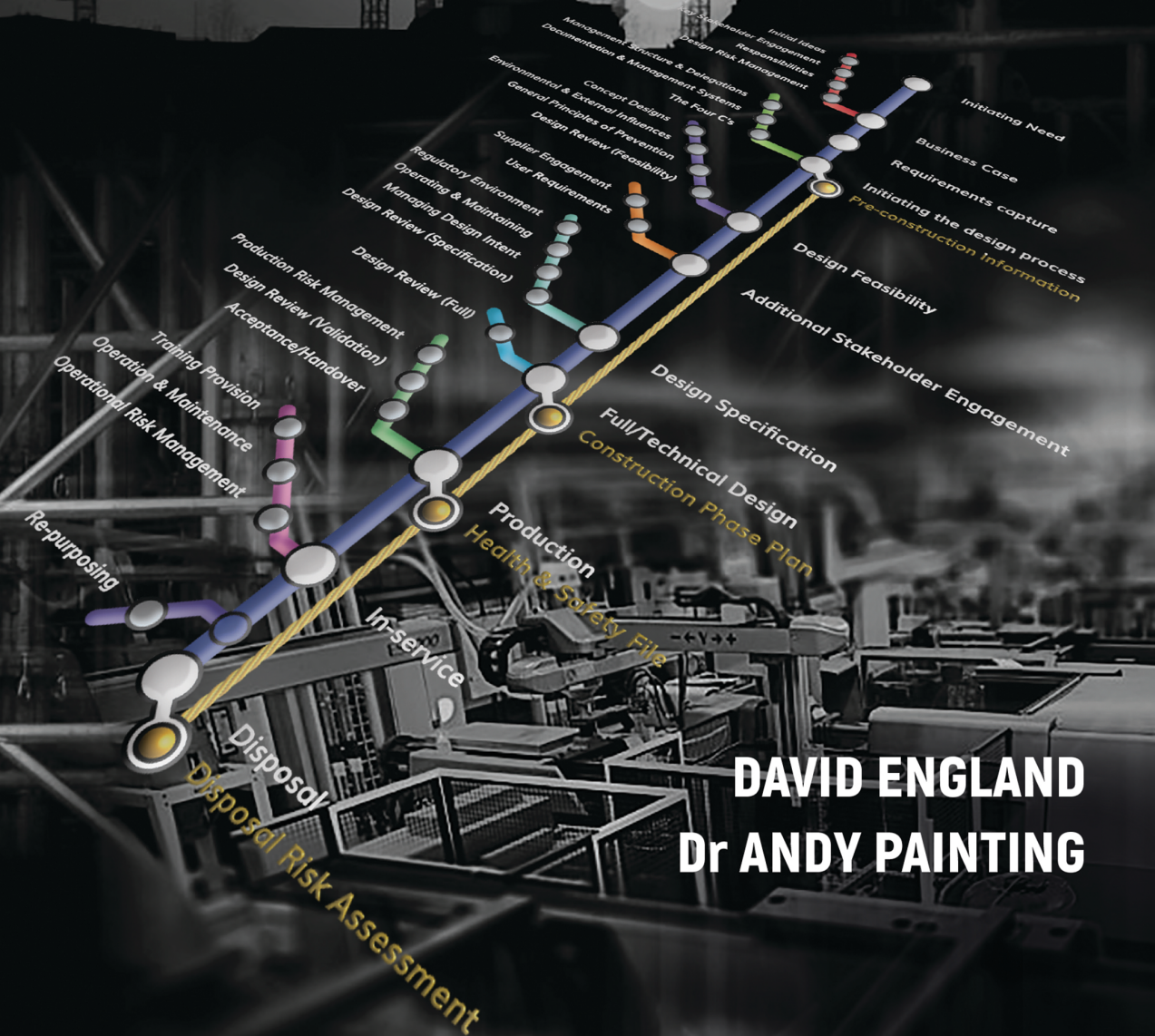
AN EFFECTIVE STRATEGY FOR SAFE DESIGN IN ENGINEERING AND CONSTRUCTION



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WILEY Blackwell

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Foreword

As a Chartered Surveyor and Fellow of the Chartered Institute of Building, with some fifty years of wide international construction industry experience, I have seen all too often the importance of "getting it right" during the design stage of any project. Ensuring that a project is delivered safely takes planning and cooperation and extends beyond just ensuring the safety of the workers at the construction stage. We saw the value of safety—and safe delivery—at the London 2012 Olympic Park, as well as my own experiences in delivering such notable designs as the concrete ski hill in Finland for the Winter Olympics; the triple water towers in Kuwait City; 55 Lombard Street and Thames House. In 2018 I was appointed to the executive board of the Institute of Construction Management (ICM) and in 2019 I started to construct a digital gateway for CDM professionals to access the exciting and vitally important new world of building information modelling (BIM).

