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- **Equipment:**

The SSI CI (Central Interlocking) system comprises of the following equipment *(see also layout on page eight):*

- PMUX: Panel Multiprocessor; this is used as an interface to convert electrical signals from a signallers conventional NX type panel into binary so the SSI can understand them. Not used if the signaller is using a SDS display system such as Westlock or Westcad.
  LED's: Power on (rear). System (on front).

- PPM: Panel processor module; two are fitted for reliability. These modules basically check what the signaller is asking and make sure it is valid information. The modules contain a memory module (MM) on the front, these have the local 'state of the railway' and are unique to that area and MUST NOT be used in other systems and must be swopped along with the PPM if changed.
  LED's: Power on (rear). System (on front).

- MPM: Multiprocessor Module; three are used. These are the actual interlocking part of the system. Using majority voting, they have to agree on what is being asked. If at least two agree the telegrams will then be transferred to the signalling. If one module disagrees with the others it will blow its security fuse, which will be indicated by the system LED going out.
  LED's: Power on (rear). System (on front).

- DMPM: Diagnostic memory processing module: This module is the logging module and monitors the interlocking and sends the critical or non critical alarms to the signaller.
  CRITICAL: anything that will affect the operation enough to stop trains, such as total failure of MPM's or TFM's or detection failure on a set of points. (Immediate attention)
  NON-CRITICAL: minor failures, such as one of the MPM's or PPM's failing, or filament failure on a signal. (Require attention, but not immediately). *Note: Track circuits do not have an alarm status if failed, as the system does not know if this is a train on the track or not.*
  LED's: Power on (rear). System (on front).

- TFM: Track Function Module; these are in the trackside location cases or the relay room. They come in two forms, a signal module coloured red, or a points module coloured black and are described as follows;

  Signal Module: can control/monitor up the eights functions which includes signals, track circuits and TPWS etc. They cannot control points. They have eight outputs and eight inputs (numbered 0-7). It is fed via a BX110 supply, and has four LED's;
  POWER: BX110 feed fuse healthy (if unlit it could also mean no power in loc).

  SYSTEM: security fuse is healthy, if blown the module must be changed.

  RX DATA: data being received from data link modules, if unlit there is no data being received, so check the DLM's, surge protectors or data link cable. It could also mean a problem back at the SSI central interlocking system (no data being sent).

  OUTPUTS: the module is not sending data back to the CI, if failed the module is not receiving information from the trackside equipment. If a module is found with the output light extinguished, try powering down and back up to reset. The failure could be the result of a voltage that should not be there (e.g. earth fault, short circuit etc) or noise on the data link.

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BXI/BXE SUPPLY: the module has its own power to supply signal lamp proving circuits and track circuits (indications only) directly, this is done via a BXI (internal) or BXE (external). The external supply is anything supplied outside the loc/relay room such as signal lamp proving, the internal supply is anything inside the loc/relay room, such as a track circuit indication (via the front contacts of a TR/TPR) or TPWS (VCR) indication. The supply voltage is between 5 & 7v AC.

Red Retaining mode: because trains cannot pass black signals, the module is fitted with red retaining mode (RR) so the signaller can caution trains.
If the module fails completely, it will automatically switch on this RR mode and supply a BX110 supply (known as 'red aspect source') to the signals most restrictive aspect.

Points Module: can control/monitor up the eights functions to power points and their indications. It can also monitor track circuits and other control/indication circuits such as alarms, releases etc. These also have eight inputs and eight outputs (numbered 0-7)
The SSI TFM was brought into service around the time when clamplocks were in country wide use, so they can control clamplocks directly, up to four ends from one module. The output feed being 122v AC.
If point machines are used, the module feeds relays for the points using a 1000ohm 6 watt dropper resistor to reduce the voltage to 60v DC.
The module has two input power supplies, the BX110 to feed the module, and a BX140 to supply the points (or point relays via dropper resistor in the case of machines).
The power supplies MUST be disconnected in a specific order or it will blow the module security fuse. Disconnecting; BX110 first, BX140 second. Reconnecting: BX140 first, BX110 second. The module has five LED's and are described as follows:

POWER: BX110 feed fuse healthy (if unlit it could also mean no power in loc).

