THE LEAD DESIGNER'S HANDBOOK

MANAGING DESIGN AND THE DESIGN TEAM IN THE DIGITAL AGE

Dale Sinclair

RIBA

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RIBA Publishing

Published by RIBA Publishing, 66 Portland Place, London, W1B 1NT

ISBN 978-1-85946-709-1 / 978-1-85946-742-8 (PDF)

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Commissioning Editor: Elizabeth Webster
Production: Jane Rogers
Designed and typeset by Full Point Creative Media Ltd
Printed and bound by Page Bros, Norwich
Cover Image: Shutterstock.com
Image Credits: All © Dale Sinclair or RIBA except; p94 © Nex Architects; p95 © David Millar Architects; p96 © Coffey Architects; p97 © ScottWhitby Studio; p252 © AECOM

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PREFACE

Leading the Team: An Architect's Guide to Design Management (2011) was written to bring clarity to the process of designing a building. It seemed to me that the majority of an architect's intellectual effort was spent getting the design right with less emphasis placed on the design process and delivering designs on time and cost, yet clients were wrestling with how to resolve these crucial topics.

Today, the status quo remains. The diversity of projects unveiled at the various RIBA award ceremonies underlines the architectural profession's ability to deliver great designs. However, while designers show enthusiasm for digital tools that will deliver new types of geometries or ways of ideating, they continue to be ambivalent about innovating the design process and delivering projects more efficiently and effectively. Indeed, many seem resistant to change that should be business as usual from a client perspective. This publication argues that the breadth and depth of digital disruption will be significant, creating the opportunity to provide transformative design processes that will deliver these great designs in profoundly different ways.

In the meantime, clients and project managers have melded procurement to achieve better outcomes, including delivering projects on time and to cost, as part of new delivery ecosystems. Within these, contractors have successfully tackled BIM (Building Information Modelling) and asset-focused deliverables, becoming more adept at managing the design team during the later design stages, de-risking design and ensuring that the right information is available at the right time for construction.
By stepping away from shaping how project processes wrap round the design process, the architectural profession no longer leads the project team, allowing the reverse to occur: on many projects the essence of design has been forgotten, with design shoehorned into project management and procurement processes.

To address these points, this publication is written specifically to consider the role of the lead designer. If architects want to demonstrate that they can design *and* deliver, they need to champion and revitalise this crucial project role. In recent years the importance of the role has been diluted, for which there are a number of reasons.
In part, it is due to new BIM roles emerging – such as the BIM manager or information manager – that create confusion regarding the project team structure. It is also due to the increased professionalism of client bodies and the greater involvement of project managers and the drive to reshape procurement.

The architect and lead designer roles are predominately commissioned and considered together. Different practices undertake these roles in different ways and there has always been tension between those experienced in delivering projects – who have the first-hand knowledge of how buildings are delivered and constructed, and who would tend to undertake the lead designer role – and the cohort of architects pushing the boundaries of design with new forms, materials, environmental approaches or the ideas that will lead to new paradigms. Interestingly, clients are more aware of this design and delivery balance than the architectural profession, and are – rightly or wrongly – able to pigeonhole a practice's ability to do one or the other or both. What this does underline is the urgent need for the profession to have a more detailed conversation on the boundaries between these two crucial topics and the need for delivery innovation to catch up with design innovation.

Amid these challenges, a new wave of construction technologies is upon us, varying from straightforward and practical designing for manufacturing initiatives to the complexities of new technologies that will allow the mass customisation of buildings. To avoid locking traditional construction techniques into our designs, the lead designer needs to facilitate early conversations around new ways of making buildings and the profession needs to be more proactive in framing these.

While there is a comprehensive body of research into design methodology, the reverse is true for delivery processes that support the lead designer, and due to this lack of research many of the views in this publication are my own, based on 30 years of undertaking the lead designer role. A core threat to the lead designer is the way that BIM is being shaped. Rather than radically transforming the design process, BIM tools are being absorbed into traditional design processes focused around the comfort of traditional deliverables, albeit with new data deliverables plugged in. If we are to move to faster, smarter and better design processes, we must consign traditional ways of designing to the bin, using digital tools to reshape the design process and how it engages with project processes and procurement. As part of this, it is crucial that the profession begins a conversation around the balance of good design and great delivery. If the architectural profession continues to propagate and advocate design processes geared to one-off buildings and fails to address the varied quality of information delivered for tendering and construction, it will find that others will do so.

The two most frustrating aspects of my career have been the challenges of passing on knowledge to the next generation – our intuitive ways of working impeding this goal – and the persistence of design trumping delivery. This book is not about how to design or how to tackle the complexities of the planning process. It is about giving those undertaking the lead designer role the means of delivering designs on time and to cost while maintaining a tradition of great designs. Importantly, the book redefines the lead designer role for the digital age, moving beyond 2D into the world of 3D: intelligent data-centric design processes with greater real-time integration of analysis tools that face new game-changing ways of making buildings.

I hope that everyone finds useful content in the publication as we enter a new era of designing and making buildings.

Acknowledgements

This book would not have been possible without the practical project experiences gained over the last 30 years and I would like to thank my clients and design team collaborators for their contributions to my experience over the years.

As we transition towards a new digital environment I am fortunate to encounter many individuals with diverse new ideas and exciting new technologies that inspire me to help define the workflow for a new and exciting digital future. I thank them for their insights and innovation including the many Directors at AECOM looking to transform our way of working.

My thanks also go to Elizabeth Webster from RIBA Publishing who has patiently steered the publication and facilitated the discussions required to ensure that themes covered are appropriate and relevant and to Jane Rogers who orchestrated the production for RIBA Publishing.

Finally, and most importantly, I would like to thank my wife Stacy for her patience, support and for constantly acting as a sounding board and my daughter Eilidh for patiently waiting for assistance with her Lego.

About the author

Dale Sinclair is a Director of Technical Practice for AECOM. His role focuses on delivering projects using innovative project process that leverage new digital tools and he is a member of AECOM's global digital transformation team. He is passionate about developing new design processes that can harness digital technologies, manage the iterative design process and improve design outcomes. He believes that redefining the lead designer role, to align it with digital, is essential if the role is to remain relevant to future ways of working where process and workflows become integral and instrumental to the successful delivery of product.

He is currently a board Director of CIC and chairs the CIC BIM Forum, is the RIBA Ambassador for Collaboration, a member of the RIBA Practice and Profession committee and chairs the RIBA Plan of Work task group along with other industry working groups. He was the editor of the BIM Overlay to the Outline Plan of Work 2007, edited the RIBA Plan of Work 2013 and was author of its supporting tools and guidance publications: Guide to Using the RIBA Plan of Work 2013 and Assembling the Collaborative Project Team. He regularly lectures on BIM, design management, the RIBA Plan of Work 2013 and on the future of the construction industry.

Introduction

The way buildings are designed is at a turning point and the context in which the design team works is rapidly changing. Current processes are no longer sustainable. Clients are seeking better and faster design methodologies that leverage digital tools and technologies – if the design team does not drive change, they will.

In recent years, the three procurement mantras of time, cost and quality have been the main focus of procurement effort as clients have wrestled with how to deliver projects on time and to budget. However, recent events at Grenfell Tower and Edinburgh schools have put the spotlight on the third, less frequently discussed, mantra: quality. There is an opportunity for the architectural profession to provide leadership of the research that will provide the evidence that demonstrates the value of good design.

This publication is split into three parts. The first part sets out the context of the lead designer role, including how it fits into the design team and the broader project team. The second part sets out the techniques necessary, looking at how design management techniques might adapt to the digital age, considering the new tools that might tumble from innovative new ways of delivering projects better and smarter using digital tools. The third part looks to the future, emphasising the need for those undertaking the lead designer role to respond to an era of perpetual change and the advent of many new technologies.

The lead designer role is crucial on any project – they direct the work of the design team, coordinating design efforts and liaising with the project team, including the client, stakeholders and the contractor, to determine project constraints and to refine the client's brief as it develops. The role involves facilitating regular reviews of the design and managing a diverse range of tasks as the design progresses, dealing with regulatory and procurement challenges. Because coordination is not just about 'clashes', and many coordination aspects are about balancing aesthetic and functional requirements, the architect has traditionally performed the lead designer role.

Part A of the book considers the need to redefine the context of the lead designer role. To do so, Chapter 1 starts by looking at what design is, why the design team's role differs from other project team roles and underlines the challenges faced by, and skills required by, the lead designer. This chapter also looks at the core interfaces in the design team.

Chapter 2 examines the project team structure, considering the roles required in each team and the issues that the lead designer needs to consider in relation to these teams. The chapter concludes by looking at the different ways of contractually binding the project team together and the tweaks required to the design process by different Procurement Strategys. Chapter 3 considers the need for a number of project stages to bring clarity to the overall project process, looking at how the different Plans of Work are used throughout the world to manage the project process.

With many clients placing emphasis on project management techniques, the complexities of the Construction Programme or new deliverables that enable better facilities management (FM), it can easily be forgotten that the design process has its own unique challenges. Part B of the book begins with Chapter 4, looking at the unique challenges faced by the lead designer, including iteration and intuition, collaboration and coordination, and interfaces and interdependencies, topics at the heart of design. Chapter 5 follows, with a detailed examination of the tools and technologies that might be used to provide the 'best in class' design management needed to transform the delivery of projects. This chapter looks at some of the digitally orientated tools that might transform the design process, including the importance of workflow and new ways of decision-making.

The value of a design is diminished if it is not delivered on time or in line with the client's budget, and Chapters 6 and 7 respectfully consider these important topics with the former noting that too much design too early can be counterproductive, underlining the importance of the lead designer's role here. Chapter 8 looks at the changing nature of deliverables and the current light touch approach around who delivers what at each stage, and how CAD continued the 'scale' paradigm despite information being produced 'full size.' The opposite is true with digital – automating aspects of the delivery process can only be achieved by consistent classification and a granular definition of who does what when. This notion is complicated by the varied descriptive to prescriptive journey of selecting the products to be used in a building. Chapter 8 looks at these challenging topics.

The way buildings are constructed has not substantially changed in the last hundred years. However, change is afoot. Many clients are looking at initiatives that will increase the uptake of Design for Manufacture and Assembly (DfMA). Chapter 9 looks at these initiatives as well as some of the more radical manufacturing possibilities that digital brings. Importantly, the chapter considers how these new ways of making buildings will change the way they are designed. Design reviews are crucial to the design process and Chapter 10 looks at the shift away from 2D workflow towards new tools that will transform the design review experience for the client.

Chapter 11 considers the topics that have changed the design process and the role of the lead designer in recent years. The book concludes by considering the range and diversity of topics that will transform the design process in the years to come, encouraging those undertaking the lead designer role to focus on those that will transform the design process: a difficult challenge with so many nascent technologies in development. CAD disrupted how design information for buildings was produced; however, the new steady state that resulted did not transform the design process nor did it change the processes wrapping around it, such as the nature of 2D deliverables or QA (quality assurance) processes. The shift to digital is different. It provides new possibilities, such as improved outcomes for clients by changing the way the project team interface or transforming how the client engages with the design process.

Crucially, we are entering an era of perpetual change where wave after wave of new digital technologies will transform the world around us, adding to the complexity of determining the digital technologies that will alter the design process and when these will be available. In this context, the lead designer role needs to be reset to reinvigorate and retain its relevance in the design team and to embrace and face the digital future that lies ahead. This publication provides the ideas and impetus necessary to do so.

Part A

Who is the lead designer?

CHAPTER 1
DESIGN AND THE LEAD DESIGNER

Introduction

Everything around us needs to be designed and every industry has its own unique way of designing. Some designs can be carried out by an individual or a small team, while others need a large design team with diverse skills ranging from those required to develop the look and feel of a design through to specialised and complex engineering contributions. The diversity of tasks for many designs requires a design process that steers the design from its initial creative spark through to the information required to make it. In a world increasingly driven by project management processes, this chapter starts with a brief overview of design, designers, the design team and the need for a design process, considering the essence of design and what makes it unique.

The chapter continues by looking at the unique challenges of designing a building. The design process required is fundamentally no different to that used for other designs: it must start with a client brief, move on to creating an idea, coordinating the work of the design team and concluding with the optimum information for construction. One of the biggest differences between designing a building and other designs is the complexity of the design team and how it relates to the other players in the project team. This chapter dwells on the strategic relationships between the client, design and construction teams.

It progresses by considering the lead designer role in detail, looking at the purpose of the role and what the lead designer does. It considers how this role relates to other design roles and the challenges of balancing great design with best in class delivery, examining who is best placed to undertake the role and steer the design team through the design stages. It examines the importance of the role, as well as the skills and experience required to undertake it.

The chapter concludes by considering the topic of design management and why it differs from project management, looking at the trends that are reshaping the lead designer role and the need for more stringent management of the design, and concluding by reflecting on where other industries might provide the clues to the future design management.

Design

What is design?

In the modern world, everything around us is designed. This includes furniture, signage, train stations, clothes, housing, cars, and of course, the graphic design and advertising used to sell these. Good design is instrumental to the success of many global brands, defining and shaping their companies and/or the products they sell.

A design is something that is conceived from someone's mind until it is made, manufactured or built. Starting from scratch is core to design and conceiving the initial idea can be the hardest part.

Emphasis is often placed on the creative side of design, primarily due to the amount of energy and expenditure used to market, advertise and sell the latest clothes, cars and phones. As Figure 1.1 illustrates, designers need to consider aesthetics and functionality differently, depending on what is being designed, although designers at both ends of the spectrum will have the same passion about creating great designs and may have similar design methodologies.

It can be difficult creating a design when aesthetics are a high priority and there is a need to generate an original or unique design. Equally, it can be difficult creating a design when functionality must be assured. For example, when designing a car, aesthetics and functionality must be considered equally. Lack of consideration for the latter will suppress sales and the former requires a plethora of national and international standards with which to be complied. Aesthetics and functionality will always be slanted in one direction or the other, dictated by the design being created. This does not infer that one is more important than the other but it underlines how different contexts and drivers shape the nature of the design process and where emphasis must lie.

Figure 1.1: Aesthetics to functionality

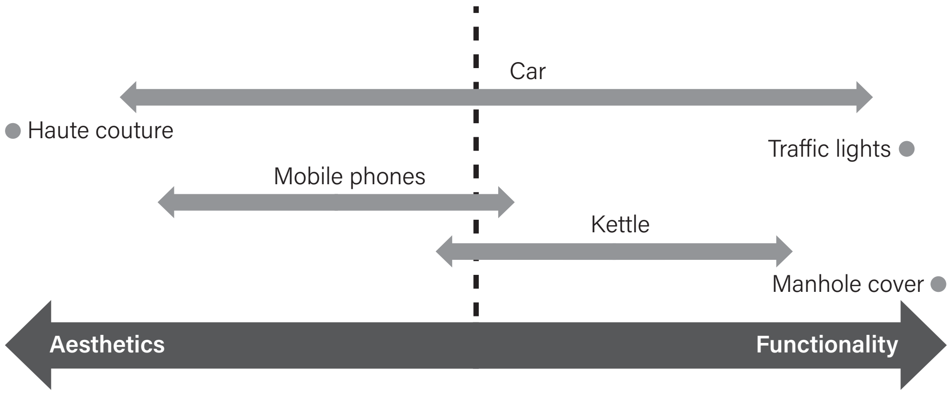
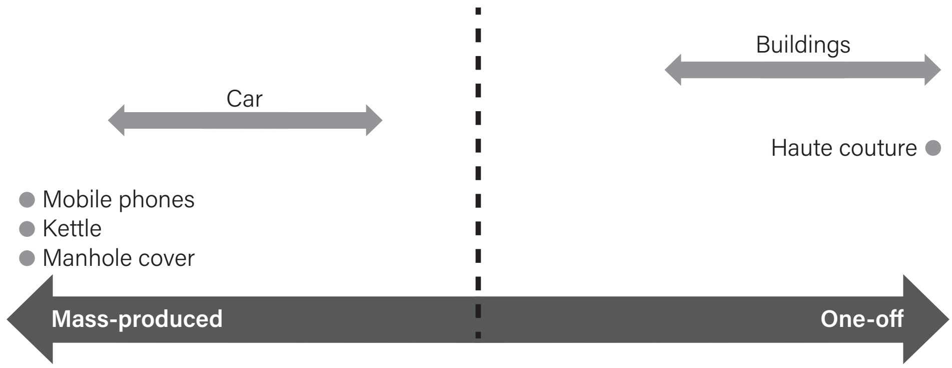


Figure 1.2 illustrates that some designs are created to be manufactured thousands of times without adjustment to the original design. Kettles or mobile phones might come into this category, yet other designs are created as one-offs, never to be repeated. The majority of buildings come into this category. Increasingly, design sits between these extremes: a design that can be configured. This process is commonly referred to as mass customisation, with new manufacturing processes such as additive manufacturing creating many new possibilities and possible business models.

Figure 1.2: Mass-produced or one-off?



What is a designer?

Designing and making used to be connected: a craftsman would both design and make. The Industrial Revolution changed this: designing and making were disintermediated. The designer was born. A designer has the goal of conceiving and developing a design until it can be made. This concept applies regardless of whether the design is for a car, a bridge, a phone, a ship or a building.

Designers come in different forms, including those who have become experienced by learning the necessary skills and knowledge 'on the job' and others who have gained a professional degree in a particular subject and are members of a professional institute. While many perceive a designer to be slanted towards aesthetics, this is not the case. The reality is that a designer is anyone who produces content that is used in or drives and influences the development of a design. Some designs need designers with the flair to produce a unique design, which may derive from gut instinct rather more than training; others require complex engineering contributions and calculations – for example, using aerodynamics to design the shape of a car.

Professionals and professionalism

The majority of designers are professionals (see above) who hold a qualification from a university backed up by membership of the corresponding professional institute. These qualifications demonstrate that the individual has the necessary knowledge to undertake a specific part of the design process. Many professional institutes also require annual CPD (continuing professional development) to be undertaken to make sure professionals are up to date with pertinent topics, such as best practice in health and safety. Of course, competence in a topic also needs to be backed up by practical experience, which is why clients will ask for the CVs of individuals as well as evidence of their qualifications.

Professionalism is different. Professionalism is about demonstrating the right behaviours in a project environment and the values set by the professional institute around topics such as ethics. In many instances the ethical bar of a professional may be above that of their client. For example, a professional may be an advocate for pioneering sustainability measures but the client may wish a scheme to comply only with statutory regulations. The challenge for professionals in these situations is persuading the client that their approach is best, while recognising and respecting the client's views. In some instances a professional may wish to walk away from a situation that they believe is unethical.

What is the design team?

While many designs can be created by individuals, the majority of designs need more than one individual, practice or skill to be created. The design team is the collective of individuals and their varied skills and experience that come together. Teams can vary from a dozen to hundreds, depending on what is being designed.

For many designs – for example, most product designs – the design team will be in-house with responsibility for the development of the product until it reaches the market. These internal teams morph as the design progresses, recognising that the skills required in the initial creative stages vary from those necessary to face the realities of manufacturing and production. This approach may necessitate the hiring of many staff; however, it avoids the need to contract-out aspects of the design or manufacturing, enabling intellectual property (IP) issues to be carefully managed.

In other scenarios, including the construction industry, the design team is assembled for a single project and might comprise many different companies contractually bound together to create the completed design prior to construction. These design teams are disbanded when a project is completed, allowing the client to efficiently flex the size of their collective project teams and to spread the risk of many projects. The downside of this approach is that knowledge of the team is dispersed at the end of a project, minimising the opportunities for facilitating innovation.

What is a lead designer?

The term 'lead designer' can be interpreted in different ways. For some designs the lead designer might be the individual with the ultimate creative control, but in others it is the individual corralling the right inputs into the development of the design and the coordination of design effort.

The film industry overcame this conundrum by creating the producer and director roles. The producer is responsible for delivering the film on time and on budget, while the director is responsible for the creative direction of the film. However, and importantly, the producer will determine the final cut, hence the recent trend for the 'director's cut.' The crucial point is that every industry and different brands place different emphasis on design quality, functionality, cost and delivery, requiring leadership roles to be considered differently. This is a core challenge of design.

Why is a design process required?

The interface between designing and making varies, depending on the design. Some designs can be created quickly, while others can take years to develop. Iteration is core to any design process and in many instances gateways are an essential part of the design process, as they allow the client or internal stakeholders to be confident that the ideas created look the part and sufficiently consider any functional requirements before greater resource is expended, layering-in more detail to the design at the next stage.

The nature of design demands a robust design process. Developing ideas from scratch can be challenging and the skills and experience required to conceive the initial ideas vary from those required to patiently put the finishing touches to a design. Increased complexity and larger design teams add to the number of iterations required. Aesthetics and functionality must be balanced to suit the design. For example, a car's shape may need tweaking following feedback from the wind tunnel test or a pair of trainers may need a thicker sole following wearing tests. Managing iteration and balancing aesthetics and functionality are core to the design process.

A design process is required to bring consistency and clarity, making sure that the right tasks are carried out at the right time. Fundamentally, the design process for any design is the same, with some subtle nuances. The design is conceived and tested against a set of constraints:

- the brief and constraints are defined
- the cost of the design is tested against the available budget
- the product or project goes through a number of design iterations
- the design goes through a number of sign-off gateways at each stage of development
- manufacturing or buildability are considered
- regulations and legislation checks are made
- digital or physical prototypes are made
- the design is ready for manufacturing and/or construction.

A design process achieves two objectives:

1. It brings clarity to how the design will be implemented.
2. It allows the lead designer to shape the design team to suit the needs of the design at a particular point in time.

Core to any design process is managing constraints and regularly reviewing the design. Constraints might be within the control of the designers or they may be influenced and dictated from outside the design team. Design reviews are essential (see Chapter 10) to design development, and setting design reviews in a Design Programme is a core requirement of any design process.

Managing the design process

Time has increasingly become a driver for the development of a design. If something can be delivered faster, it can generate income more quickly, reducing development or funding costs. Conversely, the number of constraints that need to be considered has increased. Client and customer expectations are high. To manage time and constraints, the role of the project manager was born. Simply, developing any design requires project managers who can manage external and internal constraints and make sure that the design team is working in line with the programme set.

Project managers are not designers and do not have the skills or experience to influence the design direction. They will, however, be familiar with the requirements of a design process and have the skills required to make sure that a design is delivered on time. They are also likely to be well versed in the detail of a particular sector, complementing the skills of the lead designer.

Managing design also requires design management techniques, which differ from project management approaches. This is considered later in this chapter (see p 26).

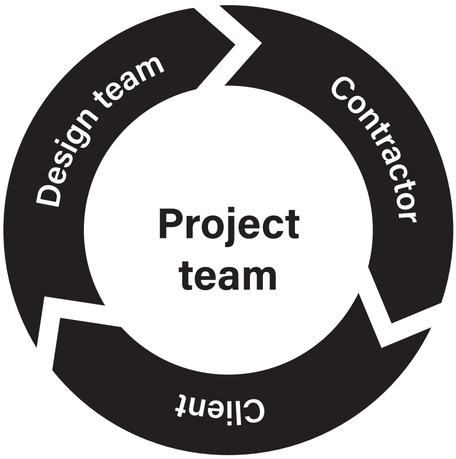
Design and designers: summary

This introductory section is not comprehensive nor is it intended to point to one solution or another. Its purpose is to highlight that designing needs a design team with a wide-ranging set of skills, strong leadership, the constraints to be applied, the complexities of brand, the balance of aesthetics and functionality, and the need to deliver on time and to budget. Project management processes help to deliver designs on time, but they have to wrap around the design process and the need for iteration.

Designing a building

This publication builds on the thinking set out in *Assembling a Collaborative Project Team* that was written in support of the RIBA Plan of Work 2013. This book suggested that the composition of the project team comprises three discrete teams: the client, the design team and the contractor, as set out in Figure 1.3 below. From the lead designer's perspective, with the project team typically consisting of many companies and entities employed in different ways, it is essential for it to be clear who is in the design team and who is not.