Despite explicit construction regulations having been with us since 1994, we are still witness to waste and error and, of course, appalling tragedy. This book uniquely provides sound, in-depth but straightforward advice at what can only be regarded as one of the most critical stages in the recent timeline of the industry—marking a paradigm shift into new ways of working, thinking, and procuring construction in a fast-evolving, digitally connected world. The message for the reader of this book is just how vitally important it is to effectively manage the improvement of our built environment. The shared expertise contained in this book is so phenomenally timely.

The authors are perfectly positioned to lead in the writing of this book at this critical time in the industry—driving safety, quality, and eliminating error to create important safe projects. This book is important to all those who are interested in construction, engineering, and the built environment, and perfectly demonstrates the duty of care we owe to those who will build, operate, maintain, and perhaps live or work in the things we create.

Since 1994, a prime focus for the industry has been creating a culture of integration, of better safety and workplace health. In those early days I was one of the very first tranche of fewer than two hundred construction professionals to envisage where the future of the safety culture needed to be positioned within the sector. Unfortunately, my early clear vision soon became disillusioned and so, for the last twenty-seven years, I have led teams championing change to construction design and management culture, proudly being recognized in 2008 by the Health and Safety Executive with one of only

three awards in the UK as "Health & Safety Champion of The Year." This commitment to safety is something I continue today as head of the ICM Competence Working Group, something that is supported by the ideals and approach contained in the wealth of content in this book. The pragmatic sequencing of safety described in this book I believe profoundly helps to solve how to view the whole landscape and detail of any project, whilst at the same time ensuring the effective management of risk.

I am personally proud and delighted to introduce the unique content in this rather special reference book—enjoy the good read; then read again and reflect.

David F Jones
FCIOB FASI MRICS MIConstM

Introduction

Aims of the Book

Design is the cornerstone of creating and producing any structure, product, or item either for bespoke use or mass reproduction. Anything that is created, constructed, or manufactured relies on design whether for aesthetic, functional, or critical purposes. Of paramount importance is the designer's understanding of the intended use and the application of the product and their subsequent ability to translate this into a finished design. Some examples of products that require specialist design knowledge are:

- Architecture—such as habitable or commercial property or structures.
- Electronics—such as printed circuit boards or electrically controlled devices.
- Marine—such as ships, oil rigs, jetties, and quays.
- Mechanical—such as mechanized plant, engines, and wearable or implantable medical devices.
- Chemical—such as nuclear, biological, and explosible materials, or structures that contain them.
- Emergent technologies—where designers may be dealing with novel production techniques or exotic materials.

Of equal importance to the designer is an understanding of the operating environment in which the product is to be used and how this environment is controlled by such considerations as regulations, standards, or social norms. These considerations may have a direct influence (such as the regulations surrounding health and safety) or indirect influence (such as ethical or moral concerns) on the design process.

Additionally, the actual individuals who will use the product should be considered, as well as any others who may come into contact with it. What is important in any design process is that the criteria of the design requirement are developed within this sphere of considerations and that the product is capable of being subsequently produced accurately to that requirement. This is known as the input-process-output cycle.

This book aims to explain this cycle in detail in order to provide the reader with a broader understanding of the responsibilities of the designer not only to their profession and industry but also of the wider implications of their output by explaining the many considerations that any design should take into account. These considerations are

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not always apparent and it is the product of not only successful designs, but also successful *design management*, that ensures that they are appropriately considered in the design process.

Equally, we aim to demonstrate the important connection between *good* design and *safe* design and how this can be achieved as well as show how the various design professions, with their own standards and practices, are often a reflection of each other, and how design can be improved through the application and management of effective safety.

There are many associations, organizations, and standards, active in a wide range of design disciplines, that aim to improve the design process for either the designer or the client. This book intends to demonstrate that the essential tools for improving safety in design for both designer *and* client are already well established and readily available but, possibly, not well understood. By utilizing these tools any design project can be improved in terms of safety, quality, cost benefit, and project outcome.

Who the Book is For

This book is intended for use by all stakeholders who are involved in the design process, either directly or indirectly, as well as students of any discipline where design is a component part of their syllabus. It is also intended for those who have a responsibility for specifying during the design process and, of course, for those who have an interest in understanding more about the process and the best practice that can be achieved in this demanding and rewarding profession. This book is therefore aimed at:

- designers;
- clients;
- design managers and supervisors;
- those with oversight for design—such as project managers, surveyors, and insurers;
- principal designers (duty holders under the Construction (Design and Management) Regulations 2015);
- specifiers—such as Building Control representatives;
- procurers—such as marketing, sales, or financial departments;
- manufacturers, constructors, and developers;
- students of engineering, architecture, software development, and so forth;
- suppliers.