SYSTEM: security fuse is healthy, if blown the module must be changed.

RX DATA: data being received from data link modules, if unlit there is no data being received, so check the DLM's, surge protectors or data link cable. It could also mean a problem back at the SSI central interlocking system (no data being sent).

'X'& 'Y'LED's: These are to indicate the points are being detected, if unlit, check the points are correct before checking module. If points are OK, try powering down the module and back up to reset. The failure could be the result of a voltage that should not be there (e.g. earth fault, short circuit etc).

- DLM: Data Link Module: is used to convert serial 20kbs 2-3v signals to 20kbs 1.5v AC signals and vice versa. They are also used to connect two or more interlockings together.
  They comprise of a A & B module (for availability) in the CI and the loc/relay room. The DLM has a power on light to indicate the BX110 supply voltage is healthy.
  At the end of the last data link, a 100ohm resistor is used to reduce distortion.

- DATA LINK cable: two core red and blue twisted cable used to transfer data to/from the CI to trackside equipment and other SSI systems. At the end of the data link cable before it reaches the DLM's it is protected by a lightning surge protector. On OHL areas an isolating transformer is used every 2km to avoid induced voltages.

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- LDT: Long Distance Terminal; If the control area is over 40km, the DLM's are not suitable. To overcome this a LDT is used. This converts SSI data (20kbs) to telecom data (64kbs) to allow equipment to be controlled directly.
  The LDT has eight LED's as follows:

  POWER: BX110 supply healthy (12v supply can be used in remote areas)

  SYSTEM: Module operating

  PCM TX: Clock is transmitting signals from the PCM (Telecoms carrier)
  PCM RX: Clock is receiving signals from the PCM

  PCM RX LINE: Messages received from PCM
  Data to SSI: Sending data to the SSI

  Data from SSI: Messages received from SSI
  Data to PCM: Messages sending to the PCM

  All eight should be lit. The bottom four should be slightly flickering to state they are sending and receiving data.

  TT: Technicians Terminal; located in the relay room where the SSI is situated. This is a computer with a printer which is used to monitor the state of the SSI and also put in commands such as track circuit/signal/route/points disconnections etc.
  The keyboard is locked and must be kept locked when not in use.
  If you have to use the TT, you **must** enter your name, company and purpose if prompted as all information is stored on a tape logger.
  If you have to put on controls, there is a data bit book as the system does not understand the geographical data, i.e. it does not understand the local signal and point etc numbers and each has its own code.
  For example to disconnect a signal aspect;
  Unlock keyboard, select option 5 to disconnect a signal aspect, select 1 to put control ON, then enter ID code (signal 'TN8345' for example maybe ID code '12'), press enter.
  It will then confirm which signal you are asking to disconnect. **CHECK** it is correct. If so, enter code 'EXEC' and press enter. The SSI will then apply the control within 3 seconds.
  The SSI system will only store that information for a set time if it has lost and regained power, but ALL disconnections MUST be written in the site disconnection log book, if this is not done, equipment that was disconnected or barred etc will become available again with dangerous consequences without anyone knowing it should be disconnected.
  Also anyone called to a total SSI failure, **MUST** check the disconnections log book against the technicians control print out against it and check it matches what equipment is disconnected/barred when the SSI is up and running again.

  The printer will print continuously any failures; therefore the paper feed must be checked when visiting the relay room.

  It is also good practise to get a failure print out before starting maintenance to see if any faults can be attended and rectified whilst doing maintenance in the same location.

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- **Basic system operation:**

Commands are sent from the signallers panel or SDS display. If a NX type panel is used a PMUX is used to convert electrical signals to binary code. The SDS display already converts this so a PMUX is not used.

From here it is sent to the PPM, this has a memory module which checks the information is correct (valid) and if so sends it to the three MPM's.
The MPM's will then decide through majority voting if the command is correct and safe, this is the interlocking side of the operation.
If at least two of the MPM's agree, the information is then sent to the trackside locations via a data link cable through data link modules and a surge protector in the location case.

