Cable Management Challenges

A document outlining the major challenges facing companies involved in cable design and installation and how CMPIC software addresses them

1 Introduction

This document lays out the main challenges that companies face in the areas of cable scheduling, routing, termination and installation. It also covers how Cloudis Ltd., in the development of their CMPIC cable management software over the last 15 years, have addressed these challenges and continue to look for new ways to optimize efficiency.

2 The challenges for cable management

An important aspect of the challenges outlined below is that they are all interdependent. For example, a decision to schedule three single core cables instead of a single three-core cable might have an effect on containment required – three cores need to be routed as a trefoil which in turn may increase the area occupied. The same change also means that on that tray or hanger, where the trefoil is placed, cables cannot now be stacked, which again may affect % fill. A decision to move a device will almost certainly have an effect on cable lengths some of which, if they are supplied cables or cables with a maximum allowable length, may not now be long enough. The issue for cable management overall is how to see all these causes and effects and to make the appropriate decisions.

3 How CMPIC addresses these challenges

To manage the interdependency of the challenges for cable management, CMPIC is designed around a relational database – Oracle. All changes to any data can be seen by anyone with access to the system. Any changes to data which might impinge on decisions already taken, or rules applied, will be prevented until the decisions are retracted or rules amended or lifted.

In this way, all data entered or amended is checked by CMPIC to ensure that it is compatible with what has already been entered, and that the rules that have been applied are being adhered to.

Audit history tracking, which is carried out automatically in the background by the system, ensures that all actions carried out are logged by date, time, action and user. This history file can be exported.

3.1 Ensuring accuracy and consistency of data

This is of course an issue which is not limited to the area of cable management. However, we have found that maintaining accuracy and consistency often cause more problems here because the electrical engineering and C&I disciplines frequently rely on tools which do not necessarily meet their needs.

As a result, cable scheduling and cable routing are often carried out using spreadsheets with the inevitable consequences of duplicated records, unused but undeleted records and mismatches in the status of cables recorded in the spreadsheets versus the reality on the project e.g. the spreadsheet does not reflect that a cable has been installed. Consequently, we have seen examples of where cables are cut and even installed more than once.

CMPIC approach

Of course, being based on a relational database ensures that simple controls such as not being able to enter the same cable tag number twice, not being able to amend the route of an installed cable etc., can be implemented to manage the consistency and accuracy of the data.

In addition, as part of the project setup, specific formats can be set for data entry so that cable tags, device tags, etc. must be entered in the correct format. Pull down lists can also be provided to the user to help with entering the data; for instance, if cable tag numbers always include the From device ID, then the system will provide a list of these IDs to choose from.

As referred to already, spreadsheets are used widely in the scheduling of cables. This may be inevitable in the early stages of a project given the numbers of people and disciplines involved. Once cable lists have been created, perhaps some of them outside of CMPIC, a Wizard can be used to take these lists and import them into the CMPIC database. In doing so, the Wizard carries out the same checks that would have been carried out if the data had been input directly.

3.2 Time pressure

Because of the nature of the design process it is common for the electrical and C&I engineers to be pushed ever closer to target completion dates because of the absence of accurate engineering data. This data, in our experience, typically comprises of at least one of the following: cable containment sizing not ready, cable types to be used not yet finalised, bulkhead and floor penetration sizing not available, final decisions on cable segregation allocation to tray or hanger tiers not yet taken, equipment not yet definitively located in an area or compartment etc.

Since the final project completion date is not likely to be extended to account for these issues, the pressure on the cabling discipline increases as delivery of the required engineering data is delayed.