Figure 1.3: The project team – RIBA Plan of Work



In this publication, Figure 1.3 has been strategically adjusted to reflect the changing client and contractor roles, which are now defined as the client team and construction team respectively. This acknowledges the increased complexity of the client's team and recognises the changing role of the contractor. It also reinforces the team responsible for the design: the design team.

How did the design team evolve?

The word 'architect' is derived from the Greek term for master builder and the original architects were craftsmen, such as stonemasons or carpenters. In the West, in around the fifteenth century the process of designing and making buildings diverged and architects focused on the design of buildings, leaving the craftsman to construct them. Moving ahead, before the twentieth century, buildings had few building services or complex structural elements. Items such as timber beams were designed using rules of thumb and elements were detailed around the limitations of the materials available.

As buildings became larger and more complex, further skills were required to design them. For example, the invention of the steel frame required detailed calculations. A number of building collapses necessitated these individuals to demonstrate competence, and the structural engineer was born. New ways of heating and cooling buildings were invented and larger, more complex buildings required specialists to consider how power, water and drainage, and other services, were integrated into a building, resulting in the emergence of the building service engineer role in its different guises.

The backbone of a building's design team continues to comprise these three core professional entities:

1. the architect
2. the structural engineer, and
3. the building services engineer.

Companies, professional institutes and the regulatory environment have grown around these three core disciplines. Although some firms have adopted a multidisciplinary approach, it is still commonplace for clients to independently appoint these three entities to form the design team. The final member of the design team is the cost consultant, whose role is to provide the client with a Cost Plan for the design as it progresses. The cost consultant does not create design content and as such is not a designer; however, their input is instrumental and invaluable to the design process.

The changing project team?

Change has not been limited to the slow metamorphosis of the design team. In recent years the majority of changes have been to the broader project team structure, although the design team has continued to evolve. For example, a greater number of specialist consultants, such as acousticians and fire engineers, have emerged, creating further complexities for those forming a design team.

This change has been driven by clients who regularly develop and build buildings. They have upped their game, employing in-house advisers to transform their processes. However, the rise of the internal or external project manager has led, inevitably, to some buildings being designed by increasingly project management-orientated processes that stifle the design process. Some have focused on the creation of procurement processes as a means to an end, yet it is and should be framed as part of the design journey. Similarly, the rise of Design and Build procurement, and the parallel increase in the design workload of the specialist subcontractors, has changed the dynamic between the design team and the contractor. Contractors have also been instrumental in driving many BIM initiatives and acting as the custodian of information for handing over to the client at completion. In tandem, the role of the architect as the contract administrator has declined.

These diverse evolutions of the design and project teams are infrequently discussed, yet the transition from master builder to the complexities of today's design team needs consideration beyond the narrow focus of procurement. The project team needs to be rebalanced, emphasising the need for a good design process that serves the needs of all stakeholders while delivering projects faster and better. For the purposes of this publication, the redefined project team comprises the following.

The client team

The client team sets the brief, including project constraints, monitors that the work of the design team is provided on time and assists with external stakeholder liaison

The client team is led by a project manager and sets the brief, incorporating the vision, project constraints, desired outcomes and any functional requirements, the budget, confirms the site for the project and is the focus for signing-off the design as it progresses towards construction.

The design team

The design team designs the building from its initial sketch up to the point that information can be issued for manufacturing and/or construction

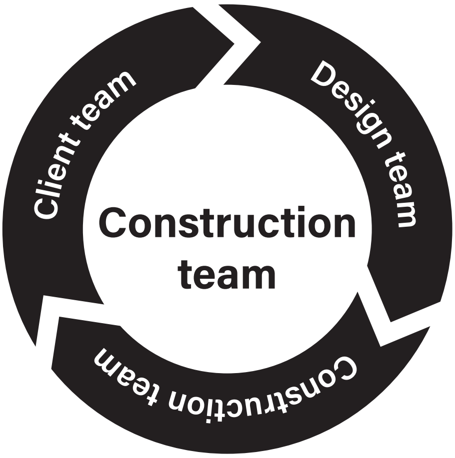
The design team is led by the lead designer who directs and coordinates the design effort, including architects and engineers, cost consultants and specialist consultants, ensuring that the emerging designs will meet the client's vision, brief and budget, and that the aesthetics and functionality requirements are developed appropriately.

The construction team

The construction team constructs the building, liaising with the specialist subcontractors designing and manufacturing discrete elements of the design

The construction team is responsible for procuring the materials, products and manufactured elements of the project and constructing these, contracting with a number of subcontractors who each undertake discrete aspects of the work required.

Figure 1.4: The construction team – RIBA Plan of Work



This structure achieves a number of objectives. It:

- recognises the increased complexity of the client team and the need for the client to secure internal or external support to help set the brief, including project constraints and the need to review and monitor the work of the design and construction teams
- acknowledges the need to recognise the boundaries of the design team who develop the design in line with the brief, including the client's aspirations for aesthetics and functionality, and the site
- underlines that the construction is typically undertaken by a separate team with diverse supply chains to manage and the need to consider a range of different topics
- allows clear leadership for each entity in the project team to be established – the project manager leading the client team, the lead designer leading the design team and the construction leader leading the construction team.

This construct applies and adapts regardless of whether the project is large or small, new or refurbished. It works globally and in every sector where a building is required. These three teams remain robust and are the backbone of any project. For example, on the smallest of projects the client team might tumble down to one individual, the design team may be an architect practising as a sole practitioner and the construction team may be a one-man-band builder who employs labour as required. Conversely, the largest projects will need many individuals and practices in each of the three teams.

Construction team v contractor

The word 'contractor' is closely aligned to the importance of the Building Contract on a project and that the contractor is being contracted to construct a building. With the shift towards collaboration, some have tried to move thinking around this term beyond contracts, for example, by using the title 'constructor.' This publication predominately uses construction team for similar reasons. However, in some scenarios it is not practical to do so – for example, when writing in relation to subcontractors and for practical reasons both contractor and construction team may be used. Looking to the future, the term 'assembly team' might be more appropriate.

One challenge with this structure is ensuring that there are no overlaps or ambiguities in the work set for each team. At present, a number of these scenarios exist and the means of eliminating or mitigating these are considered throughout this publication. For example:

- the lead designer integrating the work of specialist subcontractors in the construction team into the design
- the cost consultant advising the client team on the Project Budget as well as preparing the Cost Plan for the design team
- the design team obtaining buildability advice, for incorporating into the Construction Strategy at stage 2, before the client appoints the construction team.

The next chapter examines in further detail the three teams set out above, including the issues that the lead designer needs to be aware of in relation to these team interfaces.

The lead designer

The design team comprises a diverse set of individuals with different professional skills and experience. The timing and need for these skills varies from project to project, depending on many factors, including the sector, the complexity of the project, the site, the client brief, the challenges set by the architect's ideas and initial concepts, the timescales available and the budget set.

The lead designer role was created in response to these diverse challenges, recognising that someone needs to lead and direct the design team, navigating them through the challenges of the increasingly complex design process and ensuring that the design is delivered on time and in line with the client's vision and on budget.

To achieve these goals the lead designer's role goes beyond directing and leading. The most challenging tasks are coordinating the work of the design team and, crucially, making sure that the design is coordinated, which is the more difficult and demanding task (see p 90). The former is about the right tasks being carried out at the right time and managing the project constraints that impact on the design process. The latter is more complex, requiring constant reviews of the design team's efforts and taking the measures to ensure that everything is aligned. This seems a simple proposition; however, during the design of a project many contradictions and ambiguities are revealed and the skills required to determine the best way forward are not always clear. This can result in decision-making being deferred, resulting in a ripple effort on the design when a hot topic (see p 118) is eventually concluded.

The skills required to coordinate the design team differ from those required to produce a coordinated design. To coordinate the design team, the knowledge and experience of a particular building type is essential and the many design management-orientated tools and technologies set out in Part B of this book are pivotal to the role. Crucially, this aspect of the lead designer role needs the knowledge of a designer and involvement in the design process.

Coordinating the outputs of the design team places greater emphasis on the soft skills covered below and, importantly, involves intervening and contributing to the direction of the design. In many instances there is no right or wrong solution or a straightforward 'you do this, you do that' way forward. Driving coordination decisions to conclusion needs good technical knowledge and exemplar collaboration, communication, persuasion and negotiation skills, as well as the need to understand the challenges of decision-making and the need to listen to the views of the different players contributing to the decision-making around a particular topic. Crucially, with each designer producing their own outputs, the lead designer does not produce information at the end of the design process; however, their stamp on the development of interfaces and on the coordination process should leave an indelible mark on the look and feel of a building. This aspect can certainly be construed as designing.

While the lead designer used to focus on the work of the design team, the increasing professionalism of client teams has raised expectations, extending the time spent on the client/design team relationship. In addition, procurement interfaces vary from project to project, affecting the work of the design and construction teams in different ways. The increasing proportion of design work undertaken by specialist subcontractors employed by the contractor adds to the design challenge.

The strategic changes to the project team place even greater emphasis on the lead designer role. However, the increased demands of the role do not stop there. Other forces make the role more complex, including the growing role of sustainability, substantial efforts to transform how buildings are made, shifting the effort beyond construction, and the increased importance of making buildings more effective in-use.

What does the lead designer do?

The complexities of the lead designer role can be distilled into the following strategic tasks:

- Direct the design team, progressing the design in response to client or stakeholder comments and in line with strategic design contributions from the design team early in the design process.
- Lead the design team, setting the design process for the project, including workflows and the preparation of the Design Programme for each project stage.
- Liaise and communicate as required with members of the client, design and construction teams and external stakeholders.
- Coordinate the work of the design team, including the development of Project Strategies, the design of interfaces and designing in line with the client's Project Budget.
- Act as a foil between the architect and the client and other design team members, keeping in check ideas that may be expensive, technically challenging or make the design difficult to deliver (see opposite).

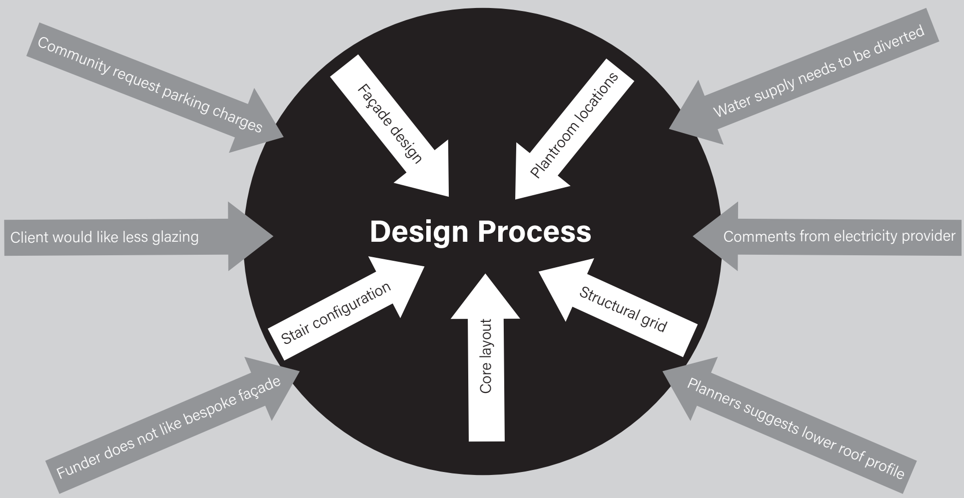
The lead designer role is crucial on a project during the design stages because:

- Design is an iterative process predominately undertaken intuitively (see p 84) and requires the skills of a practitioner familiar with the building type being designed.
- Design needs different techniques and tools to nudge it along: the lead designer connects the design to the design process.
- An interface between the design team and the client and construction teams is essential in order to communicate the design as it progresses, facilitate client design reviews and report on the progress of the design.
- Coordination is central to de-risking design and providing a robust set of construction information.
- The lead designer has a good understanding of the tasks and deliverables of the design team at a given point in time.
- Coordinating and collaborating requires an understanding of the different roles and tasks of different design team members (see p 90).
- Managing interfaces and interdependencies (see p 110) needs a good understanding of design and, in particular, the many systems in a building, as well as good construction knowledge.

External constraints

External constraints are topics outside the influence of the design team. For example, planners might set a maximum height for a building or the client might state that the building is to be made of stone. Both are external constraints to the design team that they cannot necessarily dictate. Conversely, positioning the louvres in the elevations to suit the aesthetic requirements of the architect and the air intake and extract requirements of the mechanical engineer are within their control.

Figure 1.5: Internal and external constraints to the design process



Architect and lead designer: design and delivery

While the shifts in the project team place additional burdens on the lead designer, requiring greater knowledge to coordinate the design team and complicating the coordination of the design team's work, the greatest strain is arguably on the interface between the architect and the lead designer. Increased client expectation places greater emphasis on the delivery of design, changing the design versus delivery dynamic.

Because a single practice typically undertakes both the architect and lead designer role, the interface between the two roles is internalised and practices may not be aware that the perception of their firm is increasingly driven by the balance of these crucial topics. Different clients have different design versus delivery goals, which may differ depending on the building type. For example, the design approach for a museum is likely to be different to that for a hospital, yet many practices approach design and delivery the same for every project. Early design decisions can have a significant impact on outcomes, such as cost and buildability, as the design progresses and more detail is layered in. Poor early design decisions can result in rework and further iterations of the design in the later stages, and can dilute the original design idea. This places greater onus on the lead designer to make sure that the design and delivery considerations are properly balanced early on.

There have been limited discussions around the boundaries of the architect and lead designer. Strategically, the architect produces the conceptual ideas, looking at how the building's spaces will be arranged and generating ideas for the building's form and the materials to be used. The architect will lead any meetings where the design is presented. The lead designer's role is to make sure that the design team contributes to the development of the design at the right time. Importantly, the lead designer needs to act as a protagonist, questioning the architect's decisions that might impact on the delivery of the project and calling out when the requirements of the other designers are not being absorbed into the design. For example, a façade type may be unaffordable or the riser requirements may not be shown on the plans. If the architect 'wins' too many arguments, the design may not be sufficiently coordinated as it progresses. Conversely, a strong lead designer might stifle the design direction. Ultimately, a balance must be achieved.

The architect (as design lead)	The lead designer
► Conceive and develop the ideas for the project. ► Develop the Concept Design through discussions with the client. ► Present the design to planners and other design-orientated stakeholders. ► Comment on the work of the design team.	► Comment on the ideas conceived by the architect. ► Liaise with the design team to ensure the right contributions to the Concept Design. ► Attend meetings with planners and other stakeholders: consider coordination issues. ► Coordinate the efforts of the design team.

What are the challenges for the lead designer at each project stage?

Part B of this publication looks at the specifics of coordinating the design and the design team. However, it is worth dwelling in this section on the strategic and significant differences between the design challenges at the commencement of a project and those encountered when delivering information for manufacturing or for construction.

The early design stage challenges are the most difficult ones for the lead designer. The architect may be generating a multitude of design options that need strategic engineering input and a means of being objectively assessed. These will be presented to the client when the emotion of a particular design approach may overrule practical considerations. The lead designer's touch may be lighter during this stage; however, the failure to take cognisance of key constraints or an important engineering consideration can result in the design going backwards at the next stage. It is essential for the lead designer to have a strong voice in the design conversations. During this stage good communication is crucial. Multiple stakeholders may be involved and many issues need to be managed. The fluidity of the design can make this challenging, and experience is essential.

Design

There are numerous articles published on the different approaches possible to create better designs, including evidence-based design processes that underline the need for designers to consider research and development. Many of these focus on how to improve the quality of the completed design, while others concentrate on how design can be harnessed to achieve better client outcomes. Chapter 4 focuses on the core aspects of design that impact on the work of the lead designer.

Once the Concept Design has been signed-off by the client, the focus moves away from stakeholders. This is when the design team moves into top gear, with detailed engineering analysis validating the strategic rules of thumb information incorporated into the Concept Design. With this stage focused internally into the project team, the communication challenge reduces and the skill of the lead designer is in managing the different inputs of the design team. Greater technical knowledge is required during this stage to move coordination issues forward and to make sure that the design team is doing the right things at the right time, including the inclusion of any designing to cost measures.

Once a coordinated design has been delivered, the heavy lifting of the lead designer's role has been completed. Each designer – including any specialist subcontractors working for the contractor – should be able to work independently, producing their own information for tendering and/or construction purposes. The lead designer's role is in making sure that any final coordination tweaks, particularly at interfaces, are flagged and addressed. This stage needs an understanding of the nitty-gritty aspects of a building's design.

Who is best placed to undertake the lead designer role?

Proactively resolving coordination issues needs suggestions, ideas, innovation or practical measures to be teased out of the design team. Therefore, the lead designer is generally an experienced practitioner who has the first-hand experience and technical knowledge required. They also need exemplar leadership, communication and negotiation skills in order to convey the reasoning behind their decisions and why a particular approach is the best way forward or why a specific task must be done at a certain time.

Many coordination issues require a balancing of aesthetic and functional considerations, which is why the architect has traditionally performed the lead designer role, although on many projects where the engineering challenges are significant, an engineer may undertake this role.

The lead designer is typically an individual, but when the role is considered holistically the lead designer may need assistance to:

- prepare certain Project Strategies relevant to the design process
- prepare and coordinate Design Programmes, monthly progress reports or any items necessary to report on the status of the design
- review information prepared by the design team and identify coordination issues for discussion and resolution.

Knowledge and experience is essential. The skills of the lead designer are difficult to teach, mainly because the relevant knowledge is obtained by gaining a practical understanding of how a building comes together over a number of projects. With architects increasingly removed from site roles, gaining this tacit knowledge that underpins the lead designer role is one of the challenges in developing the lead designers of the future. Many of the topics that the lead designer comes across are not covered on architectural courses and, even if they were, they are difficult to understand without the project context, realities and pressures. Those undertaking the role of the lead designer need knowledge and experience of:

- The building type being carried out. What are the core functional aspects of the design that will need to be considered?
- The briefing issues and constraints that might be expected and typically encountered, including consideration of what might be missing from the brief.
- The coordination issues likely to arise.
- How designers work. Where are they likely to put their design effort? Will they balance aesthetics and functionality appropriately?
- How engineers work: what do they do and when do they need information to undertake analysis?
- The digital approach and how it should be developed from a design team perspective.
- The topics that specialist subconsultants need to address.
- How procurement interfaces and refines the design process.
- How different specialist subcontractors engage with the design process.
- Construction and buildability for all aspects of a building.

Crucially and conversely, the lead designer does not:

- prepare design information: any ideas or sections produced by the lead designer to help unlock and resolve coordination issues need to be embraced by the relevant designer and incorporated into their design information (the lead designer would review these to confirm that agreed decisions had been complied with)
- present the design work of any design team member
- edit or alter any design work, including Project Strategies produced by other designers or specialist consultants.

Having good soft skills is a crucial requirement for those who wish to direct and manage the design process and undertake the lead designer role. The skills required include great communication and negotiation skills. These topics are considered in Chapter 5.

Conductor v lead designer

In an orchestral environment, the conductor does not play an instrument but is crucial to the performance, controlling the tempo of the music and the emphasis of particular groups of instruments. The conductor is an experienced musician and the role could not be undertaken without this experience. Similarly, those undertaking the lead designer role do not personally produce design information but they determine who designs what when, and they have sufficient experience to know how to direct and coordinate the work of different designers and engineers.

What is design management?

To respond to the three procurement mantras of time, cost and quality, the design team needs to overlay and wrap management techniques around the design process. Due to the unique challenges that design presents, some project management techniques will not be effective. Design management tools and techniques are specific to design and help assist the lead designer to manage the design process. Design management tools include the Design Programme, design status trackers, Project Strategies, design checklists and workflow diagrams. These tools and the others set out in this publication are essential for those undertaking the lead designer role; however, some can also be captured by others responsible for tracking or monitoring the design – for example, a design manager working for the contractor.

In truth, the design team may be diligently managing the design without conveying each step or decision to the broader project team. However, intuitive decision-making does not do justice to the complexity of the design process and, by setting out the basis of decisions that have been made, the design process becomes more transparent, any assumptions can be ratified and risks eliminated. More importantly, the client team will understand the amount of work that has been undertaken by the design team to match the design to the brief and site. Formalising the management of the design process is still in its embryonic stages and is, for whatever reasons, anathema to many in the design team. What is becoming clear is that informal, intuitive approaches can no longer manage the many design issues that need to be dealt with during a project nor be used to effectively record design decisions. Simply, the lead designer must articulate the status of the design as it progresses and how they are directing the work of the design team, managing design risks and closing out any assumptions made during the early stages of the design.

Lead designer v design manager

The core difference between a design manager and the lead designer is that a design manager is not necessarily actively engaged in the design process. Simply, the lead designer is coordinating the design in collaboration with other design team members. This requires design decisions to be made. The design manager is predominately hands-off, reviewing design as it progresses and helping to set or comment on the tools used by the design team, such as the Design Programme. An experienced design manager can assist an inexperienced design team by pointing out items that it may not have considered. They might work for a construction team, helping to identify risks or items that have not been addressed by the design team. Alternatively, they might be employed by a client who is undertaking many projects to provide a fresh pair of eyes and a more focused view on how the various design teams are performing, or might be employed by an architectural practice requiring assistance undertaking the lead designer role by preparing Design Programmes or reviewing the progress of the other design team members.

What can the lead designer learn from other industries?

For years observers have pined, 'Why is the construction industry not more like the car industry?' Although the riposte to this statement is that buildings are bigger than cars, are anchored on specific and differing sites and have varied client briefs, it is clear that there can be lessons to be learned from other industries. This chapter has flagged that the design process between different sectors is not radically different as designers progress from their initial ideas to the completed project. A central theme of this publication is that after decades of relative consistency the design process will be transformed beyond recognition as new digital tools unlock fresh possibilities for the design team. In this context, the lead designer can learn much from elsewhere and re-contextualise it to the design process for buildings. Examples might include:

- looking at how product designers use PLM (Product Lifecycle Management) tools to better manage whole-life considerations
- considering how car manufacturers use configurators to enable clients to customise their own car and in turn how this impacts on production line processes
- how various industries use sub-assemblies to more effectively bridge the gap between components and finished products
- how the airline industry leverages global design and supply chains to create and make their products and how they enable client choice.

This chapter:

- Noted that design is the process from conceiving to making any object.
- Confirmed that the design process requires the designers to balance aesthetics, functionality and cost.
- Ratified that the design team required for the design of a building requires different skills and experience to other designs and must be led by an experienced practitioner: the lead designer.
- Stated that various topics make the design process for a building more complex and challenging, requiring the development of design management techniques and tools to suit.
- Observed that different design industries do things differently. There are lessons to be learned by looking at how others design.

CHAPTER 2

ASSEMBLING THE PROJECT TEAM

Introduction

Chapter 1 looked at design, the benefits of a design process and the need for designers to be formed into a design team led by a lead designer. This chapter considers the client, design and construction teams in greater detail, and the issues to which the lead designer should be alert.

The client team might comprise an individual or, on the largest of projects, a number of practices and individuals. The client team is not responsible for undertaking any design work but must compose the Project Brief and review the design during and at the end of each stage. In many instances the client team will employ professional advisers or will have in-house teams to guide it through each project stage. The design team has not fundamentally changed over the years, comprising the architect, structural and building services engineers and the cost consultant. The construction team is responsible for manufacturing and constructing a building, including the logistics and contractual relationships connected with this.

The relationship between the client team and design team has become more complex in recent years as clients wrestle with different ways of improving the Procurement Strategy that will deliver greater cost and time certainty. The interface between the design team and construction team has also become more complex, due to aspects of the building increasingly being designed by specialist subcontractors. Recent moves to harness modern methods of construction (see Chapter 9) complicate this crucial project relationship further. These complexities increase the burden of work for the lead designer, requiring greater management of issues outside the boundaries of the design team.

Although the members of the project team have remained broadly unaltered over the years, the way in which they are contractually connected varies. The final section of this chapter looks at these strategic changes and the different ways of contractually binding the project team together and how the Contractual Tree is shaped by the Procurement Strategy, examining the adjustments that different Procurement Strategys require to the design process.