If one of the MPM's disagrees, its security fuse will be blown and then render it out of use.

In the location case/relay room, the data is fed from the data link module to any signal or track modules (TFM's), this is then fed directly to the signals or points and indications are fed back the same way.

The signals are converted to binary code for example where as a voltage present is a '1' and voltage lost a '0'.
Each eight inputs/outputs on a TFM is sent/received as a binary code, so for instance 00010100, but you will have to check the diagrams to see what each code represents, only the TT or interrogator (testing equipment used to check binary data on the data links/DLM's or TFM's) will know how to read the code. Obviously the signallers indications will be able to indicate this too.
The code sent/received will also contain the address of the location/relay room so the TFM's will know the data is for them.
The TFM address as identified on the location case and the TFM's will contain the following example:

40S03; the 40 is the SSI central interlocking ID number, so for example Doncaster could be 40, and Peterborough 41.
The S represents the module is a signal module. P is a points module.
And finally the 03 is the TFM address, so the data is meant for that particular TFM.
The address of each module is hardwired into the actual plug coupler, so any modules changed will always have that address specific to them.

The binary address coding is split up into 32 bits of data (limited to 30) and signified by the format of the address using the following table.

32	16	8	4	2	1

Wherever a one appears in any box, that represents the code, for example;

32	16	8	4	2	1
1	0	1	0	0	0

So the above address will be 40, as wherever a one appears it uses that number.

32	16	8	4	2	1
0	1	0	1	1	1

So this address above is now 23. This address format is used on the diagrams.

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On the diagrams the address details may look like this *(however this is only an example for module '40S03'):*

TFM **40S03**									
INTERLOCKING	**DONCASTER**			I/L ID No			**40**		000**03**
ADDRESS BIT	5 (MSB)	4	3	2	1	0 (LSB)	0V	5V	MODIFIER
DECIMAL/BINARY	**32**	16	**8**	4	2	1			-
PROCESSOR A	7	5	4	3	2	1	10	11	0
PROCESSOR B	17	16	15	14	13	12	20	21	18
BINARY ADDRESS	**1**	0	**1**	0	0	0	0	1	0

A one appearing below the numbers 32 & 8 signifies interlocking number 40

These columns shows where the hardwiring in the plug coupler is fitted on the pins for the interlocking address

These columns shows on which pins the hardwiring is in the plug coupler for the processors

Modifier used to used for; signal TFM: flashing aspects. Points TFM: switching to a three ended set from 2x2 ended.

The technician's terminal will read data as a telegram and it will appear similarly to this:

TFM	OUTDAT	INDAT	OUTSTAT	INSTAT
40	10000000	10010011	00000000	11111111

This info may not appear on the telegrams so it's important to know what each column represents.

TFM module address

Code for which equipment is functioning, so the 1 is something that is being asked to be powered up, for example the first one is asking the signal to display a red.

Code for which equipment is functioning, so the 1 is something that is being sent back as indicating in, clear or on, for instance the first '1' is saying the signal is red, the second '1' is stating the lamp is lit, and the final '1's is saying that two track circuits are clear.

Shows the status of the telegram. The out status is always zero's. The in status should be one's, unless there is a fault then it will appear as zero's.

On technicians terminal select option 3 then select monitor telegrams to receive the information above.

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- **Interrogator:**

An interrogator is only used to check the status of telegrams if a fault cannot be found be normal faulting means.
Depending on the interrogator used, it has to be inputted with the interlocking and module address and which output or input to be monitored before it can read the correct telegram.
The equipment is plugged into the test points at the field or remote end and a row of lights will report the state of the telegram as a light lit for a '1' or light out for a '0', therefore the diagrams have to be used to determine what the message is for each piece of equipment.
It will also report the status of each data link and input and output from that DLM.
Older type of interrogators where there is an output connection to change the state of the signalling MUST NOT be used by signalling maintenance technicians.