CMPIC approach

To alleviate some of the pressure associated with non-availability of design data, we have developed a number of functions in CMPIC which enable cable scheduling and routing to continue without a final or definitive design dataset. These functions also ensure that work already carried out is retained, so that re-work is kept to an absolute minimum. These functions include:

- Compartment to compartment (or area to area) routing
  - Where the location of from and to devices may not yet be finalised, CMPIC allows cables to be routed between the compartments or areas in which those devices are expected to be. If cables can be routed in this way, although the total cable length will not yet be calculated, the % fill of hangers, trays and penetrations can be monitored. If a re-route is required, since this typically takes seconds, this can happen quickly as circumstances change.
  - Completion of the cable routes can be done at a later stage or, using the dimensions of the compartment or area, an off-route length (i.e. the length of cable from the device to the nearest hanger or tray) can be calculated.
- Automatic cable re-routing after modifications to the cableways
  - This functionality enables cable routers to start routing on a network of cableways which is still under development. Using an immature and perhaps rudimentary cableway network, which has been exported from a CAD system, cables can be routed in CMPIC. Any of the facilities for routing can be used.
  - As the cableway design matures, further exports can be taken. When these updates are imported to CMPIC, checks are carried out by the CMPIC API to ensure that these updates do not contravene any rules already applied. For example, CMPIC can be set up to prevent the cable tray layout from being changed if there are cables running through it with approved routes. In this case, the tray update would be rejected. A log is created which shows the anomalies and these can be investigated.
  - If it is decided that the cableway network modifications are acceptable, then CMPIC settings preventing this can be de-activated and the modified cableways will be allowed to update the network.

- When the cableway update takes place, CMPIC looks for any cables whose routes are affected by the modifications. Where possible, CMPIC will automatically repair any routes which were broken by the cableway update. If it is not possible to repair the route (perhaps because of segregation mismatch, missing segregation data, breaks in the cableways etc.) then CMPIC produces an error log. There is also a log of successful re-routes so that the engineer can examine these before accepting them.
- Where the cableway update does not actually break routes, but simply lengthens or shortens trays or distances between hangers, then the lengths of all the cables which run through the affected cableways are automatically changed by CMPIC. Again these automatic updates are subject to any settings in CMPIC which allow or prevent such changes.

- Partial cable routing
    - If the cableway layout is only partially complete, CMPIC supports partial routing of cables along these cableways. Routes can be completed later when the finalised tray layout is available.
    - Using partial routing the user can also de-route part of a cable's route and complete it later, or complete it using a different route from a given point.
- Copying cable routes from one cable to another
    - Where several cables share a common route, rather than routing each cable, the route of a master cable can be copied to others.

3.3 Deriving accurate cable MTO data as early as possible

There are two issues involved here. Firstly there is the need to forecast, as accurately as possible, the requirements for any long lead delivery times for the various cable types. Secondly, as cable routing is completed, firming up all cable type (and associated equipment) requirements so that these can be drummed by the manufacturer, or ordered in if standard stock items.

CMPIC approach

One of the benefits of having a variety of approaches for cable routing is that the most appropriate option can be used, based on data available at the time.

- Compartment to compartment or partial routing means that accurate cable lengths for the routed part of the cable can be derived, which can be used as the major part of the initial length estimate.
- An assessment for the 'off route length' (the length of cable from the tray or hanger to the device) can be made by CMPIC based on compartment or area dimensions.
- For any cables which have firmly located From and To devices, the total device to device length of the cable can be used.

This then provides an input to cable required by cable type. Any cables which are subject to a long lead order type can be identified.

Once the cable routes have been fully completed, these will comprise the routed portion, the off route portion and any allowance made for maintenance loops and stripping and terminating. However, since all necessary data is not always available early in the project, the various routing approaches available in CMPIC help derive cable lengths based on what is available.

The Production Module of CMPIC allows for the input of drum (reel) data including delivered length. As cables are then cut, CMPIC maintains a record of material used and still available.

3.4 Managing change throughout the process

Not managing change effectively is an issue which can add immensely to the time pressures on the staff involved in the cabling process and as a result to the numbers of errors made.

Once a cable has been routed, however that is done, any subsequent change to the type of cable, segregation of the cable, location of either device, change to compatibility regulations such as the spacing of cables on trays for example, etc. will result in re-work. How easy or difficult that re-work turns out to be will be greatly influenced by the number of applications or tools that are used to make the changes. Clearly the more integration involved between the applications and tools, the less intervention is required and the greater the accuracy and speed by which the changes can be effected.