A core challenge for the lead designer is that they may not be involved in determining how the project team is set up nor be party to the selection of the design team. The final section of this chapter drills into more detail on the ways the design team is appointed and the challenges that these different approaches bring to the lead designer. Ultimately, there is no right or wrong approach. Each client must assess the pros and cons of each. When the lead designer has the opportunity to select the design team and work with it on a number of projects, refining the design process as they go, it can lead to transformative ways of working, particularly in the digital world.

The chapter concludes by briefly considering some of the trends that might shape and define the project team of the future.

Professionals, practices and consultants

Each role in the project team is typically undertaken by a different professional. It is common for professionals of a single discipline to come together to form practices using legal entities such as a limited company (Ltd) or an LLP. In some instances practices are multi-disciplinary, employing different types of professionals. For some project roles the expected professional qualifications are clear (such as an architect, cost consultant or mechanical engineer). Others are not, such as the health and safety adviser. The term 'consultant' is used commonly to define a professional contributing to the design process. This publication uses client, design or construction team member for the core members of each team in lieu of consultant to reinforce the team each role is within and the term 'specialist consultant' for consultants providing specific focused advice to a team. This term should not be confused with the specialist subcontractor in the construction team (see p 53).

The client team

What does the client team do?

The client is the commissioning entity for a project. Without a client there is no project. When considering who might be in the client team it is essential for the client to consider that, regardless of their experience, project size or sector, the core tasks the team must undertake include:

- considering whether a building is the best means of achieving the project outcomes
- setting the Project Brief, including functional requirements, the budget and outcomes required
- agreeing on the most appropriate procurement strategy and when the construction team will join the project team
- agreeing the design team members, including the architect and engineers best placed to deliver their vision
- establishing the Project Programme
- reviewing and commenting on key aspects of the design as it progresses, including the sign-off of finishes and fittings to be used in the project
- being core to the decision-making processes of the design and construction teams
- signing-off progress at the end of each stage
- making payments to the design team, construction team and any client team members as the project progresses in line with the relevant contracts
- managing stakeholder relationships and risks.

When considering who is best placed to be in the client team, the client must recognise that they are central to the decision-making process at every stage. They must decide whether to follow the recommendations of their design or construction teams or whether to follow a different direction. Some clients like to be central to the decision-making process, including the nitty-gritty decisions, while others are happy to delegate decision-making to their professional advisers.

On larger projects the client team might include in-house professionals as well as a range of external practices, including project managers. An RIBA client adviser might assist the client in the early project stages to give them impartial advice and to help frame the brief and select the design team. There is no standard way of working or of determining the roles required in the client team. Each client needs to determine the roles required to assist them through each project stage.

Who leads the client team?

The client team is normally led by a representative from the client body or the client themselves on small projects. On some projects a representative from a project management organisation will act on the client's behalf as the client lead – possibly seconded to the client's organisation to improve communication. On smaller projects, the architect might help the client write the brief, acting also as the contract administrator when construction commences. The implications of acting in both the client and design team are considered below.

The lead designer needs to be mindful that the individual leading the client team on a day-to-day basis may vary from the person or entity responsible for decision-making, signing-off stage reports or agreeing the content of planning applications.

Who is in the client team?

In order to have the requisite skills to cover the high-level tasks set out above, the client team needs to comprise a number of roles including:

The project manager

The project manager guides the client decision-making processes – for example, considering and concluding:

- the optimum timescale for the Project Programme
- what other advisers are required in the client team
- the Project Brief, including spatial and functional requirements and constraints
- what the Procurement Strategy should be
- the means of assembling the design and construction teams, including whether the design team should be employed as a 'one-stop shop' entity
- the project risks and how they will be managed
- what outcomes should be strived for
- the Sustainability Aspirations.

The project manager might be in-house in the client's company or the client may appoint a project management company. On smaller projects the designer securing the project may also be acting as the project manager (see below). They do not need to be a designer or a constructor but they do need the experience of working with these teams if they are to assist the client. The role ensures that:

- the client, design team and construction team are assembled in the most appropriate manner
- the client's project outcomes are clear from the outset
- all project team members have the appropriate skills and experience for their specific role in the project team
- all project team members have the correct behaviours towards achieving the client's desired project outcomes.

The architect in the client team

On many small projects an architect will secure a commission with an inexperienced domestic client. In many instances they will be sole practitioners. Those undertaking this role need to ensure that they have the experience to steer the client through the various decisions that need to be made. They need to recognise that being the client's sole adviser as well as their designer creates a cross-team situation and they need to consider how best to differentiate between the briefing activities undertaken by the client team and the design process undertaken by the design team. This is understandable on smaller projects when only a few individuals need to be involved in the project. This publication advocates that those undertaking any client and design team roles should note the potential conflict of interest in performing roles in both teams. For example, when acting as contract administrator it may be necessary to instruct changes in specification required by the 'architect.' In these situations, change control should be used to make the dual-team roles more transparent.

Client representative

While the client may employ a project manager to act as the client lead, and others to sit inside the client team, they may also wish their own representative to attend meetings. This individual would be involved in the project on a day-to-day basis, commenting on the work of the three teams as they progress, signing contracts and making decisions. The limit of the individual's decision-making powers needs to be clear to all. Ultimately, it needs to be clear to the lead designer who is leading the client team, the limits of their authority and how communication between the client and design team will work.

RIBA client adviser
An RIBA client adviser is an experienced architect who can assist the client in a number of ways, particularly in relation to design-related matters. They may be best placed to advise on the architectural practices who should be on the tender list for the architect role, prepare Feasibility Studies that prove that the Initial Project Brief fits on the site or comment on Site Information. The benefits of an RIBA client adviser can be obtained at: **www.architecture.com/working-with-an-architect/client-adviser**

Cost consultant
The cost consultant is a core member of the client team, assisting the client in setting the Project Budget (see p 168). In instances when the design team is appointed by the lead designer (see p 62), it is commonplace for the cost consultant to remain directly appointed by the client. This creates a project team conflict of interest. The cost consultant must advise the client on cost matters, yet is also expected to proactively assist the lead designer in ensuring that the design team designs to cost. In achieving the latter, it might be deemed by the client that they are not undertaking the former. From the lead designer's perspective, it may be more appropriate to appoint a second cost consultant who directly assists the design team and, although this is not commonplace, the take-up of 5D BIM (see p 174) may encourage this. The interface with the cost consultant is a core consideration for the lead designer and is considered in detail in Chapter 7.

Contract administrator (employer's agent)
The contract administrator administrates the terms of the Building Contract, making sure that the construction team is proceeding as planned and as required by the Building Contract, as well as issuing additional instructions or clarification depending on the form of Building Contract. Although the relationship between the lead designer and the contract administrator is not a significant one, the lead designer needs to ensure that the contract administrator is provided with any information necessary to ensure timely responses to the contractor in relation to variations or Site Queries.

The information manager
The advent of digital technologies makes it possible for the client to use the information produced during the design phase for asset and facilities management and other purposes. The diversity of information possibilities after a building has been handed over requires a party in the client team to determine the information that the client requires for inclusion in the Exchange Information Requirements (EIRs, see p 206). This is the role of the information manager. This role might also involve verifying the quality of the information produced by the design or construction teams and whether this meets the EIRs. The role does not involve validating the design, as this requires the skills of a professional.

Client monitoring team

There is value on certain projects in the client appointing a 'shadow' design team to provide advice and to comment on the design as it progresses. This is commonplace on Design and Build forms of Building Contracts where the construction team has to submit Contractor's Proposals for review.

Handover Strategy

As a building nears completion, the construction team will be focused on completing the works prior to the practical completion date set in the Building Contract. From the client's perspective, a number of activities are required in order to prepare the building for effective and efficient operation. This includes commissioning of the building services, understanding and being trained on how to use the building services systems in the building, learning about any specific maintenance requirements that there may be and reviewing the information required for CAFM (Computer Aided Facility Management) or other building systems. The purpose of the Handover Strategy is to ensure that these topics are given the same priority as the completion of the physical works. The Soft Landing Strategy published by BSRIA (The Building Services Research and Information Association) or the UK government's Soft Landing Strategy consider this topic in detail, as well as the activities required after handover until the building is up and running as intended. This aftercare period can run for up to three years.

The facilities management adviser

On many projects the client will also be the end user. It is beneficial for such clients to involve their facilities management (FM) team from the outset. In the briefing stages the FM adviser might set operational requirements that are fixed across a building estate, such as the methodology for window cleaning or how recycling will work. During the design stages the FM adviser will comment on the design proposals against what was set in the brief, asking questions relevant to the project stage. As the building nears completion, the client team might shift emphasis towards FM issues and will ramp up their team to deal with the topics in the Handover Strategy in order to understand the building's system and to ready it for practical completion when it can be occupied.

Other client team members

The client may also employ other specialist consultants in the client team to provide focused advice on a particular area including:

- legal adviser
- financial adviser
- representatives from funders
- security adviser
- construction adviser
- operational adviser
- asset information adviser
- asset information security adviser
- sustainability adviser
- environmental adviser
- BREEAM adviser.

This list is not exhaustive and will vary from client to client and from project to project, depending on the unique drivers and risks associated with each site and brief. The crucial difference between these advisers and those in the design team is that these advisers have no design responsibilities. While they may set constraints or strategies, it is ultimately the role of the design team to produce a design that meets the requirements set by the client team or to agree and derogate otherwise.

Are stakeholders part of the client team?

Stakeholders can present the biggest challenge on any project, mainly because they generally have no contractual relationships to the project team. As such, their opinions or requests are difficult to predict and manage. Stakeholders are any party outside the project team who might influence the direction of the design or create a project constraint. They include:

- planning departments
- building control teams
- utilities companies
- community groups
- environmental bodies
- specialist interest groups.

As stakeholders are not in the project team, special measures may be required to manage the constraints and risks that they create. Both the client and design teams may need to engage with different stakeholders. A Stakeholder Plan can help clarify the key stakeholders, how they are being managed, who the key contact is within the project team, whether information is required for sign-off or consent and how constraints or risks are to be managed. In certain instances the client might include key stakeholders as partners in a project or develop a means of better managing their involvement and contributions.

This publication does not consider this topic in detail, although it does counsel the lead designer to pay particular attention to the subject and to be alert to the responsibilities the design team has for managing stakeholders, including submitting information for comments and/or approvals. For example, meeting dates and hold points may be required in the Design Programme until discussions with a particular stakeholder are concluded. This topic is considered on p 151.

Figure 2.1: The client team

THE CLIENT TEAM
Project Manager
Client Representative
RIBA Client Adviser
Cost consultant
Contract Administrator (Employer's Agent)
Information Manager
Client Monitoring Team
Facilities Management Adviser
Legal Adviser
Financial Adviser
Representatives from Funders
Security Adviser
Construction Advisers
Operational Adviser
Asset Information Adviser
Asset Information Security Adviser
Sustainability Adviser
Environmental Adviser
BREEAM Adviser

What does the lead designer need to consider in relation to the client team?

The client is the ultimate decision-maker on any project and it is essential that the lead designer considers the make-up of the client team. Who is in the team and what makes them tick? What are their drivers and values? What are they expecting from the project? Without these insights the design team will not start on the right footing, as melding the design team to suit the client's objectives and outcomes is a core role for the lead designer. At a granular level the lead designer needs to consider:

- How will the design team communicate with the client team?
- How often will the client team and design team meet?
- Who makes day-to-day decisions?
- How will change control work? When will stringent procedures start?
- How are reviews to be undertaken? Are they detailed in the Design Programme?

The design team

What does the design team do?

The design team is responsible for the design of the building and producing the information required to construct it. It may also be required to produce information that will be used for the successful operation of the building. Not every member of the design team is a designer (for example, an architect or an engineer) but everyone in the design team actively contributes to the development of the design. For example:

- the cost consultant's advice shapes the development of the design
- the sustainability consultant might determine the energy source for a project
- the fire engineer's calculations might dictate how the design of an atrium space is developed
- the acoustician helps determine the specification for the glazing adjacent to a railway
- the security consultant might configure the arrangements in an entrance hall.

Anyone who designs, engineers or contributes advice or information that will be used as part of the design process needs to be in the design team. However, this excludes the preparation of the brief or constraints provided by the client team or any constraints or inputs from stakeholders.

Who leads the design team?

The design team is led by the lead designer. The tasks, skills and experience required to undertake this role are covered in Chapter 1.

Who is in the design team?

The core members of the design team are:

- the lead designer
- designers: architect, interior designer and landscape architect
- engineers: civil and structural and building services engineers
- the cost consultant
- core advisers: health and safety and construction
- specialist consultants.

Many specialist consultants may be involved in the design of a building. The requirement for them will depend on the specific requirements of a project, the client's requirements and the experience and skills of the core design team members. Specialist consultants might include:

- fire engineer
- acoustic consultant
- security consultant
- cladding consultant
- sustainability consultant
- design manager
- specification consultant
- BIM consultant.

Architect

The architect leads the creative direction of the project, including setting out the initial ideas for the Concept Design. The architect will present the design proposals to the client and to any stakeholders, and leads the architectural development of the project. As noted above on p 22, on a high percentage of projects the lead designer and architect will emanate from the same practice.

Civil and structural engineers

The civil and structural engineers are responsible for helping to select the most appropriate structural solutions and systems for the project. For example, is steel, in-situ concrete frame or a new construction methodology – such as cross-laminated timber – the most appropriate for the project? Once these systems, including the foundations, have been determined, they will be developed and coordinated through the project stages until tendering and then the construction information is complete.

Building services engineers

The mechanical, electrical and public health engineers (simplified to building services engineers for this publication) are responsible for developing the different building services systems required in a building, including:

- lighting and small power requirements
- high voltage (HV) and low voltage (LV) systems
- mechanical systems, including air handling units and associated ductwork
- hot and cold water systems
- lifts
- foul drainage
- fire-fighting requirements, such as dry risers or sprinklers.

The building services engineer will prepare an outline description for each system in the building before preparing schematics and then detailed drawings and specifications for tendering and construction. The interface between the building services engineer and the architect and lead designer is a major one due to the spatial requirements of risers and plant rooms, and the aesthetic impact of the many building services systems (on the whole the building structure is concealed).

Cost consultant

The cost consultant is responsible for setting the Project Budget during stage 1 and ensuring that the area allowances in the Initial Project Brief are aligned to this budget. During the design stages the cost consultant will prepare a Cost Plan, proactively helping the lead designer to design to cost rather than reactively costing designs (see Chapter 7). Once the Building Contract has been awarded, the cost consultant's role will support the contract administrator by providing monthly valuations of the work undertaken on-site. Where the design team might have responsibilities to redesign in the event of tenders being returned over the Project Budget, the lead designer should take extra measures to make sure that the cost consultant has the behaviours best suited to help the design team design to cost.

Health and safety adviser

The health and safety adviser might undertake reviews of the design from a health and safety perspective, including any regulatory compliance issues, and might help identify and frame any residual risks that need to be considered by the construction team or later by the users of the building, including the FM team. The health and safety adviser might also help the design team consider health and safety initiatives, such as Safety in Design (SiD) initiatives that help the lead designer to raise the health and safety bar on a project.

Principal designer

In the UK the principal designer is a legal term contained in the Construction (Design and Management) Regulations 2015.
For many construction projects there may not be a design team *per se*.
For example, during the maintenance of a building someone may need to design a new connection to a boiler. The regulations aim to make it clear that someone needs to take responsibility where design is being undertaken. On new-build projects the intent of the HSE (Health and Safety Executive) was always to have the design team taking responsibility for the health and safety aspects of design, including the implications on maintenance and operation. The RIBA Plan of Work includes the need to prepare a Health and Safety Strategy and this publication advocates that this should be the responsibility of the lead designer even where they choose to use a health and safety adviser. In this publication, the lead designer becomes the de facto principal designer.

Construction adviser

Different forms of procurement engage the construction team at different stages.
A Construction Strategy should be prepared as the design progresses to ensure that the construction team, including the specialist contractors, appropriately influence the direction of the design. The construction adviser role was created to ensure that where the construction team has not yet been appointed, an appropriately experienced individual considers buildability, sequencing and health and safety during the Concept Design, including Design for Manufacture and Assembly (DfMA) proposals. The RIBA DfMA publication (see p 214) considers this trend in greater detail, along with Chapter 10.

Specialist consultants?

A specialist consultant is someone who has detailed knowledge and experience of a particular subject. In some instances the experience may be based around new ways of doing things. For example, fire engineers became an established specialist consultant when atriums became commonplace and the regulatory environment was lagging behind emerging trends. The lead designer must know the typical issues encountered for a particular topic, the information typically produced and the interface issues that need to be discussed and managed. The core challenges resulting from the increased number of specialist consultants are:

- more design team members to manage
- more challenging to set the Responsibility Matrix
- greater risk of the information produced by different parties being contradictory
- design team meetings being more difficult to manage.

The increase in number of specialist consultants in the design team requires more of the lead designer's time to ensure that their appointment documents are properly established and to coordinate the work of the increased design team. Conversely, the lead designer has access to greater knowledge and experience on core project topics.

Figure 2.2: The design team

THE DESIGN TEAM
Lead Designer
Designers
Architect, Interior Designer and Landscape Architect
Engineers
Civil and Structural and Building Services Engineers
Cost Consultant
Core Advisers
Construction and Health and Safety
Specialist Consultants
Fire Engineer
Acoustic Consultant
Security Consultant
Cladding Consultant
Sustainability Consultant
Design Manager
Specification Consultant
BIM Consultant

What does the lead designer need to consider in relation to the design team?

From the lead designer's perspective, the core consideration is who is employing each member of the design team. This is covered later in this chapter. Strategically, the lead designer should be certain that:

- the design team has the relevant experience for the project. For example, has it delivered a similar building type?
- appropriate specialist consultants have been appointed. Are there onerous requirements that might go beyond the knowledge of a generalist?
- the right design team members are in the design team at the right stage. Contributions too early can divert attention away from the crucial tasks; conversely, too late and further iterations of the design might be required
- the design team has the right behaviours for coordinating in a collaborative environment
- it is clear who will do what when: the Responsibility Matrix facilitates this (see p 207).

The construction team

What is the role of the construction team?

The construction team is contracted under a Building Contract to undertake the construction works.

In the past, construction teams would directly employ the labour required to build a project. Most Building Contracts are now let to teams who manage the construction process with limited or no direct labour. Building work is subcontracted in packages to subcontractors experienced in that aspect of the project – for example, cladding, partitions, electrical or landscaping work. As the industry shifts towards the manage manufacturing and construction work of modular components, or sub-assemblies (see Chapter 9), construction will change. The role of the construction team is to:

- ensure that the building is constructed safely and that health and safety has a high priority
- secure the site and arrange shared items of plant, such as craneage or hoists
- liaise with the statutory authorities in relation to temporary requirements required for construction, such as cranes, office accommodation and site welfare, and seek approval for these as required

- programme the manufacturing and construction works and prepare the Construction Programme
- procure the work of subcontractors and specialist subcontractors
- manage the construction work of the different subcontractors
- deliver the completed project in line with the time and cost requirements of the Building Contract
- assess and manage construction risks
- divide the work into packages, including consideration of interfaces, tendering it to the most appropriate parties.

Who leads the construction team?

The construction team is typically led by a senior representative – the larger the project the more experienced and senior the representative will be. The construction lead is usually based on-site full-time in order to direct the work of the other members of the construction team and hold meetings and discussions with the client and design team members as required.

Who is in the construction team?

The construction team nowadays comprises representatives of the team that will manufacture and construct a building having been awarded the Building Contract to do so. The lead designer needs to be alert to the different roles and the purpose of each in order to effectively engage with the construction team. These roles include:

Commercial team

The commercial team is responsible for concluding commercial negotiations with the client and subcontractors, including specialist subcontractors. It will ensure that any subcontract contracts are 'back-to-back' with the Building Contract and will deal with any ongoing commercial discussions with the client team or subcontractors, including any disputes should these arise.

Procurement team

The procurement team prepares the list of proposed subcontract packages for the project. It will assemble the tender documentation and scope of work documents with contributions of the package managers and possibly the design team. It will identify a list of tenderers for each subcontract package and will steer the tender process for each subcontract through to completion. The lead designer might have a close relationship with the procurement team, although this will depend on the procurement route.

Package manager

The package manager deals with the minutia of detail required for each subcontract. The scope of work must be clear in the package subcontract documentation, including the information required from the design team and the extent of any design work to be undertaken by specialist subcontractors. The package manager will work closely with the designer relevant to the package and their design manager. Page 205 considers how the design team can add value by issuing package information.

Design manager

The construction team's design manager acts as the core interface with the design team. They typically have design qualifications and the experience required to comment on the work of the design team. They might:

- ensure that the design responsibilities of the design team dovetail with the packages where specialist subcontractors will complete the design or where subcontractors might produce shop drawings
- agree the information to be issued at each project stage or milestone with the design team, including the information to be issued for each package subcontract
- agree the Design Programme issued by the lead designer for the release of information by the design team
- review information issued by the design team for completeness and technical quality (depending on professional skillsets)
- review package information for completeness and to help identify project risks that need to be considered by specialist subcontractors.

Health and safety manager

The contractor's health and safety manager is responsible for the day-to-day health and safety operations on the site. They will also contribute to the tender process for selecting and awarding package subcontracts, providing the relevant questions to probe the health and safety credentials of each subcontractor.

Construction programmer

The construction programmer (see p 162 for more detail) is a core project document prepared by a construction programmer. This role requires detailed knowledge of how a building typically comes together, including the correct sequencing for construction trades and the timescales required for typical construction activity. It also requires an understanding of the critical path: the key activities that drive the construction duration. The construction programmer will also vet the programmes prepared by subcontractors.

Construction manager

The construction manager monitors the work of the subcontractors on-site, making sure that construction activity is progressing as planned and resolving any day-to-day issues between subcontractors, such as access points or areas where one subcontractor is impeding the work of another. They will refer design queries to the package manager, who in turn will defer to the relevant design team member if this is required. If the role of design for manufacture and assembly (DfMA – see p 214) in the construction industry increases, this role may transform into assembly manager.

Logistics team

Logistics are increasingly important in the delivery of major construction projects and many construction teams are collaborating with logistics companies in order to improve the methodology for ensuring that the right materials are on-site at the right time. Many city centre sites increasingly require 'just-in-time' deliveries from consolidation centres where sub-assemblies can be manufactured ready for delivery to site.

Figure 2.3: The construction team

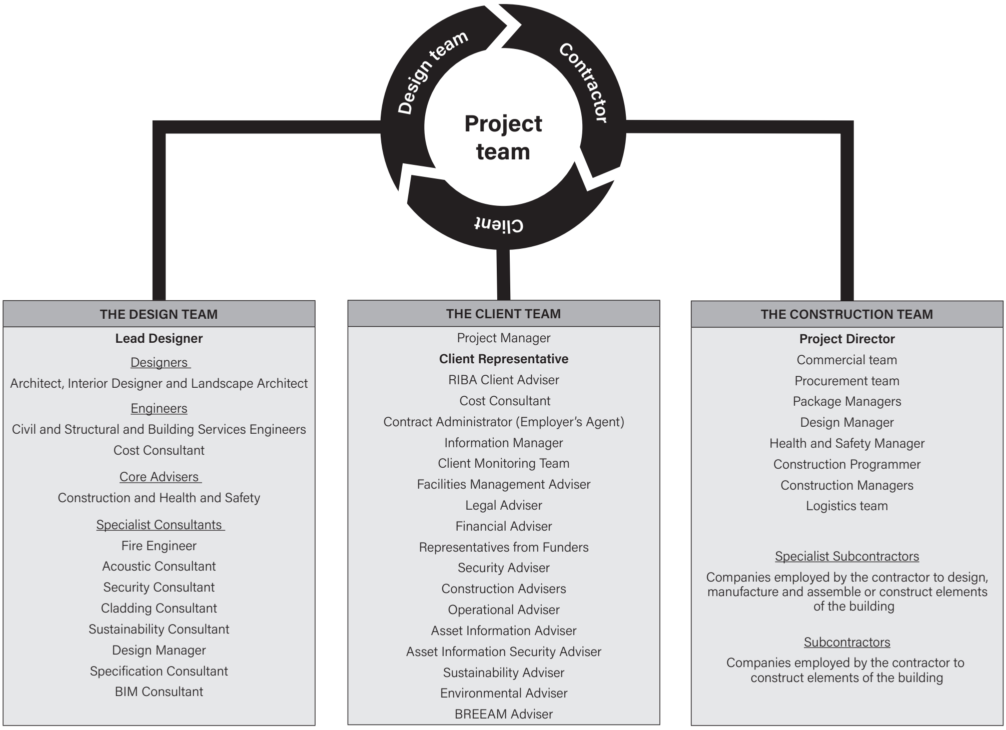
THE CONSTRUCTION TEAM
Project Director
Commercial team
Procurement team
Package Managers
Design Manager
Health and Safety Manager
Construction Programmer
Construction Managers
Logistics team
Specialist Subcontractors
Companies employed by the contractor to design, manufacture and construct elements of the building, see p53
Subcontractors
Companies employed by the contractor to construct elements of the building, see p53

What does the lead designer need to consider in relation to the construction team?