- **Faulting guidelines**

The technicians terminal (TT) is a very good tool to give details of faults on the system, however it will not necessarily mean it will locate the fault, i.e. it will tell you which lamp in a signal has a first filament failure or has blown, but it will not tell you why there is no reply from a loc or why a LED on a MPM is not lit.
But by combination of a fault print out and a LED not lit, it shouldn't be hard to find the fault.
More complex faults are hard to find, such as noise on the line which may be very hard to detect but may still shut down a TFM.

Some faults can be narrowed down from what the signallers panel is stating, for example if a signal is showing black, a TC very close to it is showing failed and the TPWS is indicating failed, it is more likely to be a TFM module failure as the data link and data link modules are duplicated, But the TT could narrow it down further if you are passing the relay room to get to the fault.
For some SSI areas it is possible to dial into the TT remotely.
Use the LED's statuses already mentioned on the above pages to diagnose why any LED's may be extinguished.

Some fault messages on the TT may be self explanatory, but here are few examples;

SIGNAL 8316 RED LAMP; blown red lamp on 8316 signal
SIGNAL 8645 YELLOW MAIN FILAMENT; yellow filament failure on main lamp
POINTS 101 NORMAL DETECTION; loss of normal detection
POINTS 123 REVERSE OPERATION; points have been called reverse but are still lying normal.
POINTS 2631 MOTOR FAULT; points module detected voltage that should not be there and therefore will shut it down, it may then have a 'NO REPLY FROM...' if it does shut it down.
NO REPLY FROM TFM 40 LINK B; module will still be working on link A, so this could be a TFM, DLM, failed surge protector, or wiring fault.
NO REPLY FROM TFM 40 BOTH LINKS; both the A & B links have failed for this module. First of all don't assume it's a data link failure, it could be the module has failed due to lack of power or it's blown its own security fuse.
OUTPUT INTERFACE FAILURE TFM 23; module has blown its security fuse, outputs are disabled, red retaining has supplied a voltage to feed to signal most restrictive aspect (if it is a signal TFM), however it's still transmitting a reply to SSI. It is more likely to be an external fault.

On older models of SSI, some messages may state the location number instead, for example; 'NO REPLY FROM LOC 155/20 BOTH LINKS'. REMEMBER: track circuit failures are NOT indicated on the TT or printout, only on the signallers panel/display.

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Other failure types:

- Triple MPM security fuse:
  Critical alarm sounds, signals put back to danger and red retaining feature in signal TFM's activated, signallers panel freezes (which may have been whilst signals where showing a proceed, so although they have gone back to red, they may have frozen in a proceed state).
  Replace all MPM's and failure will rectify itself. Signal routes will require cancelling and time out for up to 4 mins. Auto signals will require re-stroking to auto function.

- Dual PPM failure:
  Indication failure alarms sounds, critical alarm sounds, signals will continue to operate on the ground as they were previously set, but the panel will freeze. The signallers are instructed however to press all signals on button.
  Replacing PPM will rectify failure.

- **SSI specifications:**

Maximum number of	Number
Interlockings per IECC/signalbox area	30
TFM's per interlocking	63
Signals per interlocking	128
Signals per module	Up to 2
Points per interlocking	64
Points per module	4
Functions per TFM	8
Outputs per TFM module	8
Inputs per TFM module	8
Tracks per interlocking	256
Routes per interlocking	256
Km's per data link module	40Km
TFM's fed by one DLM or LDT	6
Isolating transformer used in OHL areas every	2Km
Minor cycle for transmitting a telegram approx	9.5 – 30 ms
Major cycle for transmitting all 63 telegrams approx	608ms max 1sec

Main TFM/DLM/LDT supply voltage	BX110 AC
Main LDT supply voltage in remote areas	12v DC
Additional input supply voltage for points TFM	BX140 AC
Output voltage to clamplocks from TFM	122v AC
Output voltage to point machine relays	50-60v DC (via a dropper resistor)
Voltage from TFM for BXI/E supply	5-7v AC
650v supply for one signal module	650/110v 500VA
650v supply for two signal modules	650/110/110v 500/500VA
650v supply for one points module (four C/L's)	650/140/110 4CL/100VA
Voltage on a datalink using AVO 8 or FLUKE 23	Typically 0.4 – 0.9v AC

