"The Devil's in the Detail"
(*or* An Introduction to Interdisciplinary Design Coordination) *by Iain Ellis, Member, Lancaster, Barrow and Carlisle Section*

Every designer and engineer prides themselves on their skills and abilities, their knowledge and foresight, and they are right to do so. We have permanent way designers, signalling designers, electrification designers and civils designers: but who designs the interfaces? In this paper I will look at the problems raised by multi-discipline design and some solutions to them.

Design

In order to illustrate some of the problems, let's take a simple task: a new crossover on a straight two track railway. It's track circuited, with 25kV overhead line. Simple, you would think. As permanent way designers all we need to know is the required crossover speed and whether it is CWR or not and we're away.

But hold on, where exactly are we going to put this new crossover? Facing or trailing? If there is a signalled route over the crossover, then it needs to be less than 800 yards beyond the junction signal, but more than 200y beyond so we keep the overlap clear. If we can't locate the crossover to suit the signals, then we might need to move a signal or two; but can we? Which direction is best? Best ask the signalling designer. While you're there, ask him about insulated rail joints for clearance points.

Now we've got the crossover to fit in between the signals, but what about the overhead line? We don't want to put it near a neutral section, under a low bridge or near a booster transformer. Can we get both switch heels under an existing registration arm? No. Well how about one then? Yes? Good. Hang on, the new structure at the other end gives us an illegal span differential: back to our electrification designer. We can probably help him, either by making the crossover longer or by moving the crossover along as far as it will go. If not, we'll have to do some respacing.

Right, everyone happy? The Operators aren't? Why not? It needs pedestrian access for the Pilotmen? Why didn't you say earlier? Possessions? TSR allowances?

… and so on.

The lesson here is that any single designer cannot know all the constraints in detail, and what makes one part of the design easy makes some other part harder. Now think about the problems generated where a scheme consists of 20 crossovers, not one…

Inevitably, the pway designers do their work second, after the operators have decided on a layout (although asking the people who run the railway what they want seems to have died out recently). However, it is rare that the permanent way design suits everyone else. It is at this stage that all the disciplines should get their heads together and sort it out. I have found that signalling designers are quite amicable chaps, and they can often help make things simpler. The same goes for electrification types; whose requirements for registrations in the 200mm opening often lead the design towards simpler and independent bearer arrangements.

All of this is true 10 times over if the work is built in stages, as every stage is effectively a standalone design.

A Challenge

So, do you think you've got it sorted? Try listing <u>ALL</u> the factors applicable to the positioning and selection of the humble insulated rail joint (IRJ). I'll give you until the next page to write them down.

(page break please)

Answer to the Challenge

Pens down, please. Finished? Good. My list is:

- purpose:
  - clearing point or overlap (critical relationship to signal),
  - transposition (need one in both rails),
  - clearance point (critical relationship to distance between converging lines),
  - temporary or permanent,
  - track circuit boundary (may need one in both rails, with limits on tail cable length and track circuit length);
- staged installation / removal requirements (temporary bonding);
- type (four hole, six hole, shop fitted, dry, close tolerance);
- rail section;
- adjacent rail depth and sidewear;
- sleeper or baseplate type (may require changing to suit certain IRJ types);
- stressed or jointed rail;
- proximity to:
  - existing rail joints,
  - underbridges,
  - level crossings,
  - switch & crossing units,
  - check rails;
- requirement for hollow sleepers or ducted sleepers for tail cables;

And that's just one (possibly two) insulated joints!

The point of this is that on a major scheme the process has to be repeated thousands of times, and designers have enough to do, so it can all get forgotten.

So what's the answer?

The answer is that projects need someone to manage the interfaces between the designs. There is no single discipline on the railway that isn't affected by another part, so the inter-disciplinary design co-ordination can be more involved than all the single discipline designs put together.