The lead designer needs to recognise that the strategy for engaging the construction team is set by the client team when it decides the Procurement Strategy. From the lead designer's perspective the interface with the specialist subcontractors is without a doubt the biggest challenge on any project. First, because the selection strategy of these key designers is likely to be outside their control and, secondly, because they are not inside the design team. Topics to consider include:

- What is the division of the design work undertaken by the design team and the specialist subcontractors at stage 4, and given the latter pick up the design baton from the design team, are the residual design issues and interface issues clear for each aspect of the design.
- Do the stage deliverables reflect the requirements of the Procurement Strategy? For example, where one-stage Design and Build has been selected as the Procurement Strategy, has adequate information been set at stage 3 to allow the construction team to adequately price the risks on the project?
- Any resource or meeting requirements that might result from the Procurement Strategy. For example, the extent of involvement on-site at stage 5 or the strategy for holding meetings with specialist subcontractors. What is the frequency of these meetings and is the lead designer chairing and preparing the minutes for them?
- Will the construction team expect stage 4 information to be issued in packages to the relevant subcontractors or is all of the stage 4 information to be issued on a single date? The former requires greater consideration by the lead designer.

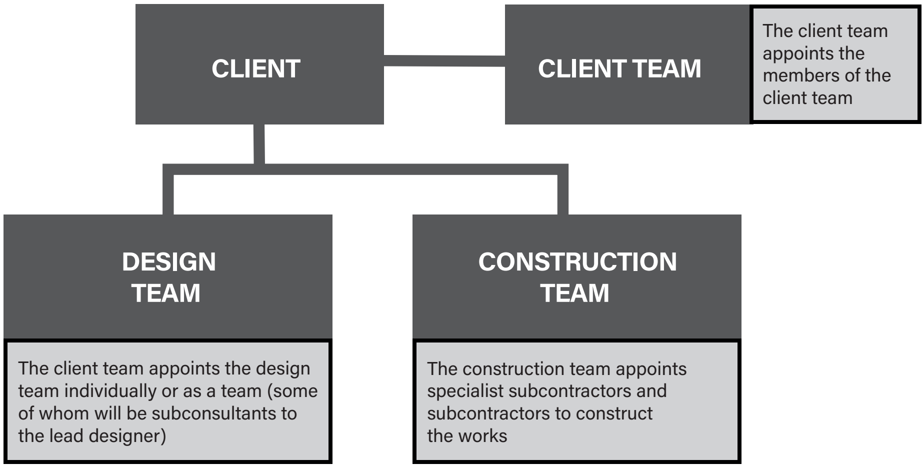
Figure 2.4: The project team



The legal construct of the project team

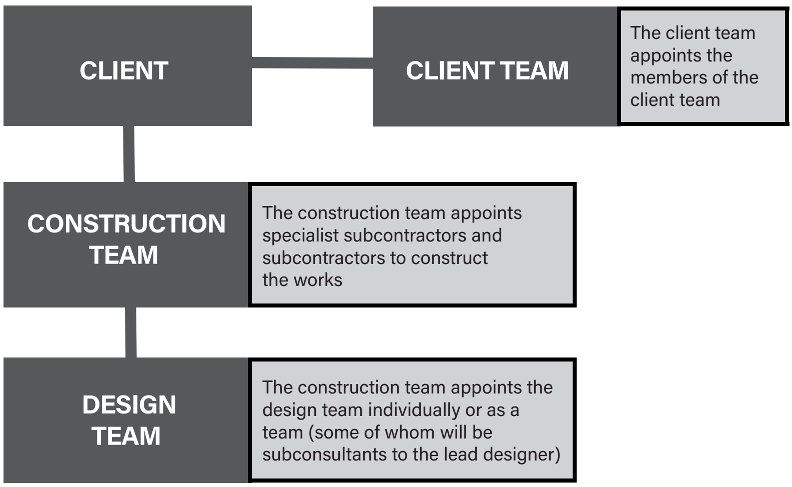
The legal construct of the project team will depend on the client's view of procurement. Some clients see the value in tendering every service on a project in order to seek the lowest costs; others see the value of appointing a single team, possibly using a collaborative contract to drive the behaviours required to manage risk and keep down the overall costs of design and construction. There is no correct approach, only pros and cons for each. There are differences between horizontal (infrastructure) and vertical (vertical) projects. For the former, alliancing contracts that bind the designers and contractors are increasingly popular. For the latter, government departments are trending towards contractor-led procurement, where the contractor selects and appoints the design team with private-sector clients preferring to appoint the design team and then novate it to a Design and Build contractor having close oversight of the design process in the early stages and passing the time and cost risks to the contractor. Some typical project structures are illustrated in Figures 2.5 and 2.6.

Figure 2.5: The legal construct of the project team – option 1



This is the most common legal construct with the private with the client employing the design team and the construction team separately (although in many instances the design team is appointed individually and may be novated to the construction team at stage 4).

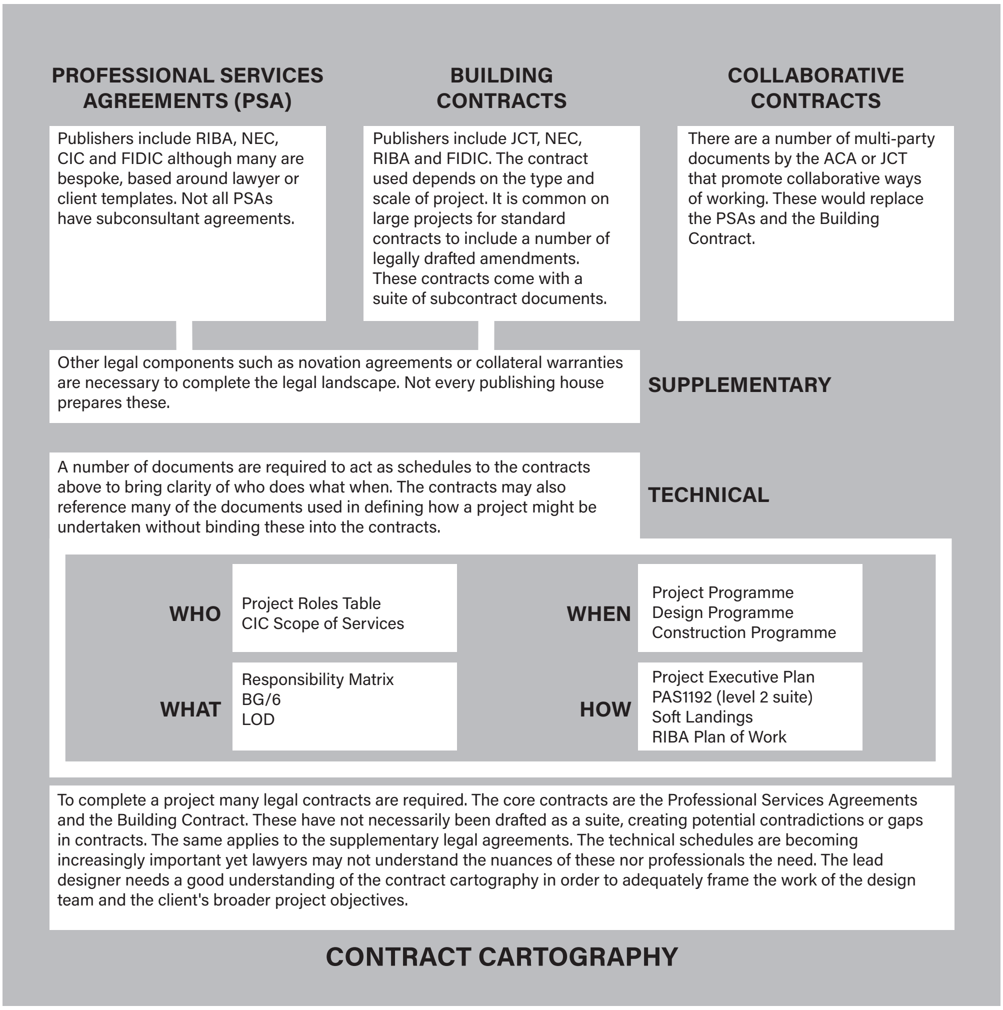
Figure 2.6: The legal construct of the project team – option 2



The simplest legal construct from the client's perspective is when the construction team employs the design team. The client will, however, still need to appoint advisers to its team unless these are in-house.

With clients wrestling with the best way to shape their procurement, the lead designer may not be able to influence how the project team is structured; however, the lead designer needs to be alert to the various relationships, their legal structure and how these may impact on the design process and the contractual obligations of the design team that might affect how the lead designer works. For example, if the lead designer has stringent designing to cost obligations, the cost consultant's schedule of services should be closely reviewed.

Figure 2.7: Contract cartography



The contractual landscape

Contracts are required when briefing, designing and constructing a building.

There are many types of contracts required on a project; however, the core contracts from the lead designer's perspective are the Professional Services Contracts and the Building Contract.

Professional Services Agreements
Professional Services Agreements (PSA) are contracts between consultants and might be made between:

- the client and a member of the client team
- the client and a member of the design team
- the client and the construction team (for pre-construction services)
- a member of the client team and a specialist consultant
- a member of the design team and another member of the design team or a specialist consultant
- the construction team and a member of the design team (potentially via novation).

There are various standard forms of PSA available from the key contract publishing bodies, including the RIBA, NEC, JCT (public sector only) and FIDIC. On larger projects it is common for bespoke PSAs to be used and the construction law teams of most legal practices have their own templates for these. Further information on the items to consider when preparing a PSA for a client team, or when reviewing the PSA on the design team's behalf, are set out in detail in *Law in Practice: the RIBA Legal Handbook*.

The risks to the lead designer associated with the PSAs of the other members of the design team can be managed by:

- the lead designer commenting on the PSAs for other design team members where they are being appointed directly by the client
- contributing to the development of a multi-party Responsibility Matrix for appending to the various PSAs. This greatly assists the lead designer because holding information in a single multi-party document removes ambiguity around design responsibility, the information to be delivered and the tasks to be carried out
- employing the design team using a Responsibility Matrix that has been tried and tested over a number of projects.

Subconsultant
A subconsultant is simply one consultant that is employed by another – for example, the acoustician employed by the building services engineer or the specification consultant employed by the architect.

Building Contracts
The Building Contract is signed between the construction team and the client. There are many standard forms of Building Contract available published by bodies such as the RIBA, JCT, NEC and FIDIC. These contracts deal with different Procurement Strategys and are also designed for projects of different complexities or scale or to suit a domestic client. The *RIBA Legal Handbook* also covers these contracts in detail. Standard forms of Building Contracts are used on the vast majority of projects, although it is commonplace for these to be heavily amended by the client's lawyer.

It is essential for the lead designer to be familiar with the Building Contract and to understand any design obligations set in this contract or other topics that might impact on the design process and the work of the design team. Subcontract agreements are required between the contractor and each subcontractor. Each standard form of Building Contract has a form of subcontract included within the suite of available documents.

Collaborative contracts
There is a shift towards collaborative contracts that connect the project team together in a way that they act more effectively in the interests of the client. In many situations, collaboration requires project team members to work counter to their contractual requirements, with the majority of project team constructs requiring numerous contracts that can become a barrier to effective collaboration. To overcome this, some clients use non-contractual 'charters' where the project team sign up to work together collaboratively, creating an ethically – rather than contractually – driven environment. However, this approach has no contractual teeth and behaviours can easily revert to normal adversarial ones when things begin to go wrong. To counter this, some contracting bodies, such as NEC, are looking to beef-up contractual commitments in traditional contracts so that team members act in a collaborative manner – for example, in the 'spirit of mutual trust and cooperation.' At the most collaborative end of the spectrum, a number of Procurement Strategys make further more substantial breaks from tradition.

How does the Procurement Strategy impact on the assembly of the project team?

The Procurement Strategy is the strategy that sets out how the client team will engage the construction team. It determines the form of Building Contract, the point in the Project Programme when the construction team is engaged in the project process and influences who employs the design team. There are a number of common Procurement Strategys:

- Traditional
- Two-stage Design and Build
- Construction team-led
- One-stage Design and Build
- Management Contracting
- Construction Management
- Private Finance Initiative (PFI)

Procurement Strategy decision-making primarily focuses around the three mantras of time, cost and quality. Each Procurement Strategy is able to satisfy one or two of these criteria but not all three. Figure 2.8 illustrates the different outcomes for each of these three mantras for various Procurement Strategys.

Subcontractors/specialist subcontractors

Regardless of the procurement route on the majority of projects the construction team will subcontract aspects of the work to companies who will tender for these "packages" of work such as curtain walling, floor finishes, lifts, substructure or electrical works. Subcontractors construct the works as detailed on the design teams drawings regardless of the procurement route used. In some instances the contractor will have design obligations (called Contractor Design Portion (CDP) on traditional contracts. In these situations the obligations will be passed on to a specialist subcontractor who will design these aspects before manufacturing and constructing them (following comments from the design team). The difference therefore between a subcontractor and a specialist subcontractor is that a subcontractor constructs the works as detailed in the design team's information and a specialist subcontractor has to design their portion of the work before they can manufacture and construct.

Figure 2.8: Different procurement, different outcome

Figure 2.8 is not meant to be interpreted as a scoring matrix. It highlights that different Procurement Strategys have their unique strengths and weaknesses.

Procurement Strategy	Time	Cost	Quality
Traditional		✓	✓✓
Two-stage Design and Build	✓	✓✓	✓
Construction team-led	✓	✓✓	
One-stage Design and Build	✓	✓✓	✓
Management contracting	✓✓		✓✓
Construction management	✓✓		✓✓
PFI	✓	✓✓	

Time

This comes in two forms: guaranteeing the date of completion or delivering faster. In the table, delivering faster is given ✓✓ and delivering on time ✓. Procurement Strategys that have a completion date set in the Building Contract but where it is common for this to be late, have no mark.

Cost

For some forms of procurement the cost is set when the Building Contract is awarded. These are given ✓✓. On others, the cost is determined at the outset but might vary. These forms of Building Contract are given ✓. On other forms a Cost Plan might exist but different issues can drive up costs significantly and the final costs cannot be certain. These forms of procurement have no score.

Quality

Quality is rarely discussed and defined. This might include the client's ability to drive and influence the direction of the design. Where the client controls the design process for the duration of the building project ✓✓ is given. Where the client controls the early design stages but relinquishes control, ✓ has been given. Where the client has no direct control of the design process no score is given.

How does the Procurement Strategy impact on the design process?

Many articles have been written about the pros and cons of different Procurement Strategys, less about how the Procurement Strategy impacts on the design process, which is of course of great interest to the lead designer. Despite the diversity of the different Procurement Strategys, they have minimal impact on the design process. Procurement Strategys determine the:

- timing for when the construction team contributes to the design process
- culture and behaviours of the project team
- degree of influence the construction team has over the design process

- ability of the construction team to input to and influence the Construction Strategy
- ownership of the design risks during the construction stage.

While the design work undertaken might ultimately be the same, different Procurement Strategys can vary the timing and information required for tender purposes and when design information is produced by specialist subcontractors. In order to manage the design process, the lead designer needs to understand the nuances between different Procurement Strategys and how they impact on the design process. With this in mind, Figure 2.9 considers the impact of different Procurement Strategys at each stage of the design process, with Figure 2.10 setting out the measures that the lead designer might take to mitigate and manage the aspects particular to each Procurement Strategy.

Figure 2.9: Procurement: impact on the design process

Procurement Strategy	Stage 2	Stage 3	Stage 4
Traditional	Contractor not appointed, requiring consideration of who undertakes the Construction Strategy	The input from specialist subcontractors is informal and may not be as focused in absence of a construction team	The work of the specialist subcontractors is delayed until the contractor is appointed
Two-stage Design and Build	As Traditional unless the contractor is appointed during stage 2	The contractor may pivot the design team from coordination towards granular construction considerations	The work of the majority of specialist subcontractors is delayed until the contractor is appointed
Contractor team-led	Designs are filtered by the construction team before presentation to the client	Specialist subcontractors can contribute more meaningfully to the design process	Design team and specialist contractors can design in tandem
One-stage Design and Build	As Traditional	Additional deliverables required (allocated from stage 4) to reduce project risks and increase scope clarity	As Contractor team-led
Management contracting	As Two-stage Design and Build	As Contractor team-led	Work has commenced on-site placing great emphasis on designing out of sequence and designing for tendering and construction purposes
Construction management	As Two-stage Design and Build	As Contractor team-led	As Management contracting
PFI	As Contractor team-led	As Contractor team-led	As Contractor team-led

Note: the above points are not intended to be pros or cons. They illustrate simplistically how the design process is adjusted by different forms of procurement.

Figure 2.10: Procurement: adjusting the design process

Procurement Strategy	Lead designer considerations/mitigations
Traditional	► At stage 2, consider who is best placed to contribute towards the Construction Strategy. Is a specialist consultant required? ► Establish strategic relationships with frequently used specialist subcontractors to enable the appropriate contribution to design information in the early stages ► Minimise the scope of CDP (descriptive) packages to reduce risks arising from changes resulting from interface issues
Two-stage Design and Build	► Consider carefully the contributions required from the construction team to avoid granular discussions that are not relevant to the design process in the early stages ► Consider what information is required in order to reduce the design risks and enable all design aspects to be properly considered in the Contractor's Proposals ► Consider whether information is to be released on a package basis
Construction team-led	► Take advantage of Early Contractor Involvement and consider the specialist subcontractors who can add value to the design process and seek their early contributions ► Prepare a Design Programme so it is clear what is expected when
One-stage Design and Build	► At stage 2 consider who is best placed to contribute towards the Construction Strategy. Is a specialist consultant required? ► Consider what information is required to include in the Contractor's Proposals and when they will be finalised in order to reduce the design risks and enable all design aspects to be properly considered in the Contractor's Proposals ► Consider the Design Programme for stage 4 early, as it is likely the construction team will want information quickly following conclusion of the Building Contract
Management Contracting	► Consider the implications of designing out of sequence ► Carefully consider how the Design Programme incorporates the inputs from the design work from specialist subcontractors
Construction Management	► As Management Contracting
PFI	► As Construction team-led, plus consider how the FM member of the consortium will contribute to the Maintenance and Operational Strategy

Novation (part 1)

On many Design and Build projects the design team is novated to the construction team. The concept of novation is simple: the construction team replaces the original client in the PSA and from that point forward the consultant's obligations and duties are to the construction team rather than the original client. Simply, the construction team becomes the design team's client, although to avoid confusion this is increasingly being called 'employer', i.e. the client remains the client, but the design team is now employed by the construction team.

ECI: Early Contractor Involvement or Early Contractor Innovation

On some Procurement Strategys the construction team is appointed early in the design process. ECI is the term commonly used to define this appointment, although it is now trending towards two meanings:

Early Contractor Involvement
This is the more frequent use of ECI, which refers to the early involvement of the construction team on Design and Build, management contracting or construction management forms of Building Contract. Benefits include conversations around buildability, sequencing, programme, logistics, site set-up and more structured engagements with the supply chain. The lead designer needs to make sure that involvement is proportionate to the stage of the design (The RIBA stages were developed to allow the design to be progressively developed). They should also try and avoid the construction team 'reinventing the wheel' by reviewing decisions already made by the design team or trying to progress aspects of the design quicker than necessary. To overcome this, the timing, scope and need for any pre-commencement duties from the construction team needs to be carefully considered.

Early Contractor Innovation
On complex projects or those using contractor-led forms of procurement, innovative design solutions driven by the construction team's specialist subcontractors can greatly assist the design process by bringing unique ideas to bear early on in the design process when they can be more effectively considered and embedded into the design.

What are the different ways of appointing the design team?

With the Procurement Strategy set, the means of appointing the design team can be considered. There are three common ways of appointing the design team:

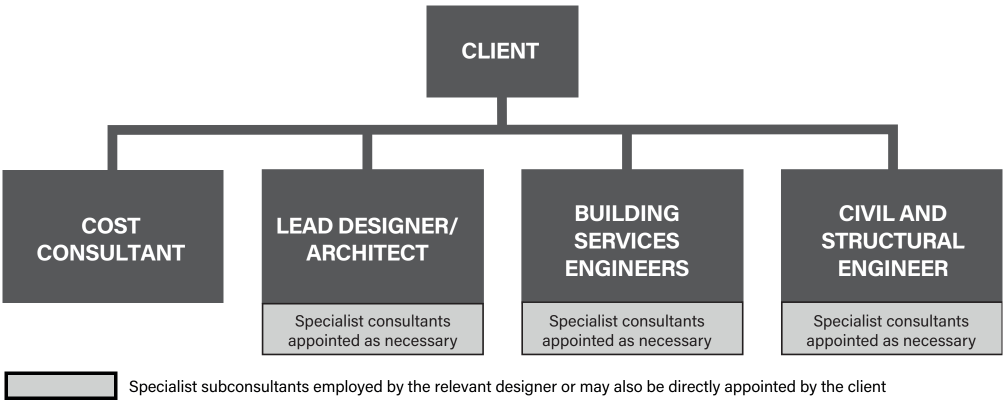
1. The client appoints each design team member individually.
2. The client appoints the design team as a single 'one-stop' entity.
3. The client appoints the construction team to employ the design team.

There are pros and cons to each approach from a client, design and construction team perspective, and as these options have a significant impact on how the lead designer might manage and direct the design team, this section considers the differences between the different approaches. Figures 2.11 and 2.12 illustrate the first two models.

The client-appointed design team

In a 'traditional' design team, all design team members are appointed directly by the client:

Figure 2.11: Contractual Tree – the client appoints the design team individually



From the client team, lead designer and construction team's perspective, there are various pros and cons with this approach.

Pros	Cons
For the client team: ► The client team can select each design team member and build the most appropriate design team ► The client has direct control over each design team member	► The client team needs to prepare detailed Professional Services Agreements for each member of the design team ► The client takes responsibility for scope gaps ► The client needs to deal with disputes between design team members
For the lead designer: ► The lead designer does not have to deal with the process of appointing each design team member ► The lead designer is not responsible for the design work of other design team members	► The selected design team members may not have an established working relationship ► The design team may not have the skills and experience expected by the lead designer, including digital ones
For the construction team: ► The construction team has direct control over each design team member	► Greater likelihood of scope gaps and design team disputes ► The deliverables set by the client team may not meet the lead designer's coordination requirements ► Members of the design team may not have a track record of delivering consistent, reliable information

Managing the risks in a client-appointed team

Although no project is without its issues, when a design team acts proactively and efficiently carries out the services required, a project tends to run smoothly. However, if one or more of the design team members fail to deliver what is required of them, the lead designer will need to expend additional time coordinating and managing, including:

- Carrying out additional design reviews of models, or other information, as a result of a design team member designing late or not taking cognisance of agreements, decisions made in meetings or design workshops or comments made during design reviews.
- Organising and attending meetings with the design team to resolve ongoing coordination issues. Failure to quickly resolve design issues can have a significant knock-on impact on other design team members' work and as the design progresses can significantly impact on a large amount of information, possibly resulting in further iterations of the design.
- Resolving coordination issues that arise on-site due to incomplete or uncoordinated information.