CMPIC approach

All aspects of CMPIC are integrated. Rules and controls are applied so that modifications to cables and their routes cannot be made if these would counteract an action already taken. For example, the segregation of a cable cannot be changed once the cable has been routed. Since re-routing the cable takes a matter of seconds, changing its segregation and then re-routing so that the cable adheres to segregation rules is not a major overhead, but the consequences of routing a cable on an incompatible cableway could be.

These controls are an inherent part of CMPIC and are, to a great extent, customer defined. Within the project setup there are over 70 customer definable settings, most of which can be activated and de-activated during the process if need be. These settings include rules on defining maximum % fill, setting cable length allowance for installation, whether cables are allowed to be deleted once created, etc.

CMPIC manages both the routing and the termination statuses of cables. This status management is carried out automatically when an action is carried out. A cable inherits a new status with each action; routing the cable, approving its route, printing a pull card, recording a partial or full pull, completing termination design, terminating the cable at the device and so on. These statuses can be seen by anyone accessing CMPIC and management of them allows or prevents modifications to cables based on pre-set rules.

For example, once a cable has had a pull card printed, the cable effectively falls under the control of Production. The assumption is that once a cable’s route has been approved and released to Production, then the route is correct. However, changes do sometimes need to be made. Because it is an integrated system and because of the underlying rules, CMPIC will not allow a cable which has had a pull card printed to be re-routed unless the cable has been taken through the Change Control process. Using this process a Change Control request is raised, agreed to, and CMPIC now reduces the status of the cable so that design can re-route it or change other characteristics. As with other activities managed by CMPIC, a history is maintained of the change control process. After the cable re-route, a new pull card can be printed which will now be at a new revision.

3.5 Accurate sizing and capacity management of cable containment

Given that the space allocation for cableways is typically created very early in the design phase, with subsequent detailed design of containment being subject to modification (because of pipe re-routes for instance), an early view of the finalised tray, hanger and penetration layout tends to be difficult to extract. Once the design is complete, however, the cable routers are normally faced with a ‘fait accompli’ of a cableway layout with defined containment sizes, potentially pre-cut penetration sizes etc. If this process of containment sizing could be carried out earlier in the design phase, time could be saved and cost avoided.

If the design is fully complete before being released to electrical and C&I then optimisation of cable routing is the challenge. This is where the speed and accuracy with which engineers can look at the effects of various routing iterations is essential. Minimising cable length, whilst obeying all other rules and specifications, is not a trivial task, particularly when thousands of cables are involved and the cabling may still be subject to change.

CMPIC approach

Being a database solution gives CMPIC a great deal of flexibility. For example, despite the potentially large numbers of cables involved, CMPIC can make changes to factors which affect % and weight fill of the cableways quickly, and then undo these changes. This increases the user's ability to make informed decisions and to use the facilities of the system to look at 'what if' scenarios.

The % fill and weight fill calculations are done in real time; when a cable is routed, the user sees the % fill of the hanger or tray or penetration as it will be if the route is accepted.

Routing rules can be used to prevent the fill of the cableways going over a given %, after which that hanger or penetration or tray will be locked to further routing. The same rules can be used to look at 'what if' scenarios. The user can see, for instance, how long a cable would be if he ignored the % fill lock or ignored the maximum length of the cable. Of course if rules are being overruled to look at 'what ifs' then the user is unable to save the routes found. He can only save these routes if the rules themselves are amended or lifted. There are many optional controls which can be applied to find the optimum route and cable length.

Another rule which can be set manages segregation spacing. Where more than one segregation uses the same cableway, CMPIC can employ segregation spacing. The spacings are set using whatever electrical guidelines are employed, for example a control cable must be separated from a low voltage cable by say 25mm or 1.5 inches. Once this rule is set against the cableway or parts of it, then CMPIC will take the spacing into its % fill calculations. If a cable with a segregation which does not need to be separated is also routed, CMPIC will use that cable as part of the spacing, and in that way maximise the filling of the tray.