How the Book is Structured

Different disciplines—or professions—where design is practised tend to generate their own language for the inputs, processes, and outputs that they perform and it is not the intention of this book to attempt to harmonize these differences. Instead, a glossary is provided in this chapter in order that the reader can disseminate the information contained herein and translate it, as required, into the language or phraseology with which they are familiar in their own profession.

Each of the first five chapters deals with a separate component or consideration of the design process. The last chapter prescribes an effective strategy for managing the logical sequence, from the initiating need prior to design commencing, through to the proposed or anticipated disposal of the product. Whilst it is clear that not all design disciplines require all elements of this book's design management process, it is the hope that the reader should become familiar with the *generality* of its intention. The chapters in the book are concerned with:

- the design process—the life cycle of the design process, its influences, and the expectations we have of it;
- regulations—how they affect design and how they can be used for effective process control;
- design management—the tools and techniques used to manage the design process;
- risk—identifying, managing, and controlling all aspects of risk in design;
- design strategy—applying the techniques of safe and successful design.

The final chapter on effective design strategy uses, as a guiding framework, the Construction (Design and Management) Regulations 2015. This is the third incarnation of the United Kingdom's statute interpretation of the European Union temporary and mobile construction site directive 92/57/EEC. The reason for this may not seem immediately obvious to the reader, but we shall demonstrate how the extensive reach of this legislation over the variety of disciplines and objectives to which they apply, combined with the spirit of the regulations with respect to good design management, make them an excellent benchmark.

Although these regulations deal predominately with what may be considered to be the "traditional" construction industry (that is to say, buildings and structures), the spirit of the legislation is to improve the safe function of design in any given project. Regulation is just one of several influences on design and, therefore, to utilize that regulation to the benefit of the design process—rather than consider it burdensome to it—can only provide positive results: by improving management of the design process; ensuring legal compliance; and providing a considered, proper, and safe design output (see Figure I.1).

Construction regulations as a separate piece of legislation were originally introduced in 1994 in response to the high level of injuries and fatalities in the industry historically and they remain one of the many pieces of legislation concerned with workplace health and safety. The third version of the regulations in 2015 encompassed a number of changes which we believe are of fundamental importance not only to the functional requirements of health and safety, but also to the wider moral and financial implications of good design. Moreover, the commercial release of designed products into the UK marketplace is governed by various safety regulations and it is an ambition of this book to encourage the reader to plan their particular project with this knowledge in mind.

Whilst not every design process will require every element described in this book, the reader is encouraged to identify which elements are salient to their particular project or discipline. The establishment of a well-defined and structured environment in which to conduct any design project is a feature of regulations, standards, and practices, which

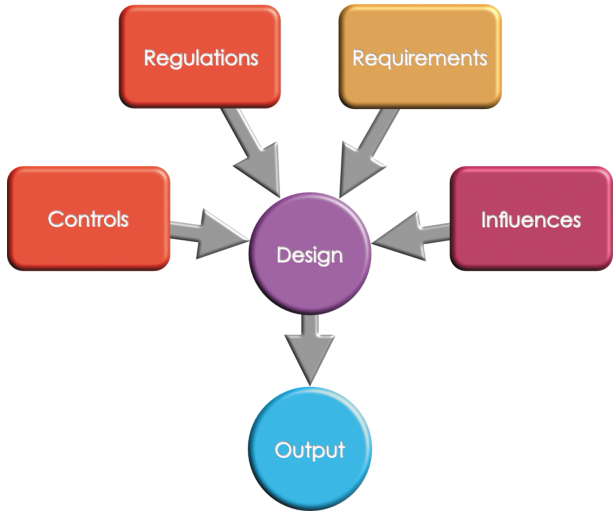

Figure I.1 Design Inputs.

we shall examine in more detail throughout this book. The advantages of creating such an environment, whatever the size or complexity of the project, include:

- better translation of the client's originating requirements for the finished product;
- clear parameters within which the designer can operate;
- control over scope creep or design variance, whether or not intentionally;
- the capture and control of risks which promotes—
  - the reduction of errors;
  - the control of costs.

Promoting Safe Design

The central tenet for this book is to reinforce the concept of safety as a critical part of the design process. Not just from the perspective of preventing harm to people, but also in ensuring the safety of the project: that is, preventing errors and miscommunication that can cause delays, increase costs, and reduce the quality of the finished product.

There are many factors which can influence any design and these will be explored in detail throughout the book. These factors can have greatly varying effects on a particular design of course, depending on what it is for, how and where it is intended to be used, and how it is to be produced and, if necessary, distributed. There are, though, three factors that affect the scope of all design projects and which are key not only to the designer's appreciation of the fundamentals of the design requirements, but are also an imperative part of the client's decision-making process.