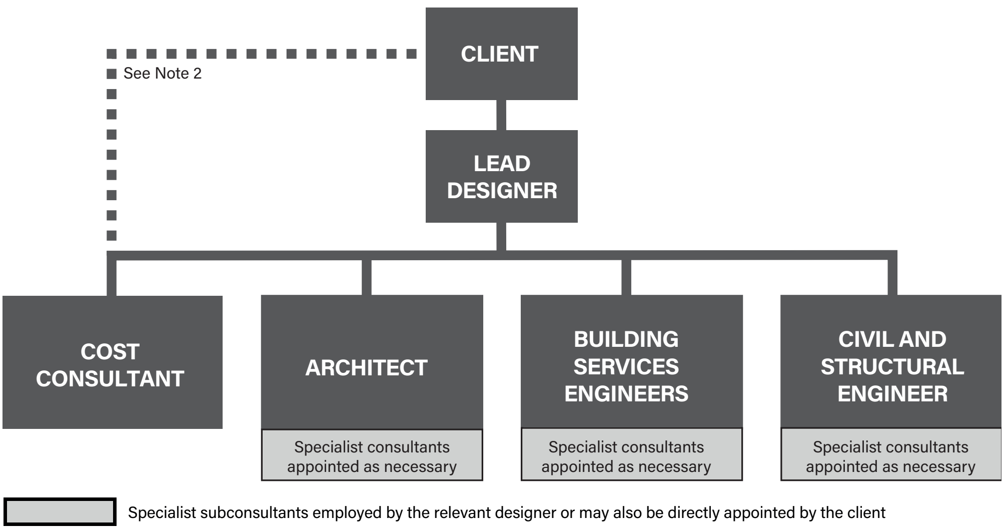
The lead designer often finds that a member of the design team employed directly by the client may not respond to requests or directions they may give. While such examples may be rare, it is essential to consider what measures assist the management of such designers. The lead designer needs to:

- ► obtain copies of each designer's appointments at the start of the project (scope of service portion as a minimum), highlighting and addressing any anomalies or contradictions with their own duties, including agreement of a design team Responsibility Matrix
- ► use monthly project reports to set out the status of the design team's progress, listing any issues that are being encountered so that appropriate representations can be made to the senior management of the other designers
- ► hold monthly principals' meetings (particularly on larger projects). These can act as a useful forum for addressing issues and dealing with any broader political issues or hot topics (see p 116)
- ► as a last resort, and to protect their own position, write to the client advising them that they are unable to perform their duties as lead designer due to another member of the design team failing to undertake their duties.

The client appoints the design team as a single 'one-stop' entity

Increasingly, the lead designer employs everyone in the design team:

Figure 2.12: Contractual Tree – the lead designer appoints the design team



Note 1: The same practice may act as lead designer and architect, however two appointment documents might be issued by the client team.
Note 2: It is common practice for the client team to appoint the cost consultant directly.

From the client team, lead designer and construction team's perspective, there are various pros and cons with this approach

Pros	Cons
For the client team: ► It only needs to deal with a single party and does not have to manage a number of relationships ► The chemistry of the team is likely to be better, as the parties have not come together in an 'arranged marriage.' An established team is likely to have a good and efficient working relationship ► The lead consultant is responsible for all of the design, and in the event of a dispute with the client becomes the single point of contact ► In the event of a dispute between the individual designers, the client is no longer party to that dispute. The design team must resolve any disagreements amongst themselves	► The fee of the combined team bid may not be as competitive as individual fees combined because the client team is no longer able to negotiate each individual fee and appointment ► If the client dislikes or has had a poor experience with one of the designers in the team, it can be difficult to change that designer
For the lead designer: ► The lead designer can select the design team members they want to work with – perhaps those with similar processes, culture and approaches to design ► A team can be assembled with a track record of working together ► By employing the design team, it is easier for the lead designer to direct them ► The lead designer can look to continually improve the design team's project processes using knowledge and feedback from projects	► The lead consultant is contractually responsible for the performance of the other designers (his subconsultants) ► The lead consultant is responsible for paying the invoices of his subconsultants, regardless of whether he has been paid by the client ► The lead consultant needs to put subconsultant agreements in place with the other designers ► The success of the team's bid could be jeopardised if one of the designers has submitted a fee that is not competitive
For the construction team: ► 'One-stop shop' for the design, eliminating any scope gaps or requirements	► The construction team needs to communicate to the designers through the lead designer ► Less ability to influence individual designers as they are managed via the lead designer ► the design team may not be sufficiently focused on buildability or other manufacturing and construction aspects

Managing the risks in a lead designer-appointed team

While there are significant upsides for the lead designer when employing the design team, the additional risks – mainly financial – must be identified and carefully managed. Ways of achieving this include:

- careful selection of design team partners
- establishing subconsultant Professional Services Agreement templates that are refined from one project to the next
- aligning invoicing to, and payments from, the client with invoices from, and payments to, subconsultants
- developing integrated working methods
- monitoring the performance of subconsultants including scope of work documents and Responsibility Matrix.

The basis for selecting the design team and specialist consultants should be straightforward. Consider:

- Who have you recently worked with on similar projects?
- Was the relationship successful?
- Do the proposed design team members have a good track record in the relevant sector?
- Is their design approach and ethos compatible with your own?
- Will the design team be entering into an exclusive agreement to be part of your bid team or does it intend to participate in another bid? If it is not possible to obtain an exclusive agreement, it is important to consider confidentiality issues. For example, consider using separate offices of the same design team member who is in a number of bid teams.

The construction team appoints the design team

On a number of the Procurement Strategys outlined above, the design team is appointed by the construction team to undertake the Concept Designs. On other Procurement Strategys the design team is novated (see p 57) to the construction team once the Building Contract has been signed. The construction team may appoint the design team individually or as a single entity in a similar vein to the client. The other considerations for construction team clients are:

- Each construction team has different preferences for the design team attending and taking minutes at a meeting, including those with specialist subcontractors and different requirements for site inspections. Make sure these are clear.

- Different construction teams have different approaches to the packages where specialist subcontractors take design responsibility for the information they require at stage 4. Make sure this interface is clear in the Responsibility Matrix.
- The commercial teams on the construction teams may have different approaches to payment terms, including how the design team invoices relate to their own applications for payment. The design team should be alert to any requirements, particularly in the initial months.
- Make sure that is clear how design quality will be dealt with particularly for items of the design that will be developed after the award of a Building Contract. (Before then design is likely to be a differentiator in the winning of the Building Contract).

Where the design team is to be appointed by the construction team, the lead designer should vet the Responsibility Matrix with additional scrutiny for any specific requirements, particularly where they are appointing all of the design team members. The benefits of a 'one-stop shop' from the lead designer's perspective soon crumble if they are caught in the middle of a dispute between the construction team and one of their specialist subcontractors.

Future procurement

While this publication redefines the lead designer role within the design team and brings clarity to how the client, design and project teams are contractually bound together, there is a need to be wary of how the next wave of innovation will change the construction of these entities.

Part C looks at the topics that will drive change. A specific example would be in the residential market where several clients are looking to transform the design to making process by funding the set-up of their own modular factories, becoming a 'one-stop shop' that controls all aspects of briefing, design, manufacturing and assembly on-site. At a smaller scale, several small architectural practices provide a similar 'one-stop shop' where, in some instances, new advanced manufacturing tools and other customisable templates are used to speed up and de-risk the design to making process.

This chapter:

- Acknowledged the breadth of skills and experience required to build a project team
- Noted the need for the client team to address a number of core non-designing roles
- Emphasised the need for the design team to be solely responsible for the development of the design, noting that the construct of the design team had not changed over the years even though more specialist consultants are required
- Considered the relationships and interfaces with the construction team and the challenges of dealing with specialist subcontractors
- Stressed that changes to the project team were likely in the future but that the dynamic of the three teams (client, design and construction) would remain robust
- Clarified the different types of contracts required on projects and how they are used to construct the project team
- Underlined how new forms of contracts were being developed to bind the project team together more collaboratively
- Set out the adjustments required to the design process to dovetail with different forms of procurement
- Explained who might employ the design team, the pros and cons of each option and the issues to which the lead designer should be alert

CHAPTER 3

THE PROJECT STAGES: WHO DOES WHAT WHEN

Introduction

This chapter considers the need for a strategic framework, including a number of project stages, to help clients navigate their way through the process, particularly those commissioning a building for the first time. How clients efficiently move from the notion of commissioning a building to its successful handover and use are core to achieving the best project outcomes.

Over the years, and around the world, unwritten and informal ways of working have been replaced by more formal process maps or Plans of Work. This chapter looks at the similarity of these Plans of Work and how the stages are utilised to steer a design from its sketchy beginnings, through the client and stakeholder review processes, navigating the regulatory environment and procurement challenges as the detail is developed towards the information required to manufacture and construct the building.

The chapter then looks at how Plans of Work are beginning to look more holistically at the life of a building, creating circular processes that question the need for a new building in the first instance and how a building performance might be improved or better outcomes achieved In Use. It also considers the other complex project drivers, including different project team set-ups, different Procurement Strategygs and different timings for engaging with the planning process that make creating a single and coherent Plan of Work challenging.

The diversity of the project stages means that different skill sets and experience are required at each stage. A Project Roles Table is an effective means of determining who should be in the client, design and construction teams at each stage and can be developed alongside the Contractual Tree considered in the previous chapter.

The chapter concludes by considering the limitations of a Plan of Work due to the different drivers set out above, highlighting the importance of other documents to provide project-specific clarity around who will do what when by setting a Responsibility Matrix, including the options for who is best placed to produce this crucial project document.

What is a Plan of Work?

In many countries there is no formal set process for designing a building. 'The way to do it' is unwritten and unrecorded, with informal processes handed down from generation to generation of professionals. Regardless of where in the world a building is required, the core tasks are broadly the same:

- agreeing appointments with the professional team
- developing a brief with a client
- creating Concept Designs options
- coordinating the design
- preparing a planning application
- applying for planning consent
- developing a set of construction information
- preparing a tender
- obtaining consents required prior to construction
- awarding a Building Contract
- constructing the building and supervising construction
- handing over the keys.

This informal approach works well when buildings are designed using traditional forms and materials and where a country has one predominate Procurement Strategy for appointing a contractor. As the design process becomes more complex through new forms of procurement, modern methods of construction or topics such as sustainability and maintainability, this approach becomes unsustainable. Without a process map different members of the project team will have different versions of the right 'way to do it', making it inevitable that the project will be undertaken inefficiently.

In most countries the process maps are set by the professional institutes or by sector bodies. Figure 3.1 illustrates some of these. Some have pre-design stages, some do not. Some go beyond completion of construction, others do not. All have construction as a single stage. Key differences are:

- Some incorporate tendering stages and others are procurement agnostic (Figure 3.2), focusing on the design rather than procurement process.
- The design stages vary from two to four, underlining the challenges of the design process and the need to divide the design into a number of coherent stages that have clearly defined purposes prior to construction commencing.
- Few consider the importance and benefit of good briefing or the need for a building at the outset and how to link the start into Feedback from previous projects (see below).
- More Plans of Works are beginning to consider the life of the building beyond construction and how the design process and the building's handover processes impact on a building's performance.

Briefing

Good briefing is central to successfully kick-starting the design process and therefore the quality of the brief is of interest to the lead designer. The lead designer and design team should review the Initial Project Brief before commencing stage 2 to consider if it contains all of the requisite information required to start the design. Additional queries or exemplar visits might be useful ways of teasing out client likes or dislikes before commencing the design in earnest. The brief is developed in tandem with the stage 2 design recognizing that the brief and design need to iterate. The brief is frozen at the end of stage 2 when change control formally kicks in. In some sectors it is commonplace for a derogation schedule to sit alongside the Initial Project Brief rather than edit the brief per se. The lead designer also needs to review Project Strategies against the Project Brief checking for compliance where required. In many scenarios the brief has served its purpose by the end of stage 2 acting solely as a record of what was agreed. On some projects the brief continues as a contractual document. The lead designer needs to pay particular attention to its contents at the end of stage 2 where it is possible that contradictions with the Concept Design may exist.

Figure 3.1: Comparison of international Plans of Work

	Pre-Design		Design				Construction	Handover	In Use	End of Life
ACE (Europe)	0	1	2.1	2.2	2.3	2.4	3		4	5
	Initiative	Initiation	Concept Design	Preliminary Design	Developed Design	Detailed Design	Construction	NOT USED	Building Use	End of Life
AIA (USA)			–		–	–	–			
	NOT USED	NOT USED	Schematic Design	NOT USED	Design Development	Construction Documents	Construction	NOT USED	NOT USED	NOT USED
APM (Global)	0	1	2		3	4	5	6	7	
	Strategy	Outcome Definition	Feasibility	NOT USED	Concept Design	Detailed Design	Delivery	Project Close	Benefits Realisation	NOT USED
RIBA (UK)	0	1	2		3	4	5	6	7	
	Strategic Definition	Preparation and Brief	Concept Design	NOT USED	Developed Design	Technical Design	Construction	Handover & Close Out	In Use	NOT USED
Spain			–			–	–	–		
	NOT USED	NOT USED	Proyecto Básico	NOT USED	NOT USED	Proyecto de Ejecución	Dirección de Obra	Final de Obra	NOT USED	NOT USED
NATSPEC (Aus)		–	–	–	–	–	–		–	
	NOT USED	Establishment	Concept Design	Schematic Design	Design Development	Contract Documentation	Construction	NOT USED	Facility Management	NOT USED
NZCIC (NZ)		–	–	–	–	–	–		–	
	NOT USED	Pre-Design	Concept Design	Preliminary Design	Developed Design	Detailed Design	Construct	NOT USED	Operate	NOT USED
Russia			–	–	–	–	–			
	NOT USED	NOT USED	AGR Stage	Stage P	Tender Stage	Construction Documents	Construction	NOT USED	NOT USED	NOT USED
South Africa		1	2	3	–	4	5			
	NOT USED	Inception	Concept and Viability	Design Development	NOT USED	Documentation & Procurement	Construction	Close Out	NOT USED	NOT USED

Figure 3.2: Plans of Work: procurement agnostic, or not

	Design			
ACE (Europe)	Concept Design	Preliminary Design	Developed Design	Detailed Design
AIA (USA)	Schematic Design		Design Development	Construction Documents
APM (Global)	Feasibility		Concept Design	Detailed Design
RIBA (UK)	Concept Design		Developed Design	Technical Design
Spain	Proyecto Básico			Proyecto de Ejecución
NATSPEC (Aus)	Concept Design	Schematic Design	Design Development	Contract Documentation
NZCIC (NZ)	Concept Design	Preliminary Design	Developed Design	Detailed Design
Russia	AGR Stage	Stage P	Tender Stage	Construction Documents
South Africa	Concept and Viability	Design Development		Documentation & Procurement
Procurement Activity	Some Plans of Work focus on design activity only with procurement activity overlaid on the Plan of Work, i.e. they are agnostic of procurement. Other Plans of Work have stages (highlighted in black) incorporated that deal with procurement, tasks including tendering and contract. This is not feasible where countries use a number of Procurement Strategys.			

What is the RIBA Plan of Work?

The RIBA Plan of Work is a high-level process map developed by the RIBA for the briefing, design, construction and handover of a building. It acknowledges the In Use phase and the need for a feedback loop. It was created in 1963 and has evolved over the years to acknowledge changes in the way buildings are procured.

Figure 3.3 (overleaf) illustrates the RIBA Plan of Work.

Figure 3.3: The RIBA Plan of Work

RIBA

The **RIBA Plan of Work 2013** organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of key stages. The content of stages may vary or overlap to suit specific project requirements.

RIBA Plan of Work 2013 — Stages / Tasks	**0 Strategic Definition**	**1 Preparation and Brief**	**2 Concept Design**	**3 Developed Design**
Core Objectives	Identify client's **Business Case** and **Strategic Brief** and other core project requirements.	Develop **Project Objectives**, including **Quality Objectives** and **Project Outcomes**, **Sustainability Aspirations**, **Project Budget**, other parameters or constraints and develop **Initial Project Brief**. Undertake **Feasibility Studies** and review of **Site Information**.	Prepare **Concept Design**, including outline proposals for structural design, building services systems, outline specifications and preliminary **Cost Information** along with relevant **Project Strategies** in accordance with **Design Programme**. Agree alterations to brief and issue **Final Project Brief**.	Prepare **Developed Design**, including coordinated and updated proposals for structural design, building services systems, outline specifications, **Cost Information** and **Project Strategies** in accordance with **Design Programme**.
Procurement *Variable task bar	Initial considerations for assembling the project team.	Prepare **Project Roles Table** and **Contractual Tree** and continue assembling the project team.	<-- The procurement strategy does not fundamentally alter the progression of the design or the level of detail prepared at	a given stage. However, **Information Exchanges** will vary depending on the selected procurement route and **Building Contract**. A bespoke **RIBA Plan of Work**
Programme *Variable task bar	Establish **Project Programme**.	Review **Project Programme**.	Review **Project Programme**.	<-- The procurement route may dictate the **Project Programme** and result in certain stages overlapping
(Town) Planning *Variable task bar	Pre-application discussions.	Pre-application discussions.	<-- Planning applications are typically made using the Stage 3 output.	A bespoke **RIBA Plan of Work 2013** will identify when the
Suggested Key Support Tasks	Review **Feedback** from previous projects.	Prepare **Handover Strategy** and **Risk Assessments**. Agree **Schedule of Services**, **Design Responsibility Matrix** and **Information Exchanges** and prepare **Project Execution Plan** including **Technology** and **Communication Strategies** and consideration of **Common Standards** to be used.	Prepare **Sustainability Strategy**, **Maintenance and Operational Strategy** and review **Handover Strategy** and **Risk Assessments**. Undertake third party consultations as required and any **Research and Development** aspects. Review and update **Project Execution Plan**. Consider **Construction Strategy**, including offsite fabrication, and develop **Health and Safety Strategy**.	Review and update **Sustainability**, **Maintenance and Operational** and **Handover Strategies** and **Risk Assessments**. Undertake third party consultations as required and conclude **Research and Development** aspects. Review and update **Project Execution Plan**, including **Change Control Procedures**. Review and update **Construction** and **Health and Safety Strategies**.
Sustainability Checkpoints	**Sustainability Checkpoint — 0**	**Sustainability Checkpoint — 1**	**Sustainability Checkpoint — 2**	**Sustainability Checkpoint — 3**
Information Exchanges (at stage completion)	**Strategic Brief**.	**Initial Project Brief**.	**Concept Design** including outline structural and building services design, associated **Project Strategies**, preliminary **Cost Information** and **Final Project Brief**.	**Developed Design**, including the coordinated architectural, structural and building services design and updated **Cost Information**.
UK Government Information Exchanges	Not required.	Required.	Required.	Required.

***Variable task bar** – in creating a bespoke project or practice specific RIBA Plan of Work 2013 via www.ribaplanofwork.com a specific bar is selected from a number of options.

The **RIBA Plan of Work 2013** should be used solely as guidance for the preparation of detailed professional services contracts and building contracts.

www.ribaplanofwork.com

4 Technical Design	5 Construction	6 Handover and Close Out	7 In Use
Prepare **Technical Design** in accordance with **Design Responsibility Matrix** and **Project Strategies** to include all architectural, structural and building services information, specialist subcontractor design and specifications, in accordance with **Design Programme**.	Offsite manufacturing and onsite **Construction** in accordance with **Construction Programme** and resolution of **Design Queries** from site as they arise.	Handover of building and conclusion of **Building Contract**.	Undertake **In Use** services in accordance with **Schedule of Services**.
2013 will set out the specific tendering and procurement activities that will occur at each stage in relation to the chosen procurement route.	Administration of **Building Contract**, including regular site inspections and review of progress.	Conclude administration of **Building Contract**.	
or being undertaken concurrently. A bespoke **RIBA Plan of Work 2013** will clarify the stage overlaps.	The **Project Programme** will set out the specific stage dates and detailed programme durations.		
planning application is to be made.			
Review and update **Sustainability, Maintenance and Operational** and **Handover Strategies** and **Risk Assessments**. Prepare and submit Building Regulations submission and any other third party submissions requiring consent. Review and update **Project Execution Plan**. Review **Construction Strategy**, including sequencing, and update **Health and Safety Strategy**.	Review and update **Sustainability Strategy** and implement **Handover Strategy**, including agreement of information required for commissioning, training, handover, asset management, future monitoring and maintenance and ongoing compilation of **'As-constructed' Information**. Update **Construction** and **Health and Safety Strategies**.	Carry out activities listed in **Handover Strategy** including **Feedback** for use during the future life of the building or on future projects. Updating of **Project Information** as required.	Conclude activities listed in **Handover Strategy** including **Post-occupancy Evaluation**, review of **Project Performance**, **Project Outcomes** and **Research and Development** aspects. Updating of **Project Information**, as required, in response to ongoing client **Feedback** until the end of the building's life.
Sustainability Checkpoint — 4	**Sustainability Checkpoint — 5**	**Sustainability Checkpoint — 6**	**Sustainability Checkpoint — 7**
Completed **Technical Design** of the project.	**'As-constructed' Information**.	Updated **'As-constructed' Information**.	**'As-constructed' Information** updated in response to ongoing client **Feedback** and maintenance or operational developments.
Not required.	Not required.	Required.	As required.

How does an RIBA Plan of Work assist the lead designer?

The Plan of Work is a crucial tool for the lead designer. A consistent framework based around industry-recognised stages provides the structure for the lead designer to overlay their own more robust processes for developing the design with the design team.

Although the lead designer’s role is focused on the design stages, the lead designer should take an interest in the tasks required in the stages either side of the design stages in the RIBA Plan of Work. For example:

- What information allows clients to make better decisions related to selecting a site or preparing a Strategic Brief at stage 0?
- What are the aspects that make a good brief from the design team’s perspective?
- How can the design team assist in preparing the right information for project handover and the operation and management of the asset?
- What aspects might make the building function better In Use?

The impact of these topics from the lead designer’s perspective cannot be underestimated. They all place different emphasis on certain subjects, impacting on the tasks and deliverables at each stage. Topics that kick in after handover need to be considered by the client team at stage 1 so that the design team can give any requirements due consideration as the design progresses. Many post-construction aspects relating to sustainability or maintenance might place constraints on the design that impact on the aesthetics of a building, requiring greater and considered dialogue between the architect and the lead designer. Simply, the impact of pre-design tasks, particularly those framing post-handover information requirements or constraints, need to be carefully considered during the appointment process by the lead designer and the design team, and any requirements set out in the Professional Services Agreements.

Defining the roles required at each stage of a project

The RIBA Plan of Work underlines the different outcomes of each project stage and the diversity of the strategic tasks undertaken at each stage, highlighting the importance of the project team flexing at each stage in response to the tasks being undertaken. The Project Roles Table, illustrated in Figure 3.4, can be used to strategically set the project team. The crucial role of this table is to flush out the strategic considerations around who should be in each of the three project teams at each stage before the granular detail of who does what when is considered in the Responsibility Matrix. For example, the conversations that underpin the development of the project team in the example below might include:

- the client accepting that a management consultant is required to ensure that the Business Case is robust at stage 0
- the client acknowledging that a specialist FM adviser will help ensure that best practice in maintenance and operational requirements are considered in the Initial Project Brief at stage 1
- the client accepting that a Sustainability Adviser is required to set the brief and consider the design team's response at stage 2, with the project manager having sufficient experience to deal with any residual issues in the later stages
- the client agreeing that due to political issues surrounding the site a planning adviser is essential for joining pre-application discussions at stage 2 and for submitting the application at the end of stage 3
- the construction team's cost planning process negating the need for a cost consultant in the design team at stage 4
- the assumption that the lead designer will continue to drive forward health and safety issues after the Health and Safety Strategy has been set by the health and safety adviser at stage 2.