Keyboard unlock code	Usually 1234
Execution code to change commands	EXEC

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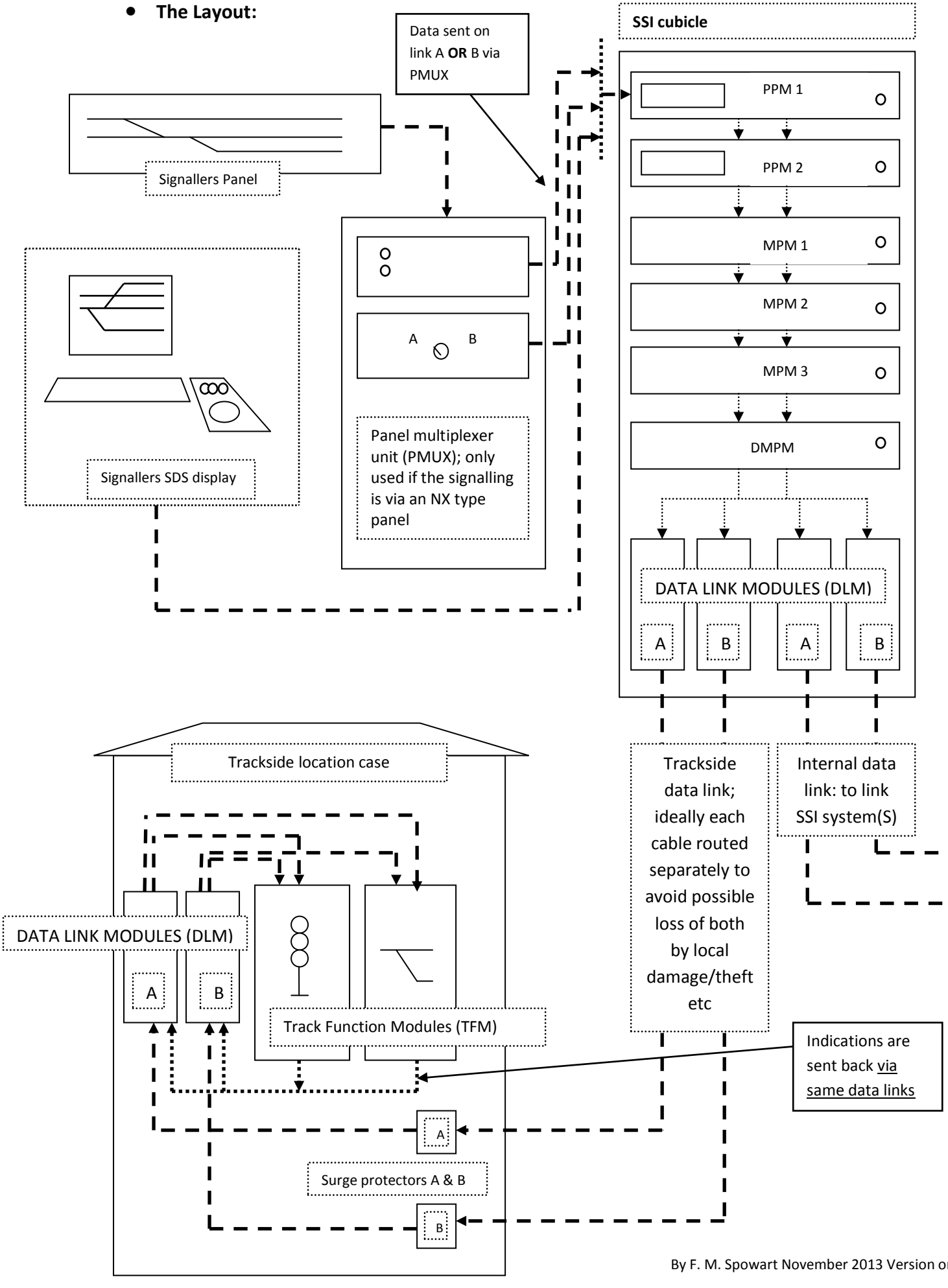
- **The Layout:**



By F. M. Spowart November 2013 Version one