for driving signalling relays or similar loads.
VSEV	Vital Serial Enable Voltage—a vital control voltage used to enable vital serial communications to and from a *WESTRACE* installation.
VTC	Vital Telemetry Continuous Module—a *WESTRACE* module used for vital communication (17 bit) between two WESTRACE systems.
WCM	*WESTECT* Communication Module—used to communicate signalling information from an interlocking or *WESTECT Encoder* to an *ATP* equipped train. It is used as part of the *WESTECT ATP* system.
WESTECT	**WES**tinghouse automatic train Pro**TECT**ion.
WESTECT ATP	WESTECT **A**utomatic **T**rain **P**rotection is a Westinghouse Rail Systems Australia proprietary system that overlays on a *WESTRACE* signalling system and prevents driver error from endangering the train.
WESTECT Encoder	In its simplest form, a WESTECT Encoder comprises a *WESTRACE* system, a communications rack and an antenna system.
WESTRACE	WESTRACE is an acronym for **WES**tinghouse **T**rain **R**adio **A**dvanced **C**ontrol **E**quipment. It is a modular, safety critical, programmable electronic signalling system that has been designed for safety control systems for Railway Signalling.
WESTRACE I/O Module	General term for any module designed to be plugged into a slot in a *WESTRACE* housing, excluding diagnostic and logic processing modules.
WNC	WESTRACE Network Communications—generic name for complete *WESTRACE* system using and *NCDM* to facilitate communications over an Ethernet network.
WNCM	WESTRACE Network Communications Module—comprises the *VLM6* and *NCDM*.
WRSA	Westinghouse Rail Systems Australia
WSA/S2	A serial telemetry protocol developed by Westinghouse Rail Systems Australia.
WSL/S2	A serial telemetry protocol developed by Westinghouse Signals Limited (UK).

Reader's Comments

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