Figure 3.4: Project Roles Table

	When							
Who	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Client team								
Internal PM	✓	✓	✓	✓	✓	✓	✓	✓
Management consultant	✓							
Project manager	✓	✓	✓	✓	✓	✓	✓	
Cost consultant 1	✓	✓	✓	✓			✓	
RIBA client adviser		✓	✓					
Contract Administrator					✓	✓	✓	
FM adviser		✓	✓					
Internal FM team		✓	✓					
Sustainability adviser								
Planning adviser								
Design team								
Lead designer			✓	✓	✓	✓		
Architect			✓	✓	✓	✓		
C&S engineer			✓	✓	✓	✓		
M&E engineer			✓	✓	✓	✓		
Cost consultant 2			✓	✓				
Health and safety adviser			✓	✓				
Fire engineer			✓	✓				
Acoustician			✓					
Construction team								
Commercial team				✓	✓	✓	✓	
Procurement team				✓	✓	✓		
Package managers				✓	✓	✓	✓	
Design manager				✓	✓	✓		
Health and safety manager				✓	✓	✓		
Construction programmer					✓	✓		
Construction manager						✓		
Logistics team						✓		

Note: In this example, it has been assumed that a Planning Application will be submitted using the stage 3 deliverables and that the Procurement Strategy will be two-stage Design and Build, with the construction team appointed on a limited scope of duties for the commencement of stage 3.

A core challenge of using the Project Roles Table is that while it is sensible for the client to consider who is in the client team, it may not be wise for them to set who is in the design or construction teams. For example, who is best placed to decide if an acoustician or fire engineer is required? This is the challenge of determining who should be in the project team at each stage.

At what stages are the lead designer required?

The lead designer's skills are not required at every stage: if there is no design team there is no need for the lead designer. Figure 3.5 below adds clarity to this.

Figure 3.5: Project stages and the lead designer

Stage 0	The lead designer role is not required. However, if a number of large sites are being appraised by the client team as part of this stage, someone may be required to coordinate the effort.
Stage 1	The lead designer role is not required. However, if Feasibility Studies are undertaken by the client team as part of this stage, someone may be required to coordinate the effort should these studies go beyond massing models that demonstrate the brief can be accommodated on the site.
Stage 2	A key design stage with the lead designer role required. See throughout this publication.
Stage 3	A key design stage with the lead designer role required. See throughout this publication.
Stage 4	A key design stage with the lead designer role required. See throughout this publication. The complexity of this stage is the increasing role of the specialist subcontractors and the changing nature of deliverables. These topics are considered in Chapter 8.
Stage 5	The lead designer's involvement is not strictly required and will depend on the Procurement Strategy. A lot depends on the complexity of interfaces and if any Site Queries can be dealt with by the designers or if a lead designer is required to assist with the resolution of these. It should be noted that on many Procurement Strategys stages 4 and 5 overlap and that the lead designer is likely to be around anyway.
Stage 6	The lead designer role is not required, although inputs may be required to close out the Building Contract depending on the contractual arrangements.
Stage 7	The lead designer role is not required.

The more specific tasks and challenges for the lead designer are considered throughout Part B of this publication.

The limitations of the RIBA Plan of Work

A Plan of Work is an important tool on any project and while setting a more detailed framework for 'the way to do it' helps the client, and in particular those undertaking their first project, it is increasingly clear that a Plan of Work has its limitations and that greater definition on a number of topics is essential in parallel. For example, the RIBA Plan of Work cannot possibly cover the diversity of options for procurement, town planning, handover, modern methods of construction and many other core project aspects. To sit alongside the Plan of Work the following are required:

- Professional Services Agreements
- Building Contract
- Responsibility Matrix
- Schedule of Services
- Design Programmes
- Procurement Strategy
- Employer's Information Requirements
- BIM Execution Plan
- Project Strategies
- Project Execution Plan.

This list is not exhaustive; it merely underlines that the Plan of Work is a strategic tool and not a contractual document.

This chapter:

- Set out the need for a number of project stages to move a design through its different development stages to construction, completion and beyond
- Emphasised the importance of using a Plan of Work but recognises that this tool alone has limitations, due to different approaches to procurement, planning and other core topics
- Underlined the changing nature of the skills in the project team as the design is completed ready for manufacture and construction
- Clarified the goal of the Project Roles Table in strategically setting the members of the project team that are required at each stage

Part B

Leading and directing the design team

CHAPTER 4

MANAGING THE DESIGN PROCESS

Introduction

With the project team assembled the lead designer and the design team are ready to begin a project. This chapter considers some of the high-level concepts that frame the lead designer role, including intuition and iteration, collaborating and coordinating, and interfaces and interdependencies. It examines how technological changes are driving innovation and increasing the complexity of these challenges, which are unique to the lead designer role. It explains why these concepts, and the design process, need more than project management processes.

Iteration is crucial to the design process. A core role for the lead designer is managing the iterations of the design as unpredictable comments from clients and stakeholders are absorbed and fed into the complexity of the design process. The iterative challenge eases as the design progresses and aspects are progressively 'locked down', but the lead designer needs to be aware that a great deal of design is undertaken using the intuitive skills and experience of the designers. Clients have raised the bar, expecting their design team to understand every issue impacting on their specific sector and the lead designer must therefore unpick the biases and assumptions underpinning heuristic processes and the resultant information: was the design produced using knowledge and experience? Have detailed analysis, calculation and current best practice been used?

Facilitating good design and coordination requires a positive relationship between design team members and with the client and construction teams. The architect might provide the design leadership on a project, but the engineering requirements that might influence the aesthetics need to be developed, coordinated and integrated into the design by the lead designer. This chapter looks at the characteristics of exemplary teamwork and when collaborative efforts should be brought to bear to drive forward coordination efforts.

As well as understanding how each design team member works, the lead designer needs to understand how the tasks of the design team come together. They must understand the interfaces between the different tasks of the design team and, more crucially, the design dependences, i.e. when one design team member needs to receive an output from another. Managing interfaces and interdependencies has become more complicated due to an increase in the number of topics influencing the design process, such as sustainability or modern methods of construction (see Chapter 9) and shifts in design responsibility (see Chapter 8).

Technological change points to a future where less intuition and greater set knowledge is used on projects to aid client decision-making, leading to automation of parts of the design process and in turn fewer iterations. Ideas are woven throughout this chapter on how the lead designer can adapt to knowledge-driven design processes, facilitated by rapidly changing digital tools, to transform the design process and the work of the design team.

Intuition and iteration

The iterative nature of the design process

Many project tasks occur in a linear fashion: one task following another. However, one of the unique facets of design is that the detail cannot be undertaken in a repeatable, logical and linear fashion. A design must be iterated in response to many topics until it reaches the level of detail consistent with the end of a stage when it can be rigorously reviewed and signed-off to allow the next design stage to commence. These topics include the need to:

- find the right design solution
- balance the briefing requirements and constraints with the right design solution
- respond to client or stakeholder comments and reviews
- accommodate different solutions for different briefs or site constraints
- react to the many factors that influence the design process
- act in accordance with directions and decisions given by the client
- bring the design in line with the Cost Plan
- coordinate the design
- align Project Strategies
- replace assumptions with fact

- replace rules of thumb engineering contributions with more detailed engineering analysis
- acknowledge the dynamic of assembling the project team in different ways
- react to the nuances of different Procurement Strategys.

This list is not comprehensive; however, it underlines the depth of topics driving iterations on a project and the challenges that the lead designer faces. Although there are means of reducing the iterations of a design, such as seeking early client decisions or examining feedback and re-using successful design elements from previous projects, the variables on any project make it difficult to predict what will need to be iterated and when. For example, on some projects the ideas might flow early and be well received by the client, yet on the next project the right solution might require adjustments to suit the client – with stakeholder comments creating further complexities and iterations. Reacting in response to these changing dynamics is core to the lead designer role.

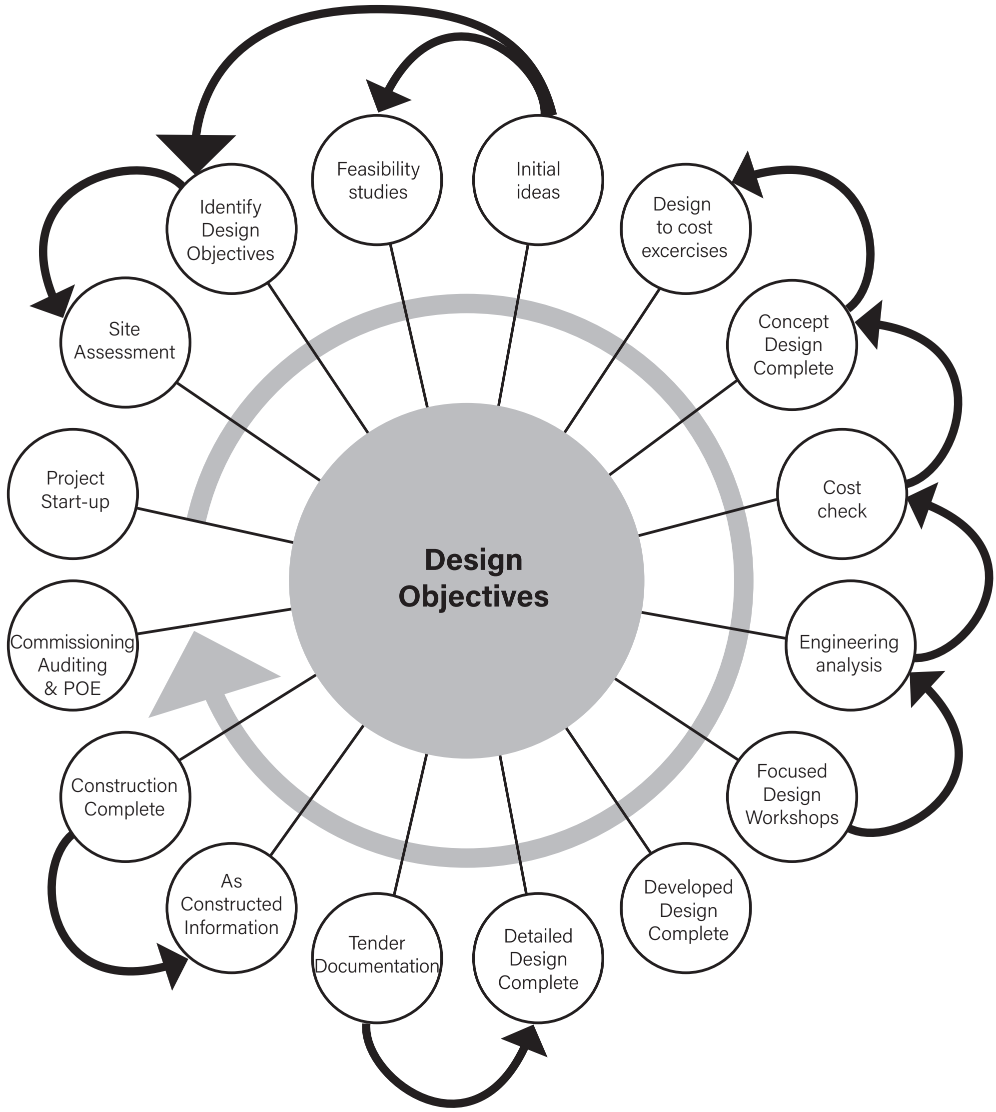
Iteration is the act of repeating a process with the aim of achieving a specific objective. Each repetition of the process is called an 'iteration', and the results of one iteration become the starting point for the next.

Iterative design is a *design* methodology undertaken using a cyclic process of prototyping, testing, analysing and refining a product or process. Based on the results of the most recent iteration, changes and refinements are made.
This process is intended to ultimately improve the quality and functionality of the final design.

Iteration is at its most dynamic during the Concept Design when the big picture may not yet be clear. Conversely, by stage 4 any iterations should be minor, relating to interfaces or discrete parts of the building – for example, the detailing of a services component in the façade or the detailing of a canopy.

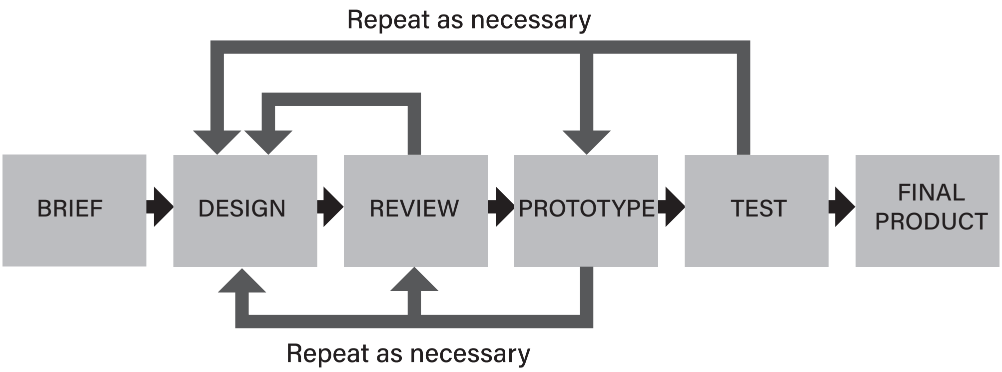
The iterative nature of design is better understood in the product design industry. This industry acknowledges the need for different stages to manage the development of a design, from the initial idea towards something capable of mass production. More importantly, it acknowledges that within each stage a number of tasks will have to be repeated. Figures such as 4.1 and 4.2 are commonly seen in design management books for product design; less so for architecture.

Figure 4.1: Iterative design process – example 1



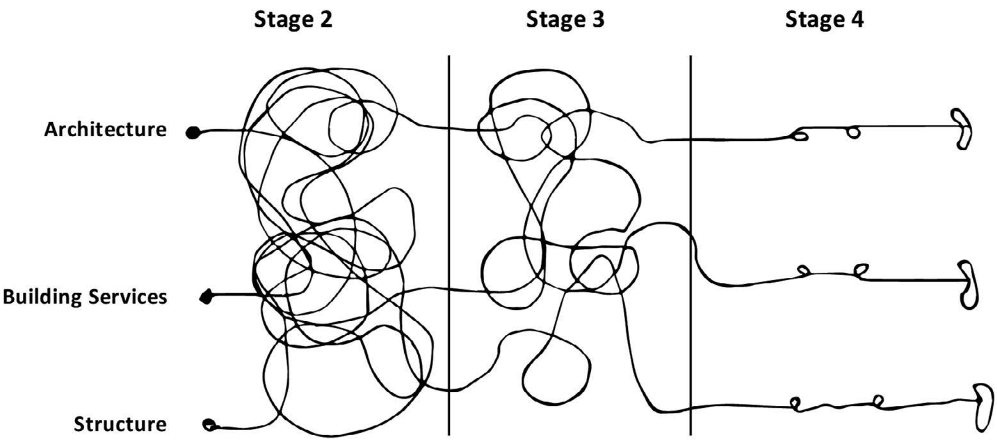
In manufacturing industries a prototype is refined in an iterative manner until it is ready to be put into mass production. This process is essential to discard ideas that do not work, in order to develop and integrate the aesthetics and engineering aspects, and is essential in preventing design or manufacturing errors that could have significant ramifications once a product has gone into mass production.

Figure 4.2: Iterative design process – example 2



Over the years various attempts have been made to improve the predictability and programming of the design process. Such initiatives, where task A leads to task B, to task C and so on, fail due to a lack of understanding of iteration in the design process. The lead designer needs to be alert to the need for iteration and to use the tools set out in the next chapter to manage the iterative process, avoiding pressure to produce detailed Design Programmes that are doomed to fail because of rapid changes in the design environment. Simply, iteration is core to a successful design process and the lead designer must create a Design Programme that acknowledges this.

Figure 4.3: Iteration on a project



The number of iterations is highest during stage 2, when comments from the client team and stakeholders influence the direction of the design and strategic coordination is underway. Fewer iterations are required during stage 3, as the design team finalise the coordination of the scheme and at stage 4 iterations should be restricted to minor ones at interfaces.

The dangers of intuitive design processes

Iteration is inevitable and essential. Conversely, intuitive design processes create design risks and can be the root cause of many iterations. Designing intuitively has always been core to the design process. While this is likely to remain the case for some time, the lead designer needs to consider ways of minimising the risks of heuristic processes. For example:

- Carrying out reviews of the design to make sure that proposals are aligned to the best practice for a particular sector or to meet statutory requirements (see Chapter 10).
- Carrying out peer reviews to ratify that the design is in line with the client's objectives and outcomes set out in the Project Brief or that it resonates with a practice's values and design ethos.
- Ensuring that the project constraints and any assumptions are clearly understood and monitored until they have been closed out.
- Reviewing the design against the Project Strategies to ensure that these strategies are aligned with each other and the geometric aspects of the project.
- Using Decision Trees, checklists or guidance notes (see Chapter 5) to capture practice knowledge and provide a more robust basis for creating and reviewing the design.
- Reducing decision-making processes on projects by using Decision Trees to consider the design topics with which the client wants to engage.
- Considering ways of capturing and reusing information from one project to the next and sharing knowledge with the next generation of designers.

It is inevitable that topics will be forgotten about if designers use wholly heuristic means of designing. Furthermore, with a greater number of specialist consultants providing more detailed advice on a project, the knowledge required to manage and navigate through the design process has increased. It is progressively difficult for the knowledge coordinated to reside in the head of an individual and this needs to be factored into how the lead designer works in the future.

Facilitating better decision-making

Decision-making based around intuitive processes creates design and project risks because decisions are made:

- without the right information
- on the basis of assumptions not facts
- without considering the holistic impact on the design
- without recognising that one decision can impact on many aspects of the design
- without proper discussion or the right specialist present
- without considering regulations or the view of stakeholders.

Decision Trees, checklists and guidance (see Chapter 5) can provide greater clarity of the decision-making processes used by the lead designer and cause a shift towards a knowledge-centric design process. Some will be concerned that mapping out this knowledge in detail gives away the 'crown jewels' of the lead designer i.e. the knowledge and experience underpinning the coordination process. They should be comforted that this information alone does not result in great coordination. This requires good design skills, great communication and facilitating the right meetings and workshops at the right time along with the project experience required to maintain and update such information. Besides, these tools can be kept below the radar and not made available to everyone in the project or design team.

The benefit of the lead designer adopting Decision Trees, checklists and guidance is that it allows a shift away from the knowledge of the individual towards the knowledge of a practice and onwards to industry-wide knowledge. Digital tools and Artificial Intelligence (AI) love rules, and as more is mapped and understood about the design process it is inevitable that Decision Trees, checklists and guidance will lead to greater automation of the design process, starting with automated quality control processes. Those undertaking the lead designer role need to consider if they wish to drive and inform these new processes or if they wish to continue working in entirely intuitive ways.

Shifting away from intuitive design processes exposes the scale of decision-making made on a project. The Decision Trees on p 136 reveal that hundreds of 'hidden' decisions are required for seemingly straightforward topics. By exposing the volume of decisions made intuitively on a project, new ways of making decisions can be made. These will define the design processes of the future. More importantly, the client can be engaged with decision-making earlier in the design process, speeding up design by reducing the number of iterations required.

Coordinating and collaborating

Whilst iteration and intuition are concepts at the heart of the design process, coordinating and collaborating are core skills that underpin the lead designer role. The challenges of coordinating in an iterative environment are substantial, particularly when the lead designer needs to collaborate with a heuristically orientated team that is coming together for the first time.

What is coordination?

Coordinating a design is about making sure that the work of everyone in the design team is aligned and in accordance with the requirements of the client's brief. For example:

- the spatial arrangements meet the requirements of the brief
- the architect's partition specification meets the requirements of the acoustic brief
- the building service's information is aligned to the fire strategy
- the façade design is aligned to the Cost Plan and meets the vision set in the brief
- the mechanical design is seamlessly integrated into the architectural concept.

There are a number of crucial factors that impact the coordination process:

1. The initial spark that creates the first ideas for the building concepts may take time and a number of options may need to be developed and evaluated before the client selects the best solution.
2. A design increases in detail as it progresses from stage 2, when the Concept Design is created, through to stage 4, when the information for manufacturing and constructing the building is prepared, creating different coordination challenges at each stage.
3. When designing a building, aesthetics are important. Many coordination tasks are driven by the consideration of how engineering aspects impact on the appearance of the building.
4. On many occasions a number of approaches will be possible and a number of designers will need to contribute to the coordinated solution. The client team's views also need to be factored into the coordination and decision-making processes.
5. The design team has diverse skills, experience and knowledge, with some individuals contributing to the design regularly and others providing specific and strategic advice at a particular point in time.

6. The end of a stage may serve a specific goal or be used as a gateway for a client's internal processes. This might need the coordination bar to be raised for the end of a stage or additional information to be provided and coordinated – for example, submitting a planning application at stage 2 or providing a more detailed financial appraisal to obtain approval from a client's board at stage 3.
7. Coordination is not just about the geometry and geometric clashes. Text written by the design team in Project Strategies or other reports must be aligned and ambiguities or contradictions resolved.

'Coordinate' v 'coordinated' – there is more than a grammatical difference

The difference between tasks and outputs is very subtle but they create quite different liabilities. For example, to 'coordinate the preparation of a Design Programme' requires the lead designer to obtain information from the relevant parties (design team, client team and possibly third parties, such as utility companies) and to produce a Design Programme using the information obtained. The obligation to produce a 'coordinated Design Programme' is far more onerous and, indeed, may not be achievable. For example, the periods requested by everyone may not enable the Design Programme to work within the period set in the Project Programme. In these circumstances, it could be said that the lead designer has coordinated the inputs to a Design Programme with the design team but that the programme is not coordinated.

Equally, the requirement to 'coordinate the design' is less onerous than the requirement to produce 'a coordinated design.' For example, a discussion at a workshop may conclude how a specific design aspect is to progress: the structural and mechanical engineering aspects of a plant room, for example. The Design Status Schedule might record how the design was coordinated but one of the design team members – say the mechanical services designer – may not incorporate the agreed approach into their design. The lead designer can demonstrate that they carried out their obligation to 'coordinate the design' but as the mechanical services designer's drawings will not correlate with this there is not a coordinated design.

It is important to dwell on these differences and more importantly to consider how the lead designer can demonstrate that they have successfully carried out any coordination duties.

A core role of the lead designer is to determine when and how the skills of the design team must be brought to bear in response to these topics. Although the Responsibility Matrix sets the logic of who does what when, the iterative nature of design makes it difficult to determine precisely the co-ordination activities that will move forward a design at a specific point in time. This requires the experience and judgement of the lead designer. A design cannot be fully resolved at the outset and it can be counterproductive to try and produce too much information too quickly when there are substantive design issues being discussed. Simply, if it was easy to coordinate, there would only be one design stage.

Stage 2: Concept Design

The coordination challenge is greatest at stage 2. The architect starts with some initial ideas in response to the brief and information is fluid as these are created, tested, discarded, presented and iterated until one that meets the project outcomes becomes clear. The complexity and difficulties of this stage depend on many factors, including the size and complexity of the project and the chemistry between project team members and key stakeholders. During this stage coordination focuses on two topics:

1. The architect's geometry

By the end of stage 2 the architect's geometry needs to be as robust as possible. This entails:

- producing a Concept Design that meets the requirements of the Initial Project Brief, including the areas set out and any adjacencies that must be adhered to or agreeing derogations and adjustments to the brief
- everything that the client can see should be illustrated where possible – using new digital tools enables the new types of design review (see immersive technologies on p 232)
- incorporating the right strategic rules of thumb engineering contributions into the architect's geometric project information and the right time to do so – for example, plant room locations and dimensions
- unpicking the tasks that need to be done in order to set the architect's geometry – for example, acoustic advice that might influence the building's position or a point cloud survey to provide information on a sloping site.

2. The Cost Plan

There is no point pinning down the building's geometry if the resultant building is unaffordable. As the geometry is progressing, the lead designer must facilitate designing to cost measures. These are set out in Chapter 9.