Another important aspect of calculating % fill is how cables are to be arranged or bundled. CMPIC allows for cables to be run singly, in pairs, trefoils or bundles (bunches). Using this designation, CMPIC calculates the % fill on the cableways based on how the cables will eventually be grouped for installation. Where these groups need to be separated from each other, CMPIC uses another rule. Where cables of the same segregation need to be spaced, then CMPIC automatically spaces them based on a pre-defined rule.

Depending on the maturity of the cableway design, another useful function is being able to look at what the effects would be of changing the size of containment. In the database the cableways are made up of tray, hanger and penetration types, with each type having a defined size. A 'what if' can be done quickly by using a drop down list, changing the tray, hanger or MCT size and looking at the effect on % fill. These changes can also be made in batch – for the entire network if need be.

These functions can also be applied to multi-tier hangers or trays in exactly the same way. If multi-tiers have been defined, then % fill will be shown by tier.

Where penetrations (MCTs) are concerned, CMPIC can treat these as either a defined size or as a usable area. Usable area can be employed if the penetration is an irregular size, or if the penetration is already partially occupied, which could be the case on a refit. Once the size is defined, the % fill of the penetration is calculated and updated as cables are routed. Where MCTs are used, CMPIC uses the size of the containing block (e.g. Roxtec or Brattberg), as defined in its library, rather than the diameter of the cable.

If a cable needs to be contained in a protective conduit, which then sits on a cableway, then it is the OD of the conduit which of course contributes to % fill and not that of the cable it contains. CMPIC also manages the scheduling of these conduits.

3.6 Ensuring the integrity of all cable routes

There are many factors that engineers have to take into account to ensure that cables are routed in a way which meets regulations but also optimises material and enables the cables to be installed in an efficient and cost-effective way. These regulations include: adherence to segregation rules, allocation of cables to appropriate tiers of trays or hangers, taking into account spacing between segregations where required, optimising cable lengths, recognition of maximum (or minimum) cable length allowed where applicable, adherence to % fill rules, use of protective conduit if required, arrangement of cables in trays etc.

CMPIC approach

There are many regulations which affect the overall integrity of the cable routes and the cableways that they use. By 'integrity' we take into account the following: adherence to segregation rules, allocation of cables to appropriate tiers, use of spacing between segregations where required, optimisation of cable lengths, application of maximum (or minimum) cable length allowed where needed, adherence to % fill rules, use of protective conduit if required, arrangement of cables in trays.

CMPIC manages this multiplicity of regulations and, once they have been set, applies them consistently so that as cables are scheduled, routed, approved, installed, terminated and checked, the user can be assured that, in the background, all his actions are being ratified against the regulations. If an action contravenes a regulation then either the user will be prohibited from carrying out the action or will receive a warning about its consequences.

In terms of routing cables, there are many rules which can be applied to optimise cable length whilst ensuring the route's integrity. Examples of these rules are: required or prohibited tray, hanger or penetration (i.e. must use or must not use this or these), required or prohibited zone (which can be a set of areas or compartments), the cable must run alone etc. These rules can be grouped together into different 'rule sets'.

Where an engineer wants to see the effect of routing cables using more than one set of rules and to then compare the routes found, CMPIC employs the concept of 'rule sets'. A cable could be routed automatically in CMPIC using two or more rule sets and CMPIC shows the cable lengths and the routes found based on each rule set.

3.7 Block construction

This challenge is one which faces the shipbuilding industry. To utilise available skills and manpower, and depending on the size of the vessel and existing infrastructure, ships are being designed in blocks, sometimes with blocks being constructed and outfitted at several yards before final assembly. From a cabling point of view this produces a number of hurdles to overcome including the partial routing of some cables (i.e. through block cables), the complete routing of cables contained within blocks, the production of documentation which reflects where cable coils have been left etc.

