The use of computers in power supply design for a railway mega project

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Abstract

The design of the power supply network for a modern metro railway mega project is a complex undertaking. From the earliest conceptual designs through to the finished project a large number of issues must be addressed and a vast amount of data reviewed, collated and held for posterity. Computers offer the only means available of managing this information.

The paper describes the computer systems that are currently being used in a modern design office. These computer systems range from the humble spreadsheet through the complex network simulation packages to advanced system engineering tools.

The author draws on experience in the development of software engineering tools to give his views on how the design process can be managed with the use of computer systems. A common thread is drawn through the latest thoughts in system engineering and software engineering to give a vision of what the next generation of power system design tools will look like. The use of object oriented methods such as the object modelling technique as a underlying technology within these next generation design tools is proposed.

Introduction

A large number of computer tools are now available to the railway traction power supply designer. These range in their degree of dedication from spreadsheets and databases, through mathematical document processors, to power systems analysis tools, finally, to products such as the Multi-Train Simulator (MTS). I have resisted the temptation to say degree of sophistication when describing these tools. In a graphical user interface, threaded process environment, all these systems can be regarded as being as sophisticated as
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each other. All that changes as they become more dedicated to the railway design task is that their flexibility to achieve other tasks decreases.

The design process now is far more exacting than in the past, Allan et al [1]. The power supply systems being installed rely on more electronic and software based systems. Compatibility between these systems must be maintained. Resources for the projects are scarce in every aspect; finance, time, land, energy. A large number of projects are now renewals and not greenfield site build. Therefore the need to keep an existing railway operating also puts new restrictions on the designer.

Finance can be controlled more accurately by gathering finer details on the system to be built (and replaced). The spreadsheet and database offer this functionality.

Time is now quantifiable through the use of project management tools. Very large projects with a large number of interactions can be captured. Slippages can be spotted and the consequences simulated before the project alters too drastically. The project management tools can also manipulate important financial information. This allows the designer to investigate a number of construction scenarios quickly and accurately before building commences.

The use and availability of land is becoming increasingly significant, especially in urban centres. On a renewal project every effort must be made to maximise the use of existing land (while still operating the railway). CAD packages offer the ability to generate the huge number of drawings to accurately plan a phased changeover.

The energy savings offered by regeneration over the life of a project can justify its execution. Load flow packages and MTS-type tools offer the facilities to produce this information, Digby et al [2]. Only through studying a large number of simulation scenarios can the designer accurately forecast the level of the energy savings and usage.

In attempting to control all these different strands of the design process it is clear that the designer needs detailed knowledge of the objects, their attributes, and their properties that go to make up the railway system. The designer needs to monitor and control the interactions between the railway system objects as the railway is designed and built.

System Engineering

An emerging discipline within railway design and project management is that of system engineering, Allan & Williams [3], Williams & Allan [4] and Doherty [5]. The individual technologies within the railway project, such as optical fibre-based communication, power electronics, radio-based signalling, have approached their limits to improve the metro in their own right. Only the synchronous interaction of these technologies can bring a sizeable improvement for the investment given. For example, using radio-based
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signalling and optical fibre-based communication to pass messages to and from the train and the depot can improve rolling stock maintenance. System engineering can therefore provide an important function in ensuring the benefit of this interaction can be extracted. The system engineers are attempting to track projects through the use of tools such as RDD100.

This tracking is done by capturing the system specification in its various technologies. The resulting relational database follows the path of documentation that goes on to provide the specification. Although this ensures that issues are raised and subsequently dealt with, it does not directly ensure compatibility between the objects in the railway and show their achievement of the design aims through simulation.

Software Engineering

The software engineers have for a number of years been trying to gain control of technology that is growing in sophistication almost exponentially. Their desire is to give clients a working, maintainable system that is completely documented in as short a time as possible, Holt [6].

Development time can be shortened dramatically by the use of code that is already working, maintainable and well documented. As system complexity, and complexity of use grows, the management of their development process becomes increasingly more complex.

The software engineers have developed tools based on techniques such as the Object Modelling Technique (OMT), Rumbaugh et al [7], to model the interaction between the objects that go up to make their software systems. Tools such as Kappa, Intelicorp [8], have taken these object oriented techniques a stage further by allowing automatic code generation straight from the object oriented description of the system. Hence the process of capturing the system design within Kappa results in the finished product, Holt et al [9].

Extensions to these object oriented techniques through the use of the QUIRK model, Quirk & Gilbert [10] and Motus & Rodd [11], now allow the real-time interaction between objects to be assessed, Rodd [12] and [13].