From the lead designer's perspective, everything other than the above is superfluous at stage 2. If a subject does not impact these two topics it should have a low priority. With larger project teams every member of the team will want to contribute to the design or a project manager tick off tasks that do not add value to the design process. Focusing on these two core points will result in a well-coordinated building. Being flexible and able to rapidly respond to changes to the Concept Design as the architect iterates following design reviews with the client and other stakeholders are central to this goal.

Creating the right Design Programme (p 150) and using the best supporting tools (Chapter 7) is important. Determining the best time for the design team to dial up their contributions requires a combination of gut instinct and an objective review of the status of the design. The lead designer should monitor initial ideas and always be considering the technical issues and design challenges that need to be addressed.

A core challenge for the lead designer is how to kick-start the coordination process. There is no right solution. Using 'light but right' engineering principles based on rules of thumb is an effective way for the building services engineer to provide the information required to embed engineering requirements into the architect's geometry. It is better to have quick and dirty high-level strategies incorporated into the architect's information to allow coordination conversations to take place. Waiting until the design has settled sufficiently to allow detailed calculations to be undertaken is counterproductive to the coordination process and can result in further iterations of the design, requiring additional presentations to the client. Conversely, although locating engineering aspects such as plant rooms, riser locations or the structural grid is crucial, there is no point in considering these until the basics of the scheme have settled down: will it be a five-storey building with 3,000 sq.m. floor plates or a 30-storey building where they are 500 sq.m.? To get things going, the lead designer can identify the challenges and information required to start the design process solution, providing the bones from which to build the collaborative process. For example:

- A city centre site in a historic location might dictate that less plant than normal is located on the roof, requiring early consideration of alternatives. Facilitating conversations with the building services engineer will allow feasible strategies to be filtered into the architect's concepts early, allowing these to be tested and refined as the design progresses and the client's reactions to these are determined.
- Height restrictions might dictate the reduction of floor-to-floor heights in order to create more lettable floors or saleable apartments. The lead designer needs to be cautious of going below sector norms and in such instances may need to carry out additional coordination early on around common pinch points. The lead designer might facilitate workshops with the structural and building services engineers to provide the initial information required to allow different options to be explored and developed.
- Large span spaces might be required in a mixed-use development, resulting in different floor-to-floor heights as transfer structures or other solutions are explored.

Indicative beam depths can be provided by the structural engineer to allow the architect to test the implications of changes to the floor-to-floor heights on other aspects, such as the staircases, allowing any constraints that the engineer must work to be determined.

These examples illustrate the diversity of coordination tasks, which might include:

- Developing options for the structural solution for the building, including grids and floor-to-floor heights. The architect's geometry becomes more robust when this is illustrated.
- Considering the best locations for plant rooms and major riser locations. Show approximate sizes and adjust these in line with a riser schedule when it is provided by the building services engineer.
- Analysing ground conditions and considering possible substructure and foundation options, and recommendations for the most appropriate solution to allow costs to be determined.
- Developing typical bay drawings, showing the different grid and structural options that have been considered for the main frame, along with major services routes, ceiling heights, floor voids or other requirements. Consider knock-on strategies, such as the design of staircases.
- Sketching details for any specialist structures that may be required for atriums or entrances to allow costs to be considered.
- Preparing initial strategies and schematics for the various building services systems in the building with geometric information where these impact on coordination or cost.
- Considering the inputs from specialist consultants. For example, a residential scheme next to a railway line or the idea of an open atrium will clearly need early contributions from acousticians or fire engineers, respectively. However, on other projects the contributions – if any – from these specialist consultants might wait until stage 3.
- Aligning health and safety, modern methods of construction, sustainability, maintenance and operational considerations with the rest of the design. The lead designer needs to work closely with the architect to review which topics should be investigated early. In many instances contributions can be left until stage 3.

More experienced lead designers will have a good understanding of the topics that need to be investigated at a given time without wasting the valuable resources of the design team. Producing too much information can be counterproductive to the design process, whereas producing too little can result in areas of the design not being robust and information taking a step backwards at the commencement of stage 3.

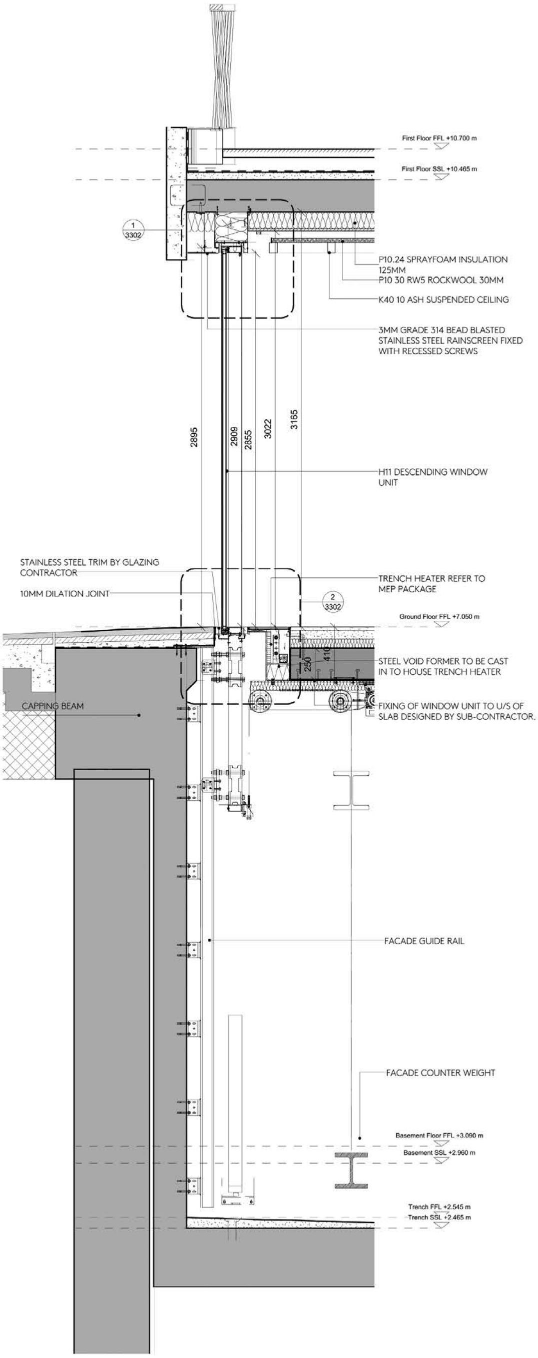
The more robust the engineering contributions to stage 2, the more effective stage 3 will be. As there is no common understanding of 'what good looks like', the lead designer will need to tease out the tasks required to make the Concept Design as robust as possible. In some instances these may be dictated in the Responsibility Matrix. If not, the lead designer needs to determine what has to be done, although this may be tempered by the time available or the complexity of the project. For example, on a small residential project there is no reason why engineering considerations should not be properly considered early. However, a complex mixed-use development may have certain engineering aspects that are not possible to explore early on. It is important to always check against the two criteria above and the purpose of the stage information.

Stage 3: Developed Design

At stage 2 the architect/client relationship is crucial, with the lead designer having a light but important touch on the design process. Changing the architect's geometry after stage 3 can have a significant impact on everyone's design work at stage 4. To avoid this, the lead designer comes centre stage, coordinating the design and making sure that the architect's geometry is robust, save for minor details. The core coordination goals of this stage are therefore:

- ► undertaking detailed engineering analysis and preparing the geometric information required to conclude the architect's geometric information
- ► moving beyond typical bays to the building's edges and more complex areas to check that the same logic for heights or grids work throughout the building
- ► looking at specific aspects of the building, such as a canopy or the development of a core, making sure that every coordination issue has been considered. Task teams (see p 106) might be created to collaboratively work from one complex area or topic to the next
- ► involving suppliers or specialist subcontractors where the design needs specialist input to conclude the architect's geometric information
- ► considering engineering schematics in greater detail, including access arrangements or items that require aesthetic consideration, such as fire alarm panels or dry riser inlets
- ► considering regulatory or environmental issues in detail
- ► updating and coordinating the contents of the Project Strategies (assuming that any impacting the architect's geometry or cost have been dealt with at stage 2), including the detailed work of specialist consultants
- ► undertaking engineering analysis to contribute to development of façades, e.g. wind tunnel testing or daylighting analysis.

Figure 4.4: Section through the retractable glazing at the Duke of York Restaurant by Nex Architects, showing the coordination associated with a retractable glazing system



1 **DETAIL SECTION AA RETRACTABLE GLAZING**
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Figure 4.5: Leveraging BIM for coordination

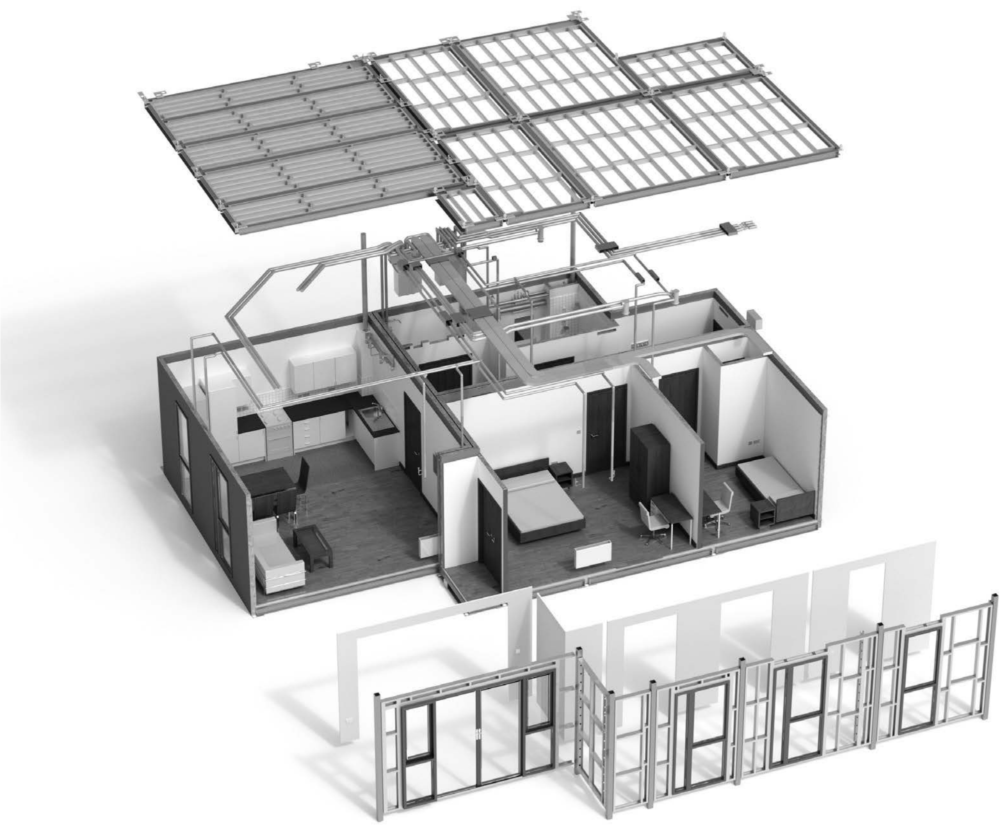


Figure 4.5 shows BIM being used to identify and coordinate the different building systems for a residential project, including the façade, mechanical services, structure and architectural finishes.

Figure 4.6: Leveraging 3D for design

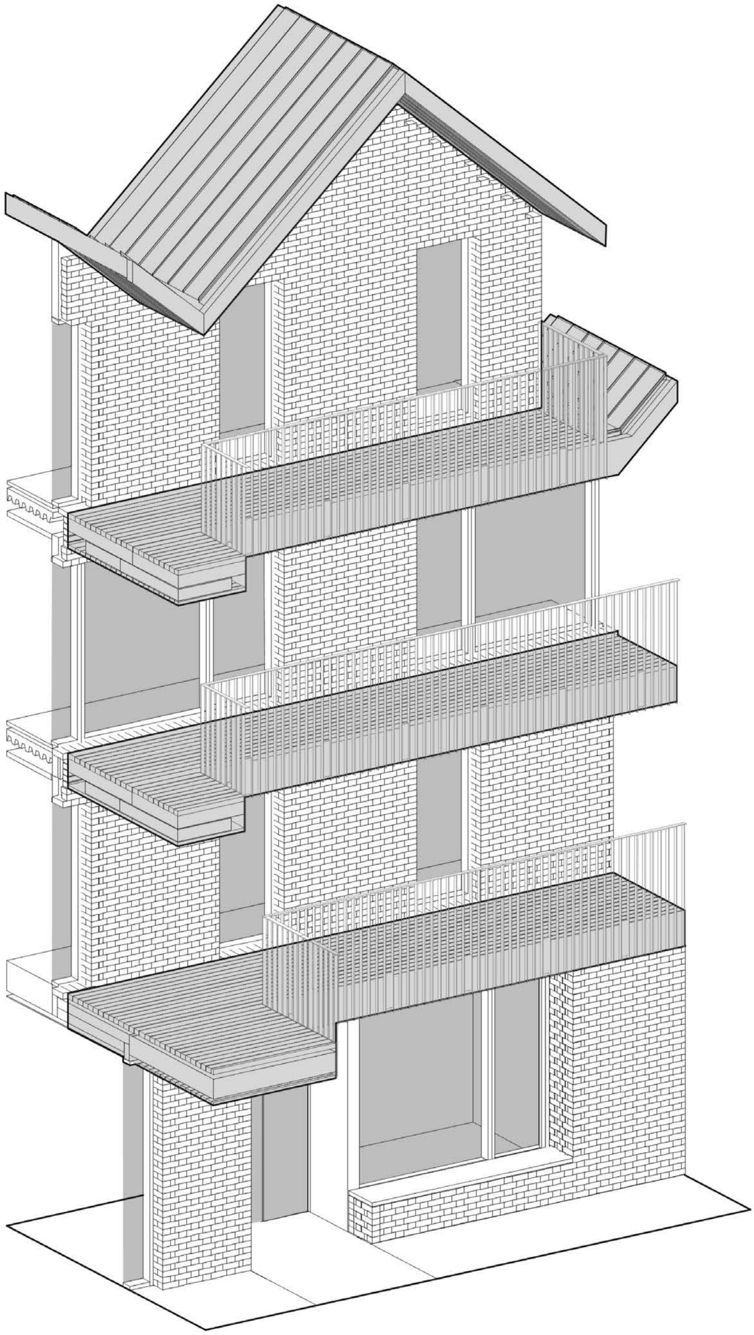
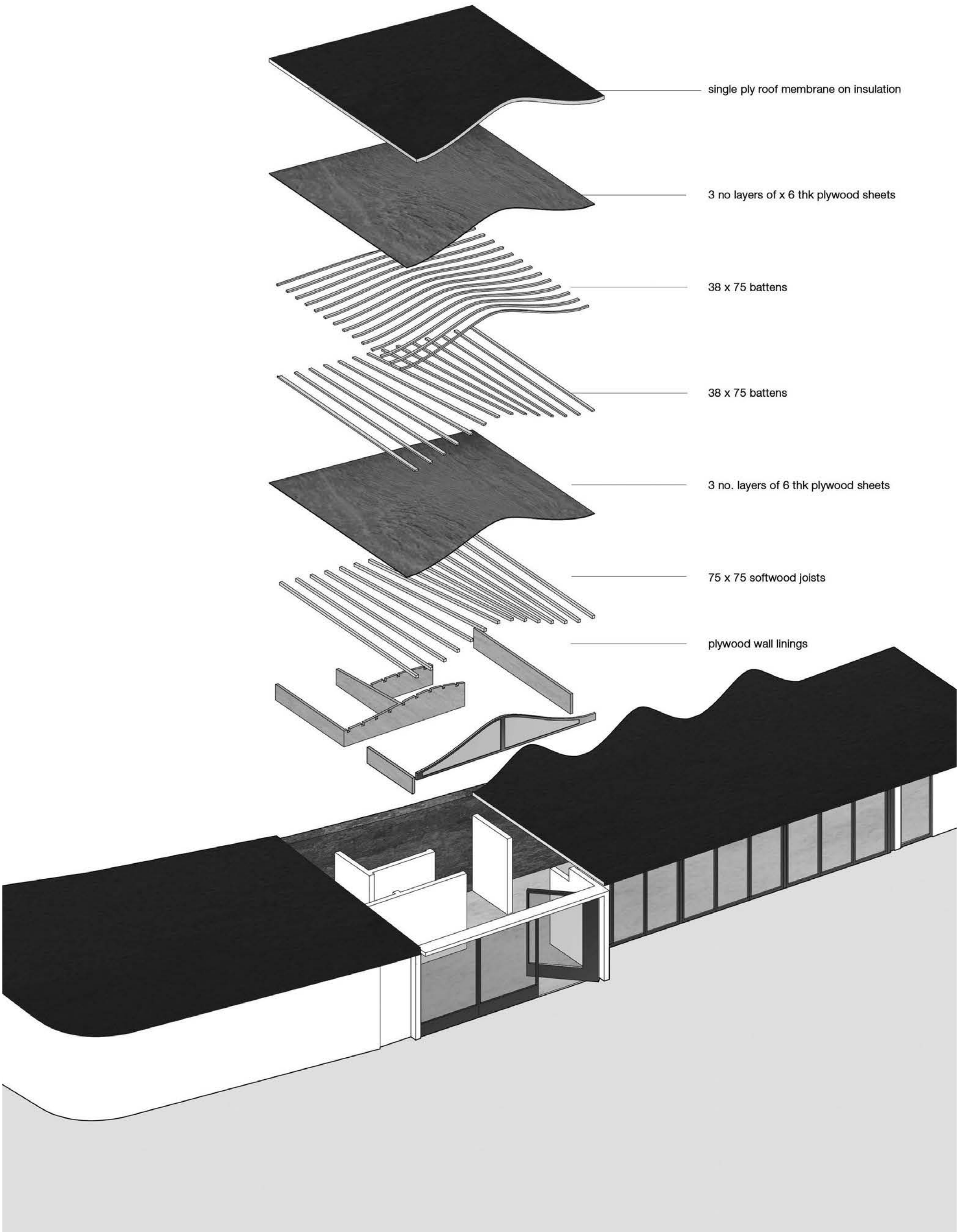


Figure 4.6 shows 3D drawing being used to study and coordinate brickwork and balustrading detailing on a residential project and to examine roof and threshold detailing.

Figure 4.7: Exploded Axonometric exploring the roof construction for the Jubilee Pool in Penzance



With the Concept Design signed-off, stage 3 needs everyone in the design team involved and might be defined as validation of the Concept Design through engineering. The engineering teams must shift beyond rules of thumb contributions and take their designs to the next level. Contributions from specialist consultants must be developed and incorporated into the design. The architect will want to look at aspects where aesthetics are important, as more granular aspects of the design progress and geometry, data and analysis progress in tandem. The objective at the end of stage 3 is a coordinated design completed in sufficient detail to enable each designer to prepare their design intent (descriptive) or construction (prescriptive) information at stage 4.

More importantly, the coordinated information should include the architect's final geometry, although minor tweaks around interfaces may be necessary at stage 4. The single biggest challenge to this goal is the contributions required from specialist subcontractors. A core object for the lead designer is recording where the architect's geometry cannot be progressed with this goal in mind. The Design Status Schedule is a useful tool for making sure the reasons are clear and that the timing of closing out any residual issues are comprehensible to all parties, although high-level issues should be agreed at the outset. Lifts are a good example. Have they been designed to British Standards (BS) or to suit the sizes of a number of manufacturers? Will fixing the shaft result in additional costs during the tendering process? Or, can a way of adapting the shaft later in the design process to suit the successful lift manufacturer be agreed? Can the lift manufacturer be appointed early?

The work of the specialist consultants should, on the whole, be complete by the end of this stage, as they do not generally produce information at stage 4. Members of the design team may pass the design baton on to another team at the end of stage 3 and a means of determining the robustness of the design team's information needs to be considered for this scenario. Coordination goals should take precedence over other project goals at stage 3; however, additional tasks may be required in order to provide information for procurement purposes to conclude statutory consents such as submitting a Planning Application or to achieve Building Control Approval. The Responsibility Matrix should take cognisance of these factors, allowing the lead designer to prepare the stage 3 Design Programme accordingly (see p 153).

One challenge is the diversity of digital tools used by the design team during this stage. This can be a crucial consideration and workflow diagrams (see p 139) may be necessary to unpick how the tasks of this stage will be undertaken prior to the preparation of a Design Programme.

Stage 4: Technical design

With the core iterative processes complete at the end of stage 3 and the architect's geometry substantially concluded, stage 4 focuses on the development of information for manufacturing or construction purposes. This information will be prepared by different members of the design team and/or specialist subcontractors as set out in the Responsibility Matrix.

Coordination at this stage is about the detail and should not impact on the spaces set in the architect's geometry. The Design Programme at this stage will be dictated by the Procurement Strategy and when the specialist subcontractors are appointed. The most effective stage 4, from the lead designer's perspective, is created when the design team and specialist subcontractors work in tandem and interfaces can be developed with the right design contributions. Where further information has been identified to conclude the architect's geometry, this must be prioritised. It should be remembered that the work of the specialist subcontractors should be integrated into, and not alter, the coordinated design, although minor tweaks at interfaces are inevitable. Coordination activities at stage 4 include:

- developing details where building services products interface with the architecture, such as door contacts, CCTV, grilles or lighting, and making sure that the aesthetic aspirations are aligned to the products selected by the building services engineer and the specifications and geometry coordinated accordingly
- considering how the detailed bracket arrangements by a specialist subcontractor, such as for a façade or a staircase, are aligned to the engineering assumptions made earlier in the design process and the aesthetic requirements set out in the architect's design intent information
- making sure that the final selection of materials and products does not change assumptions made elsewhere in the design – for example, the final glass specification is in accordance with daylighting and heat loss or gain assumptions.

If stages 2 and 3 have been successful, stage 4 should be straightforward. Where this is not the case it may be necessary to revisit aspects of stage 3, requiring adjustments to the architect's geometry which would have a knock-on effect on a number of designers' work. Understanding interdependencies (see next section on p 107) and workflow (p 139) are crucial to facilitating a successful stage 4 design and coordination process prior to manufacturing off-site or construction on-site during stage 5.

Stage 5 typically runs concurrent to stage 4 and the lead designer always needs to be mindful of the information required to maintain progress on-site. Quickly responding to Site Queries is core to concluding the design process; however, by leveraging digital tools and using the techniques and tools outlined in this publication it should be feasible to minimise Site Queries. The goal should be working towards a project with zero design queries, although given the nature of sites this can be challenging, particularly in relation to groundworks.

How is the work of the design team coordinated?

There are a number of measures that the lead designer can take to ensure that the design is coordinated, including:

- allocating a team member to focus on the work of another designer to ensure that this designer is developing their inputs in line with the Design Programme
- embedding a member of the lead designer's team in an engineer's office to contribute to and review design work as it is produced
- holding face-to-face and focused workshops with the right design team members present: it is beneficial to rotate such workshops around each designer's office
- using the Design Status Schedule (p 114) to communicate the status of the design to everyone in the project team, including hot topics (see p 116) and current coordination issues and actions
- devising an effective Communication Strategy, including how project meetings and workshops will contribute to the coordination process
- developing Project Strategies to sit alongside the geometry and data in the federated model, allowing decision-making processes to be clear and unambiguous
- developing checklists and guidance notes to use from project to project to decrease reliance on intuitive knowledge
- using Decision Trees (p 136) to tease out coordination issues and to consider any interfaces crucial to design development
- proactively reviewing design team information to avoid any design surprises at the end of a stage.

Ultimately there is no right or wrong way to coordinate. The lead designer must use knowledge and experience to determine the best means of moving a design forward at a given point in time.

Redefining coordination: digital tools

Digital tools and technologies allow the coordination process to be transformed. Conversely, they may encourage members of the design team to do too much too early. The lead designer must therefore place great emphasis on the purpose of the tasks being done at a particular point in time, setting out why they are important for the coordination process. This is particularly so at stage 2, when it can be easy to develop aspects of the design too far when the Concept Design has not been signed-off by the client nor well received by the planners or other stakeholders. Digital tools come into their own at stage 3. They allow the geometry of the core design team members to be assembled into a federated model, shifting away from 2D and towards 3D design reviews (see p 231).