Let's illustrate this with another example; the ubiquitous cable route. The normal place for it is in the cess, about one to two metres from the track. This is also the area occupied by the track drain: anyone see a problem? If the permanent way engineer is to meet the requirement for a clear drainage path for water from the track formation, then this path will often pass underneath the cable route. If the project is to build a new cable route, why not include reballasting of the cess beforehand as part of the scheme? Or arrange the cable route to be further from the track than the drain?

With all these things, they are expensive to put right on the weekend, but very cheap to fix on paper six months earlier.

Parallel Design

Enter the red-eyed monster of parallel design. It is a living hell, where a design change in one discipline can force a change in the unfinished design of another. If you didn't need an Interface Engineer before, you do now. With the current trend towards rapid design and delivery to compensate for tediously protracted authority processes, parallel design is something we are all going to have to get used to; we also need to recognise that in this fragmented industry there are holes in the system, and projects need to appoint someone to bridge these holes and help produce a single integrated design.

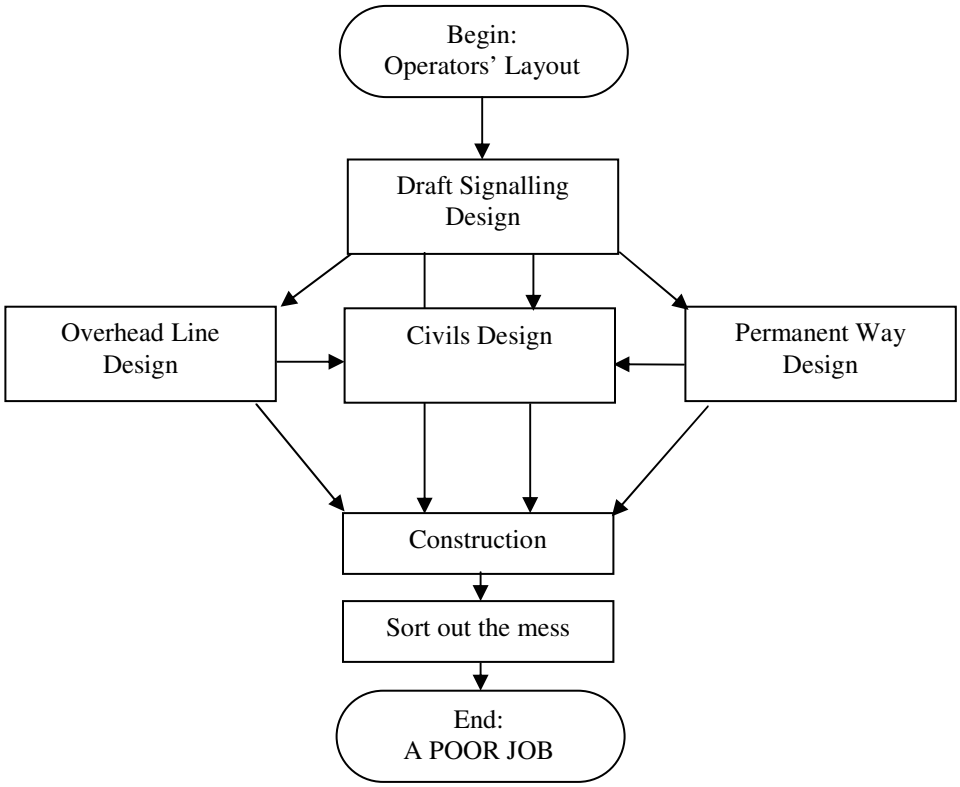
A typical project can have a minimum of five different design companies, each with their own discipline engineers within the client team and all providing information to a fragmented contractor's organisation, itself often composed entirely of sub-contractors.

Now tell me that you don't need someone whose sole task is just to co-ordinate things!