The Next Step

It can be seen that railways are being improved by the use of interacting technologies. The most obvious underlying technology is that of software. In every aspect of the system, software is giving us the opportunity to get more out of the individual parts. For example, a flexible, distributed, workstation-based control centre can take information from the power system SCADA and the signalling system etc. and allow any operator to use a workstation at any location to control only their area of responsibility, Brunton et al [14]. Or, the radio-based signalling could interact with train regulation systems to restore train service to timetable. These improvements can only come about if the
railway can be represented in greater detail. The final total system improvement offered, provided the interactions are arranged correctly, can exceed the sum of the individual parts.

Therefore the management of the system by system engineering, may be enhanced by using techniques such as OMT and tools similar to Kappa, to control the design process, Hewings & Digby [15]. An object representation of the railway simplifies the boundaries while allowing every element to have the same representation, an object, whether it is hardware or software, Hewings & Digby [16]. The boundaries between hardware and its embedded software becomes seamless.

The benefits are enormous when using an object oriented representation. The technology specialists deal with the methods necessary to create the object. Their knowledge is encapsulated in the object. The attributes of the object are available to others to use or define. The system engineers’ role is to track these attributes and ensure that each one has either an input or output. It is through this mechanism the system engineers can ensure the design and hence the project is complete.

Another benefit also arises once the project is represented in the object domain. The movement of information between tools becomes easier. For example, Microsoft Excel can be used to implement an object model of a system. The Excel product exhibits the object oriented techniques of encapsulation, inheritance, identity and association, Hewings [17]. With MS Windows the object method could be described by mathematical document processor. The method can be encapsulated with only the attributes passed in and out through the use of the Microsoft Windows Dynamic Data Exchange (DDE) mechanism.

Using tools based on the software engineering tools allows the resulting object oriented documentation to form the system specification. The encapsulation allows the individual equipment specification to be self-contained and concise within the individual equipment object definition.

**Network Aware Tools**

By their very nature the more dedicated design tools get used less frequently during the design process. Given total project timescales, the purchase of a tool such as the MTS may be unreasonable for a single project. Therefore a company such as London Underground Limited will attempt to use an MTS tool in many projects. However as sophistication increases so does the development costs for such a tool. For a software tool developer there is the need to spread the development costs across an ever increasing number of customers. But if the customer base is fixed, tool costs will rise and customers will be less inclined to buy the tool or any subsequent versions. Especially if the tool is going to sit on the shelf for a large amount of time.
If the customer only has to pay for each execution of the tool, the costs could be cut. If the developer only has to maintain one copy of the tool and not have to distribute the revised versions, the costs could be cut. This concept is now feasible. A single, network aware, version of a tool could reside on a developer’s server. Every time designers wished to use the tool they could download the single-execution copy of the tool via a network (such as the Internet) to run it on their local machine. That way they get the latest version of the tool every time but only use it when they need it. Technology such as Java by Sun Microsystems [18] could be used to implement such a scheme.

In practice the size of the application may be too large to transport across a network. Therefore it may be more appropriate to use network aware “applets” to transport the designer’s data to the tool developer’s server where the simulation is actually run. The results are then transferred back to the designer via the network for display on a local workstation. This could be considered analogous to the batch processing used by mainframe computers.

As skills become scarcer another scenario presents itself. The system engineers sketch out a design for the railway using network aware tools. The individual objects and their specification are then passed on to (remotely sited) designers and manufacturers who then refine the objects using their knowledge. At any one time the system engineers can track and ensure compatibility of the whole project by accessing the latest version of the object via the network.

Conclusions

The paper has described the range of the computer tools that are currently available to a designer in a large railway project. The paper has shown that all aspects of a project can be monitored through the use of computers.

However these computer tools cannot be used in isolation if the full benefits of a modern railway project are to be realised. System engineering and its computer tools have to be brought to bear on the problem but the current generation of system engineering tools do have limitations.

A large number of products and systems that are being installed in the railway are of a hardware/software mix. In light of this the paper proposes that some of the latest software engineering techniques be modified in order to successfully system engineer these railway projects.

The use of these object oriented techniques would allow the maximum benefits to be achieved from the use of complex software based products in the railway project.

As the increasing globalisation of the railway design and construction industry takes place, the use of network aware computer tools is discussed. These could help reduce a project’s software tool costs while at the same time allowing the project to use the latest tools. They also offer the ability to actively system engineer a project that is being executed by partners in geographically separate locations.
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