CMPIC approach

To meet the needs of shipbuilders who are designing vessels for construction at more than one yard, we offer functionality to route cables fully within a discrete block, or partially at one or both ends, if the cable is a through-block cable. The production documentation reflects this and shows where cables have been coiled for completion of cable routing when blocks are brought together.

In terms of production planning, planners can schedule installation work by using 'block' as one of the criteria for selecting cables to go on a work package (production order).

3.8 Management of sub-contract cable installation

It is of course a common approach to have a design authority which is separate from the production or installation authority. This is probably more prevalent in the cabling area than in any other. Although the business case for managing the project in this way will be justifiable, the difficulties of managing cabling as result are greater than they would have been had design and production been managed 'in house'. The problems which have to be overcome include; managing the effects of change across at least two separate entities (which may well not share the same IT infrastructure or toolset), feeding back status information from production to design in a timely and accurate manner, and ensuring that cable routing and other design data is provided to the installation authority effectively.

CMPIC approach

Although in many cases the design and the installation authority are the same company, on occasions this is not the case. If the same company is responsible for both design and installation then they are most likely able to use the same tools and the same IT infrastructure. In this case, any actions carried out by any user accessing CMPIC, whether they be from design or production, will see their actions managed by the system, and the results of the actions reflected immediately.

Where installation has been sub-contracted, either by the customer or by the overall project owner, then it may not be possible for that sub-contractor, for technical, commercial, or security reasons, to access the same tools and infrastructure as the design authority. To cater for this eventuality, CMPIC can be used to effectively create a clone of the CMPIC design database at the sub-contractor, under the sub-contractor's own control. This cloned CMPIC system will then be fed by database updates from the design authority as cables are approved for installation. The installer downloads this export file and uses it to update his own database. This export and download can be carried out as needed and is not an onerous task.

Once the list of routed and approved cables has been loaded into the installer's CMPIC system, the production planners can group cables together for installation and cables can be taken through the installation process, managed by CMPIC.

Any design changes made in the meantime are identified by CMPIC when loading the subsequent export and appropriate warnings, log files etc. are created if any of these design changes affect the integrity of work already carried out on those cables by the installer.

In this way, CMPIC is being effectively used as an integrated design through production system.

3.9 Minimising material wastage

Minimising wastage is a significant driver in a company deciding to manage its cabling more efficiently. The factors contributing to cable wastage include: inaccurate cable lengths, over-compensation on cable length by production to try to avoid re-laying of cables designed too short, re-cutting of the same cable, inability to re-use cables cut too short, changes of cable type during the installation process etc.

CMPIC approach

Minimising wastage is a significant driver in a company deciding to manage its cabling more efficiently. The factors contributing to cable wastage include: inaccurate cable lengths, over-compensation on cable length by production to try to avoid re-laying of cables designed too short, re-cutting of the same cable, inability to re-use cables cut too short, changes of cable type mid-way through installation etc.

Avoiding material wastage can be achieved primarily by optimising cable lengths using CMPIC's routing and routing rules functionality. As long as the cableway design and device locations are accurate, the end to end cable route can be calculated very precisely.

If production engineers have faith that the cable lengths defined by design are precise, then the temptation to add cable length 'to make sure' can be avoided thus preventing the need to cut away cable which ends up as waste.

There is also the issue of cable which was cut but not used (because for instance the cable type was changed, or a device was re-located resulting in a too-short cable) and returned lengths which were damaged part through and have been cut shorter. CMPIC can hold all such lengths as well as reels (drums). This is a way of ensuring that cable, which could potentially be used in future, is not classified as waste. CMPIC, as part of its material usage algorithm actually looks for pre-cut lengths that could be used before looking at reels. It then gives the cutting shop the option of using the cut length or using a reel.

3.10 Progress reporting

The problem of progress checking and reporting is, of course, exacerbated when several tools are used to monitor progress, inaccuracies in data because of this, the overhead of having to co-ordinate the data collection and the inherent time-lag in getting the data together.

CMPIC approach

CMPIC has a vast range of standard reports and screen queries. Both these, in the majority of cases, can be exported as .CSV files which can then be opened by spreadsheet and other applications.