Time, cost, and quality—often thought of as a triangle—affect the scope of any project through being inextricably linked: affecting one will always have an effect on either of the other two or, will affect, either positively or negatively, the quality of the output (see

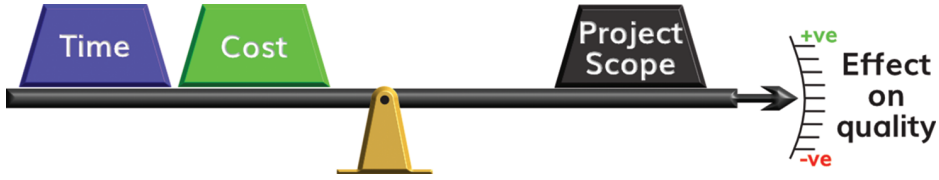

Figure I.2 Time, Cost, and Quality Balance.

Figure I.2). In this sense, they can be thought of as a see-saw, where the effect of increasing or decreasing any one element can be imagined. What can also be imagined is the necessary response in order to return to equilibrium. Demanding a better-quality product will either affect the cost of it or the time it takes to produce, for example. Demanding a less expensive product may make it quicker to produce but will invariably reduce the quality. Understanding their interrelation and, most importantly, understanding how the client views this interrelation with regard to their requirements, will help to ensure that the design remains as relevant to the client's needs as possible.

The concept of a safe, effective design strategy overall can help to promote the following factors:

- The reduction of harm occurring to users or operators of the product.
- Ease of maintenance methodologies through the thoughtful provision and layout of systems and access points.
- The reduction of losses occurring during the product's life cycle.
- The prevention of errors in the design, which necessitate redesigns and reworking.
- The inclusion of external factors in the product's requirements resulting in a more mature design output.
- The inclusion of expectations from the product's use, and environment of use, which will provide a better experience for the end user.
- A design solution that "learns" from previous examples and builds upon them to advance technologies, techniques, materials, and experiences.
- Better experiences for future users from having a well-considered and well-documented disposal process.

Example Case Studies

Throughout the book, we shall be using five hypothetical case studies in order to highlight the differences between the various concepts and processes discussed. These five have been chosen to demonstrate that, whilst there may be disparity between perhaps the levels or intensities required of each process in comparison, they are all intrinsically linked by the core process of design management. Often this is for different reasons and equally for differing outcomes. The impression that should be gained, however, is that proper design management—and the need to work towards the safest possible outcome—is relevant to *all* projects.

A precis of each study is given below in order to provide background to the reason for choosing them.

Nuclear Power Plant

A nuclear power plant is arguably the zenith of critical design input in terms of operation, maintenance, and disposal. Despite worldwide public concerns, they continue to contribute a large part of non-fossil-fuelled electricity generation in several countries. Everything to do with this type of infrastructure is on a huge scale: preliminary works, design, construction, maintenance, and, of course, disposal, which—in terms of the waste they create—can be counted in thousands of years.

Office Block

Worldwide, the office block has long been a rather dowdy and functionary building. In the late 20th century, however, novel architectural solutions were being developed as a result of new materials being available and the desire of clients to incorporate other spaces into the design; such as accommodation, retail, and leisure. In the aftermath of the global pandemic of 2020, the value of offices as a workspace began to be questioned and once again architects are developing novel ways of enhancing and repurposing these buildings.

Warship

Naval fleets were once populated with many types of specialized vessels: frigates, destroyers, battleships, support ships, and so forth. In recent years the tendency has been towards fewer, large command vessels combined with smaller, lighter vessels which can fulfil a multirole function. Although the operators of warships are highly trained, they often have to work under extreme conditions. Reliability is an absolute requirement. And, as has long been the case, warships often get sold on to other navies after their initial period in service, so the ability to remove sensitive equipment and materials is important.

Home Printer

Printers for domestic use are generally designed on a strict cost/quality basis and with an eye to having relatively short-lived periods in service due to the market forces and upgrades to consumables. Internally they are often composed of proprietary components but externally they must fit the client's aesthetics and brand image. Made in large numbers, design errors can cause large-scale, even potentially worldwide, recall issues.

Motor Car

Ostensibly, the car has changed very little from that developed by Karl Benz in 1885, which was, in turn, a progression of self-powered vehicles that had been developed for over a hundred years before it. Critically built to a price point, the design must take account of aesthetics, aerodynamics, brand image, safety, security, a raft of legislation in each national marketplace, as well as the knowledge that the vehicle will be operated by persons of widely varying levels of skill. Composed of many third-party components,