Interdisciplinary Design Co-ordination

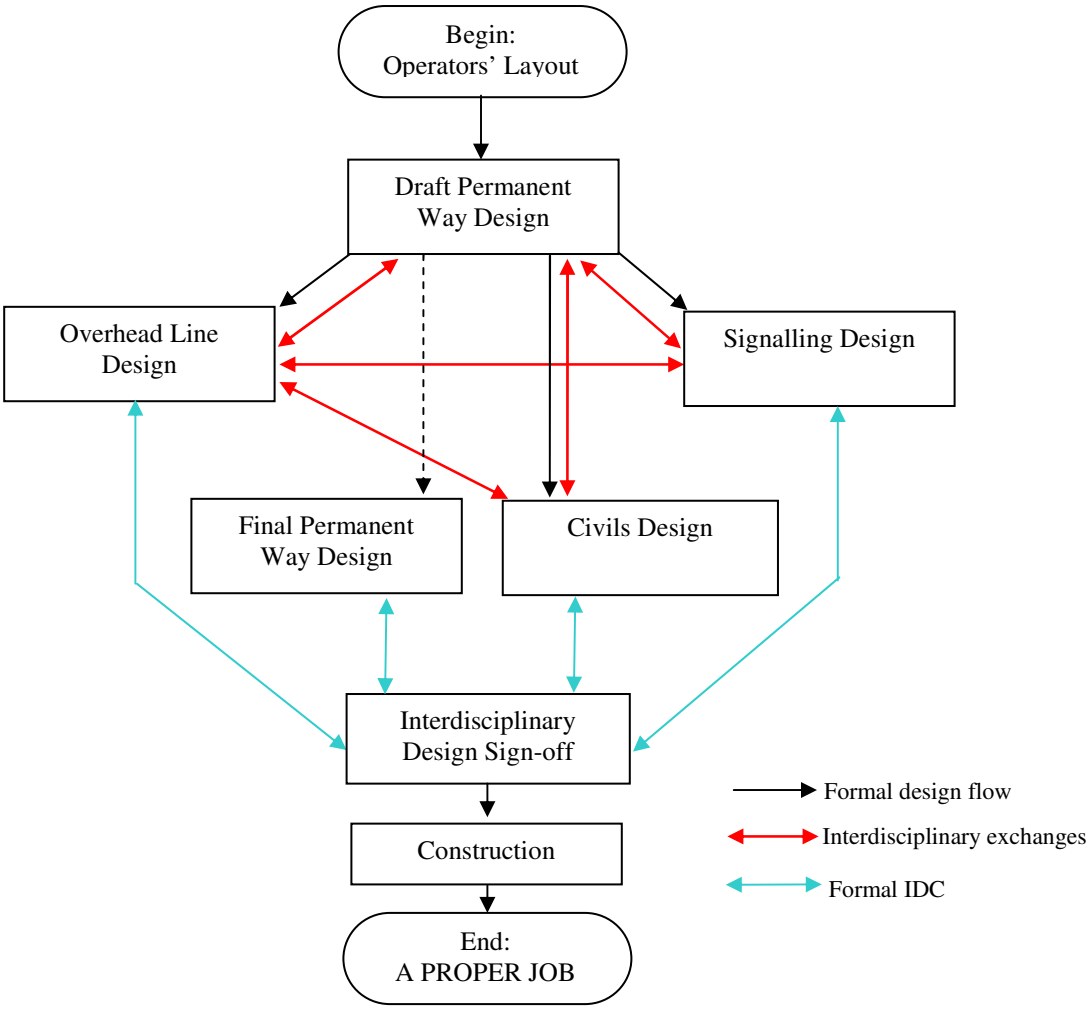
Pro-active inter-disciplinary design co-ordination (IDC), including regular inter-designer contact at all stages, is the key. Since no contemporary paper would be complete without them, I introduce exhibits A & B, the obligatory flowcharts. For clarity, they only show the main disciplines:

Exhibit A: The Traditional Approach.