Because it is an integrated solution, all changes made, data added, data modified etc. is held in the same database. As such, reporting looks across the entire database and selects the data based on report parameters such as; system, device, cable type, segregation, compartment or area, % fill statistics by hanger, hanger type, list of cableways where % fill is a given or range of values etc.

And because CMPIC is an integrated database system, the reports are looking at the data in real time.

3.11 Installation management

Whilst there are exceptions of course, the management of cable installation is predominantly handled on paper. Whilst pull cards, termination cards, testing sheets etc. play a massively important role in cable installation, there are problems inherent in a uniquely paper-based system. A major problem is that of immediacy; if a cable's route has been changed, then that fact should be communicated to production as soon as possible to avoid wasted time and material. Conversely, if a cable has been installed by production in a way which is not consistent with the designed route, then engineering needs to know. There may be other considerations which were not taken into account e.g. segregation spacing, anticipated fill in trays and penetrations, whether there are other cables with which the recently installed cable could have or should have been bundled. So engineering need to re-route that cable as it is now installed to see what other implications there may be. And of course any associated documentation needs to be updated accordingly.

CMPIC approach

Having both design and installation of cabling managed by the same system and within the same database offers enormous advantages. Specifically, the fact that data, wherever it was entered or modified, is visible to any other user and that this data reflects the real-time status means that decisions can be taken and implications seen much sooner than would be the case if data required coordination and consolidation from different sources.

From a production planning point of view, CMPIC provides planners with lists of cables pre-selected based on the criteria used for their production orders (work packages). In addition, they can look at the entire database to see the status of any cables which they might want to add to the production order, but which have not as yet been released to production. They can then chase progress based on this information. Once a production order has been created, the installation progress of the cables on it is tracked by CMPIC. This will show when the cables were cut, installed, terminated etc. and which team, shift or individual carried out the task.

Of course, any changes required to design as a result of cables being installed in a different way can be input and audited by using CMPIC's change control process ensuring that design and installation remain in sync.

As well as cable routing, CMPIC can also be used to design and manage cable terminations. The terminations functionality covers terminations design (i.e. allocating cable cores to terminals, or to plugs or sockets), approval of these terminations, subsequent termination at the devices and then checking. In the same way that rules determine how a cable is routed, so there are controls that prevent illogical actions from being logged in the database. An example would be trying to register a cable's terminations as being completed at the device when the termination details have not yet been entered. CMPIC would prevent this action being taken.

3.12 Configuration management

The problem of configuration management is largely a shipbuilding issue and is extremely prevalent, particularly in naval construction. Where 'classes' or 'series' of vessels are designed, it is efficient to save time and resource by consolidating the common elements of the design and concentrating on the differences. A class of vessels would expect to replicate the majority of systems, equipment, tray and penetration design, deck and compartment layout etc. However, there are vessel specific differences, for example relocation of devices, new devices, new systems etc. These vessel specific differences will have an effect on cable management, routing and installation. Typically the data management solution to this is to copy the entire dataset from one project to another. Although this approach can be moderately successful, the downsides include: multiple projects to store and manage, increase in the vessel specific work which needs to be done rather than cross-project (class) applicable work, duplication of documentation, difficulty of cross-project communication to avoid repetition of the same mistakes etc.

CMPIC approach

CMPIC addresses the Configuration Management issue by allowing cables on a 'class' or series of vessels to be managed centrally and simultaneously. Rather than having several copies of the same data, taken at a given point and then managed separately, CMPIC uses the concept of 'applicability' to represent whether a cable, tray, penetration, system, compartment etc. is valid on either the entire class, or only on specific hulls within the class. In this way cables can be routed on one or more vessels, selected by the user, or on the entire class.

The objective is to create a design database which holds both 'class' items and other items which are applicable to only nominated vessels within the class.

Once design and routing of the cables is complete, any production documentation created from the configuration managed database will reflect both class items and vessel specific items. Consequently each set of production data is by default vessel specific.