In this approach, there is no co-ordination between disciplines, other than everyone has a signalling scheme plan (SSP) to work from. There is little or no flow of information between designers. The construction phase (or the Friday before it) is the first time anyone gets to see the whole problem. IDC checking does not easily fit into this structure, as each designer has to badger the others for signatures; the wheels turn very slowly indeed.

Exhibit B: The Correct Approach



In this approach, the permanent way design takes the lead, albeit in draft, as it is best to have something to discuss first. The permanent way tend to do huge and detailed topographical surveys, allowing the other designers to verify locations of key features using real distances (rather that the arbitrary miles/kilometres/chains/yards/feet/links systems, none of which agree with the others).

This draft design is used as the basis for the other disciplines' layouts, with each designer's changes being fed to the others via the IDC process until all the designs settle down. The final and definitive permanent way layout is then produced, in the full and certain knowledge that it is right.

The last stage is important – don't build anything until the design is formally accepted by ALL the designers. If it isn't right at the final IDC signing-off point, it should go back to design until it is right, with any changes made passed to the other designers. Seemingly innocuous problems can lead to grief later, like missing an overlap IRJ out of a switch and crossing layout. What at first seem like alien experiences (like signal sighting committees checking new overhead line structures, and permanent way, signalling overhead line and civils designers all agreeing locations for under track crossings) are well worth doing

An example of an IDC certificate is shown below.

			IDC Certificate Number	
Certificate of Interdisciplinary Design Check				
Drawing Title / Description				
Drawing / Document Number				
Discipline			Revision	
Designer				
Has been checked by the following design representatives:				
Function	*Name*	*Signed*	*Date*	*Comments*
Civil Engineering				
Electrification and Plant				
Overhead Line				
Permanent Way				
Signalling				
Telecommunications				
This certificate has been accepted by the following:				
Designated Project Engineer				
Project Manager				

Staging

The design process will always create a situation where some parts of the work must be removed or constructed to allow other parts to be completed. A staging book, whilst by no means as detailed as a full programme, is an invaluable tool to make sure that everyone understands firstly the correct order of construction, and more importantly that there actually *is* a correct order of construction.

In its infancy, a page for each major change with an accompanying diagram and short description will do; later evolutions will probably cover a possession per page and be inordinately detailed:

The signalling types need detailed staging information, as 99% of track-related stageworks will require some form of signalling design work.

The Future

In the future the railway industry needs to see the discipline of Inter-discipline Co-ordination (IDC) taking up a position equal to the likes permanent way, signalling, OLE, operations, telecomms and civils, with a consequent reduction in the number of expensive last minute re-workings of designs.

Lastly, I would like to propose my ten commandments for project design success:

- Thou shalt make no appointments before the appointment of an IDC champion. Agree what deliverables there will be and which ones need to go through IDC. Hold IDC meetings regularly and start the dialogue; it is rarely too early to start IDC-ing;
- Thou shalt have only one chainage system within the project. I recommend that this a metre based system, starting at zero just off one end of the job. Mark this system up along the site using paintsticks and pegs as soon as possible;
- Thou shalt ensure that you have twice as many survey control stations as you think you need and that at least half of them are on immovable objects clear of the site;
- Thou shalt use the pway topographical survey to pick up mileposts, signals, IRJs, OLE structures, wire runs, signs, location cases, bridges and telephones, and use this as the master reference by actually giving it to people;
- Thou shalt not prevaricate: As soon as a basic permanent way layout is done, get the designers together and get all the input you can to it (i.e. rip it to shreds). Update this layout and send it electronically to all the designers. All the designers should then be working to the same achievable target;
- Thou shalt get thine designers round the table on a regular basis thereafter and throughout the project;
- Thou shalt foster an atmosphere of co-operation, as small changes to one design can solve huge problems with another;
- Thou shalt honour and cherish thine staging book;
- Thou shalt make sure the construction side have easy access to the IDC champion;

And finally:

- **Thou shall not build anything unless it has been IDC'd**

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