The lead designer needs to think beyond geometry, considering how the data in the model can be leveraged into the design process or how other possibilities can be leveraged using digital tools. For example:

- using 5D tools (see p 174) to better integrate the Cost Plan to the work of the design team
- better connecting the engineering analysis packages to the geometric information – for example, using software that links to the architect's model to allow real-time feedback on topics such as the amount of glazing on a particular elevation
- using big data as part of evidence based design workflow
- linking 4D information to rehearse buildability and sequencing for aspects of the building as they are designed.

Digital tools can be powerful but they need the lead designer to consider new ways of working and to think through the possibilities offered by different tools using workflow diagrams (see p 139) or other tools. Although digital tools will transform the design process, they still need to be aligned to traditional design management tools such as the Design Status Schedule, making the transformative challenge more demanding as the lead designer figures out how to harness the best of old and new.

Federated model

A federated model comprises, as a minimum, the geometric information of the architect, the structural engineer and the building services engineer. When the federated model has been assembled it can be used to carry out coordination tasks, allowing the lead designer to direct the work of the design team and determine what aspects of the building need to be worked on at a specific point in time. The federated model progresses through WIP (Work-In-Progress), Shared and Published areas, recognising the need for individual designers to work on their own information before sharing it with the design team for collaborative coordination exercises prior to issuing for viewing and reviewing by the client team.

Common Data Environment (CDE)

The CDE is used to collect, manage and disseminate all project information. It might hold the native models – including the graphical model and non-graphical data – information extracted from these models – such as 2D information – as well as reports and other project information whether it has been created in a BIM or digital environment or using more conventional means. The CDE is sometimes referred to as the 'single source of truth' as it can be used to view all current information as well as previous versions. Aligned with the guidance given under PAS1192 and BS1192, the CDE is a core tool for the lead designer. The CDE can add value to the design process by fostering collaboration through faster and more effective sharing of each designer's current design, speeding up the iteration process. The CDE should not be confused with the EDMS (Electronic Document Management System), which is the means of transferring information to what is effectively an electronic and time-consuming document management system that brings no value to the design process.

Coordinating collaboratively

After decades of adversarial contracting, emphasis is being placed on the project team working together towards a common goal, regardless of the contractual mechanisms that are in place (see p 60). Any lead designer should encourage and endorse these approaches; however they need to carefully consider collaboration and dive deeper into the topic before considering it further.

Many award-winning buildings were created before collaboration became a buzzword. How the design team are assembled (see p 58) can have a significant impact on the design team's attitude towards teamwork. Design team members, regardless of who appoints them, can learn to understand that they need to work beyond their own skills, silos and competencies if a great design is to be created. They learn how to understand and accommodate the goals of the design team and contribute to the iterative development of aesthetic and functional requirements. Many effective design teams have been formed over the years, only to be disbanded at the end of a project when the client's goals have been achieved and the building is completed. This publication encourages clients to consider the benefits of employing high-performing teams who have worked together before.

Coordinating collaboratively

Cooperation
Cooperation is when a team shares information; however, no implicit shared purpose or goals are set, resulting in group members working primarily in pursuit of their individual goals and specifically those required by their contract.

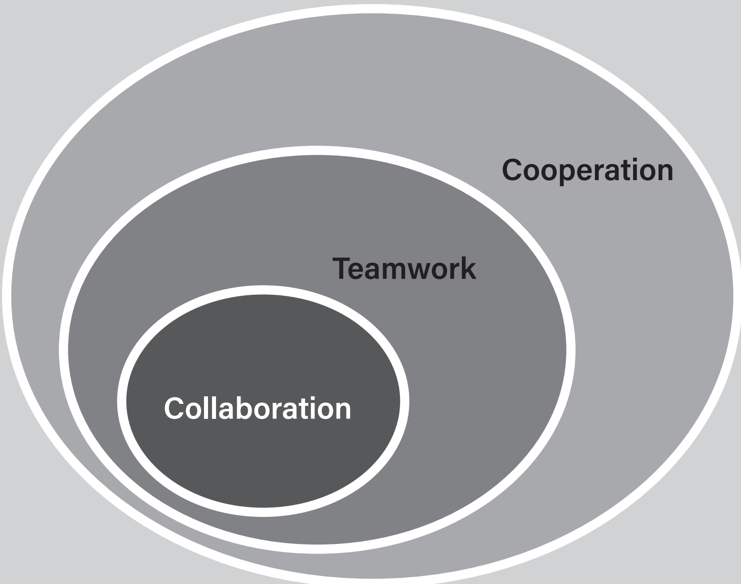
Teamwork
Teamwork takes cooperation up a notch and occurs when there is a shared purpose. Each team member undertakes identified tasks which contribute to the progress and outcome of the group as a whole. While teamwork requires excellent interpersonal and group communication skills, a successful team must have a strong leader to guide them towards their goal. With a strong leader and a clear outcome, it is not essential for team members to like each other in order to complete the project, because the leader controls the work of the group. With teamwork the goals might require team members to act against their own interests, including those contained in their contracts.

Collaboration
Collaboration, like teamwork, requires two or more people to work together towards a common goal. Unlike teamwork, where individual roles prevail, collaborators work together, feeding off one another as they make decisions, develop ideas and prepare strategies, filtering and refining their creative ideas as they collectively move a project forward. Core to collaboration is accepting the consensus of the group. Unlike a team, collaborators cannot rely on a leader to resolve differences and cannot walk away from each other when they disagree. Collaborators need to be carefully selected. It is essential that they have a high degree of respect for the technical knowledge, experience and competence of team members and they must trust each other. The best collaborators are not just creative; they are flexible, knowing when to let the ideas of others flourish.

Collaborative behaviours in the design team
- Everyone needs to have a high degree of commitment to achieving the common goals
- Problems need to be properly defined before they are resolved
- Everyone should listen to and acknowledge the concerns, views and ideas of others
- Allow everyone to air their views
- Credit for good ideas needs to be acknowledged and shared

- The knowledge, skills and experience of each team member need to be respected
- The need to creatively balance aesthetic and functional requirements needs to be acknowledged by all
- Personal opinions and areas of disagreement should be made tactfully
- The means of resolving any differences of opinions or disputes need to be considered
- Group decisions always need to be supported, even if everyone is in agreement

Figure 4.8: Cooperation, teamwork and collaboration



Shifting from cooperation to teamwork to collaboration requires improved behaviours. Collaboration is best used for those able to work in this type of environment.

When the descriptions above are transcribed to the work of the design team, it is clear that much of what the design team does can be done using teamwork. Many of the tasks, such as undertaking engineering analysis or the preparation of construction information for a building system, can be efficiently and effectively undertaken by individual design team members without broader collaboration, with the lead designer using the tools set out in this publication, such as the Design Programme or design status trackers, to manage and monitor progress.

A core dilemma for the lead designer is determining the situations where the design team needs to go beyond teamwork and employ collaborative practices. Situations requiring close collaboration might include those with complex interfaces and interdependencies. For example:

- A steel connection, where the architect and the structural engineer must work together to create an elegant solution that resolves the structural loads.
- The reflected ceiling layouts, where the architect and the building services engineers must balance the aesthetic demands with the rules for how different services are integrated into the ceiling.
- Designing the elevations to cost where a project has a challenging Cost Plan and stringent environmental criteria need to be adhered to.

Collaboration aids the design of key aspects of the building. An important point to note is that every task does not require every member of the design team to participate. However, to complicate matters the client and construction teams may have different interests in these topics. Using one of the examples above, the specialist steelwork subcontractor has a vested interest in how the steel connection is made and the construction team in the installation logistics, yet the client team may have no interest in its appearance. So from the lead designer's perspective, in summary:

- teamwork and collaboration are not the same thing
- good teamwork can deal with the majority of tasks undertaken by the design team
- collaboration may not always be required; teamwork is sufficient for many design team tasks
- topics benefitting from collaborative efforts need to be considered and framed carefully
- some design tasks benefit from collaborative teams assembled beyond the design team
- collaborators for selected topics need to be carefully selected
- removing leadership encourages everyone to be innovative and inventive.

Collaboration creates the right environment to enable those selected to put the correct energy and behaviours towards solving the challenge they are set. As everyone acts together, it creates a shift from the multidisciplinary working promoted by teamwork towards interdisciplinary working where everyone acts together to face a challenge, and the skills and experience of individuals is blurred: the design team of the future.

This publication advocates great teamwork for the development of a design with collaborative task teams formed to deal with a project's biggest challenges. Collaborative work can be framed in the Design Programme to acknowledge this approach (see p 145). As a great deal of the collaborative effort will be between the client, design and project team, the lead designer will need to liaise with all teams to consider what aspects need to be worked on collaboratively. What aspects would benefit from the client's direct involvement in the design process? Where can the construction team add value to the design process? What are the project challenges and hot topics that would benefit from a more focused effort?

Task teams in the design team

One of the notions embedded in the UK level 2 BIM suite of documents is the creation of task teams. Task teams are in essence mini-interdisciplinary teams focused on developing the design around a specific area of a project. For example, a task team might focus on the development of the façade system, the core of a building or the coordination around a complex area such as a plant room or entrance hall. The creation of task teams is a crucial step towards collaborative working and the first steps on the journey from multidisciplinary towards interdisciplinary working.

As the design team employs more digital tools and the number of iterations reduce, it is feasible that more aspects of the design will be undertaken collaboratively. However, in the short term, as teams transition from cooperative ways of working towards teamwork and beyond, collaborative efforts need to be considered carefully. More specifically, from the lead designer's perspective, they might include:

- Sharing information more effectively, allowing it to be leveraged more successfully by other members of the design team
- Better considering aspects from the client's perspective – for example, listening to their attitude to cost or seeking to obtain a deeper understanding of the requirements set out in the brief rather using a skin-deep review to kick-start the design process
- Understanding what information is required by the construction team for procurement or on-site, or helping facilitate greater use of manufacturing off-site before the information is produced
- Accepting the consensus of the project team where a topic might be counter to the aesthetics or design requirements.

Interfaces and interdependencies

Managing the interfaces and interdependencies amongst the design team are the final challenges for the lead designer. Interfaces are the detailed aspects of the project and how they come together. Most interfaces relate to geometric aspects. For example, how does the brickwork interface with the current walling or what is the interface of the ceiling with the air intake grilles? Interdependencies relate more to the tasks that need to be undertaken. For example, the architect finalising column positions to allow analysis of the building frame to be finalised and the structural frame layouts concluded.

What needs to be considered in relation to interfaces?

Interfaces:

- require the skills, experience and iterative contributions of a number of design team members before they are resolved
- can be complex, requiring two participants to resolve a mixture of aesthetic and functional considerations through design exercises and engineering analysis
- can be straightforward, requiring contributions from many designers
- can impact on only the geometric aspects
- may not impact geometry but have implications such as requiring Project Strategies to be updated
- can require the client team to make decisions.

Examples of interfaces between design team members include:

- setting out reflected ceiling plans to coordinate the lighting, smoke detection, air intake and extract grilles and sprinklers so they are aligned to the ceiling grid in a logical manner
- detailing exposed steelwork for a canopy and locating light fittings and other services in line with the aesthetic requirements for the canopy
- considering how the palette of materials selected by the architect meets the requirements set out in the Sustainability Strategy.

Interfaces have been historically managed using intuitive knowledge; however, they are best managed using design checklists (p 128) and guidance notes to make sure that every aspect is considered. Decision Trees (p 136) can be used to tease out the issues associated with new points with which the design team is unfamiliar and the Design Status Schedule can be used to monitor the progress of interfaces and of forthcoming actions from each design team member.

Due to the iterative nature of the design process, the Design Programme is not the most effective tool for managing interfaces but there may be value in producing a 'mini' Design Programme to help monitor progress or setting up a multidisciplinary task team for the more complex interfaces. This task team might work from a single designer's office for a short period of time to drive key aspects of the interface to conclusion.

Managing interfaces

Interfaces are best managed by considering who needs to contribute to their development and when the interface is best tackled. If it impacts on the architect's geometry it will need to be developed at stage 2 and if it is core to the coordination process at stage 3. Monodisciplinary interfaces can wait until stage 4, assuming, of course, that any cost considerations have been factored into the Cost Plan.

In some instances assumptions will need to be made to progress an interface. It can be easy for these to be forgotten about and not revisited with final information. Recording assumptions in the Design Status Schedule can act as a reminder for them to be revisited. Where descriptive approaches are being made, the lead designer will need to set zones or advocate that the relevant designer produces design intent information that can act as a placeholder until the specialist subcontractor is on board and can complete the design. These interfaces need particular attention to avoid iterations late in the design process.

As some designers may not be involved in the early design stages, the lead designer needs to consider how to obtain the requirements or constraints from those designers. For example:

- contacting suppliers to determine the constraints set by their products, such as power supplies, loadings or finishes limitations
- meeting specialist subcontractors to discuss ideas and how interfaces, such as those with the structural frame, or interfaces with other specialist subcontractors might work
- holding workshops with the construction team to review likely sequencing or other site constraints.

To resolve interfaces, the lead designer needs to facilitate meetings with those that can best contribute to their resolution, including members of the design team, the contractor, specialist subcontractors or the potential suppliers of products and materials. In some scenarios, the client's view or a cost decision may also be required.

How do interdependencies differ from interfaces?

Interfaces focus on the relationship of the building's systems. Interdependencies can impact on any aspect of the design where one designer needs an input from another. The lead designer needs to understand the interdependencies that occur on a project in granular detail in order to manage the design process. Examples of interdependencies include:

- At stage 2 the architect cannot add plant rooms and main risers to his developing plans until the areas for this have been provided by the building services engineer. While the Design Status Schedule may state when this information is required, there are benefits in having a milestone date in a programme to monitor this closely. However, an iterative process may be required to enable the building services designer to produce this schedule. (Are we using gas, electricity, renewable energy? Where do the utilities companies want incoming supplies to be located?) And, afterwards, there will certainly be an iterative process to get a location and size to fit within the building concept and the emerging structural grids. Programming and persistent discussions at design workshops are the only means of driving interfaces to a conclusion.
- Without the ceiling grid the building services engineer cannot begin to position grilles, light fittings and any other elements positioned in the ceiling. To overcome this the architect can develop a ceiling layout early in the design process, have it signed-off by the client and cost-checked following discussions with suppliers. Coordination workshops determine how the services might be laid out in the ceiling. A by-product of this approach is that the model is more robust when viewed in an immersive environment.
- The location of curtain walling brackets, stair or atrium balustrading brackets, and their method of fixing, is required from the relevant specialist subcontractor and they might be fixed to the top or side of the adjacent slab. These variables may impact on the design of the adjacent structure, which may already have been constructed, and any constraints should be stated on the design intent drawings. To overcome this, the principles of fixing will need to be discussed with the structural engineer to enable them to make load allowances when designing the main frame.
- A building maintenance unit (BMU) for cleaning façades is proposed on the roof. Every manufacturer has different rail details and support plinths centres, and the structural engineer cannot issue the construction information for the roof until they are provided with this information. The design intent information might be created to be flexible in this regard, allowing all the systems to be compliant at tender stage and therefore allowing the most competitive price. However, if the procurement cycle stalls and the specialist subcontractor for the access equipment is brought on board late, and is therefore unable to complete his design, there could be delays to

the structural engineer issuing his roof slab information, resulting in a claim from the concrete subcontractor. There is no specific solution to scenarios such as this other than making sure that the issue of late information is not a result of the design teams actions and continuing to press the construction team to obtain design information from the BMU specialist subcontractor as early as possible.

These examples underline the diversity of interdependencies encountered during the design process and the difficulties for the lead designer in determining when each should be tackled in order to add value to the design process and reduce iterations at the next stage. Core to this should always be unpicking if one topic impacts on a number of designers or the design, or if an aspect can be dealt with by one designer.

How are interdependencies determined?

The majority of interdependencies are clear on a project. The lead designer needs to be alert to the fact that the increased rise of specialist consultants during the early design stages and the increase in topics influencing the design – such as sustainability or modern methods of construction – brings a significant increase in the complexity and importance of this topic. As the design concludes, the interdependencies between the design team and the specialist subcontractors create further complexity where there is limited information advising on the best way forward.

Managing design dependencies

Although intuitive knowledge derived from experience is essential in managing design interdependencies, design checklists, decision trees or guidance can be used to map out and determine the interdependencies on a project. Once these have been identified, it becomes easier to manage them. There are a number of methods of doing this:

- Milestones can be included in the Design Programme for critical interdependencies, such as the issue of plant room schedules or ceiling layouts.
- The Design Status Schedule can be used to add and track less critical but nonetheless important interdependencies.
- Activities can be reprogrammed and produced earlier than originally anticipated. This is of particular importance with the work of specialist subcontractors whose packages may have to be procured earlier in order to close out key design interdependencies.
- The design team can make assumptions and then ensure that those tendering are aware of these (using the Design Status Schedule) and the tenderers can then price on the basis of these assumptions. An example of this would be basing the lift shaft sizes not on the British Standards but on the smallest size capable of fitting all tenderers lifts but placing this as a constraint due to steelwork being manufactured.

At the outset of a project interdependencies need to be flushed out by the lead designer and the right stage for the necessary inputs agreed with the design team.

This chapter:

- ► Explained the importance of iteration and intuition in the design process and how these unique concepts might be harnessed effectively by the lead designer
- ► Considered that team teamwork and collaboration need careful consideration if they are to assist with the complexities of the coordination process
- ► Set out the challenges of design interfaces and interdependencies, and how these are best managed

CHAPTER 5

EIGHT ESSENTIAL DESIGN MANAGEMENT TOOLS

Introduction

If the lead designer is to limit the number of iterations to those adding value to the design process, it is essential that the intuitive knowledge about the coordination of a project no longer resides in the head of the lead designer or other members of the design team. Knowledge and decision-making needs to be shared and made available to everyone in the project team.

A Design Status Schedule can be used to perform this function. This chapter looks at this and other design management tools that can be used to underpin the lead designer role, and at the importance of effective communication, including how different types of meetings can be leveraged by the lead designer to effectively direct the design team.

To shift away from design processes driven by heuristic knowledge, the lead designer needs to develop and advocate the use of checklists and guidance decision-making tools, such as decision trees (see p 136) can also assist a digital approach. Digital tools require a constant evaluation of new approaches and in this context workflow diagrams become crucial as more and more aspects of the design process are automated. However, traditional design management tools are still required. For example, Project Strategies are likely to sit outside the model, yet they are of equal importance in a project environment.

No one tool will make the design process successful. In reality, a number of tools are required. The secret of good design management is using the right tools at the right time and to do this, the value that each tool brings to the design process needs to be understood. If a tool is not adding value at a specific point in time, the lead designer needs to be flexible and look at other tools. The eight essential design management tools alluded to above are considered in this chapter. In summary they are:

1. Design Status Schedule
2. Effective communication
3. Project meetings
4. Project Strategies
5. Checklists
6. Guidance
7. Decision-making
8. Workflow diagrams

There are a number of strategic design management topics that sit above these eight tools, including:

- designing on time
- designing to cost
- better connecting design to manufacturing and construction information
- the need for different types of design review.

These four topics are considered in detail in Chapters 6 to 10 exclusively.

Design Status Schedule

The lead designer needs to demonstrate that they are successfully directing the work of the design team and managing the iterative nature of the design process and the subtle nuances of each stage. This can be done orally but it is much more effective if the lead designer can demonstrate in writing that they are on top of things. Communicating the current status of the design is a crucial task for the lead designer. It:

- gives the client team the confidence that the design is progressing as planned
- highlights design risks, allowing those managing them to take appropriate measures
- alerts the client team to the current concerns or challenges of the design team
- allows the design team to understand what tasks they should be focusing on next

- allows the design team to understand decisions that have been made by the client team
- records decision-making by any member of the project team.

Formal minutes can be used to record the discussions of any meeting and while they may be useful for a design team meeting, they take time to craft and are not an effective way of recording and monitoring workshops where separate minutes or notes become difficult to track, particularly if different subjects are discussed and different people attend each week. A Design Status Schedule can overcome these issues. To be effective it must be up to date and, crucially, concise, so that the design team use it as a working tool. A 100-page document serves no purpose whatsoever if it is not constantly referred to and seen as a proactive coordination tool. The lead designer can use this schedule to:

- record discussions associated with the development of structural engineering and building services designs in the early stages of the project, such as the:
  - development of structural grids
  - plant room and riser locations
  - materials being considered for the façade
- record decision-making with the client team – for example, the specification of finishes
- demonstrate that the design is being coordinated as planned
- ratify that the design is progressing as set out in the Design Programme, noting key coordination tasks and actions
- record the status of key aspects of the design
- record discussions on cost allowances, the level of specification or design aspects where the Cost Plan needs to be developed
- categorise the importance of items (hot topics)
- flag elements where responses from stakeholders, including utility companies, are preventing aspects of the design from being developed
- inform the construction team of the status of the design and allow them to:
  - familiarise themselves with the status of the design and determine an appropriate level of risk in a Design and Build form of contract
  - progress items of the design with specialist subcontractors
- highlight the design risks on a project, including key decisions required around interfaces and interdependencies.

If a spreadsheet format is used for generating the Design Status Schedule, the following headings could be considered:

- date item raised
- date item last discussed
- date by which resolution is required
- design team member responsible for item
- uniclass, or another classification, reference
- the level of importance (this could be aligned to hot topics)
- a brief summary of the context of items relevance
- the brief summary of the design status of the item noted.

Items remain on the schedule until they are satisfactorily closed out, and once they have been recorded they 'disappear' on the next issue, keeping the Design Status Schedule concise and relevant to the design tasks at hand. It should be a 'live' document that is circulated on a regular basis. The spreadsheet format allows sorting by designer, date, hot topics or other headings that the lead designer wishes it to include.

Depending on the size of the project, a number of schedules might be created for different purposes – for example, recording coordination decisions, conveying design information to the cost consultant or communicating the design risks to the client team.

What are hot topics?

The success of a lead designer depends on defining the issues that arise on a project – 'hot topics' are issues that need urgent resolution to progress the design or items that lack conclusion from one design team meeting to the next – getting 'on top of them' as promptly as possible and managing their closure as efficiently as possible is central to the success of the lead designer role. Failure to deal quickly and effectively with hot topics allows them to fester and might impact on the design process.

What might a Design Status Schedule look like?

An example of what a Design Status Schedule might contain is shown in Figure 5.1, opposite.

Figure 5.1: Extract from a Design Status Schedule

Date raised	Last discussed	Item	Status	Priority (1-5)	Required by	Action by
11 Dec	8 Jan	Riser doors	1) Strategy agreed 12 March: to be added to architect's model. 2) Stage 2 Cost Plan assumptions to be checked against strategy once completed. 3) In Use health and safety to be discussed with client facilities management team.	2	DS	A
11 Dec	29 Jan	Lift car	Ability of three possible tenderers to provide the car as designed to be investigated.	3	MC	E
11 Dec	15 Jan	Lift architraves	Client has confirmed that standard stainless steel lift architraves should be used. Architect to look at finishes options beyond architraves.	3	DS	A
11 Dec	8 Jan	Doors to tenant areas	North and south doors to tenant areas to be paint grade with vision panels; however, full-width glazed metal screens with integral electronic openers to be specified for west entrance. Cost consultant to process change control order no. 6 accordingly.	4	RB	C
11 Dec	29 Jan	Access control	Client has agreed to provide a concealed electrical connection outside doors to tenant areas on each floor to allow tenants to fit access control systems. Electrical engineer and architect to note for stage 4 development.	4	–	–
18 Dec	22 Jan	Wash hand basin vanity unit	Options for vanity unit presented to client including: 1) bespoke cantilevered top requiring higher specification bottle traps and other elements, and 2) removable frontage options from two suppliers. Sink and tap options being checked for compatibility, including pop-up plug options prior to cost check.	2	DS	A
18 Dec	22 Jan	Hand-washing and drying	Report issued to client on options for taps, soap dispensers and hand-driers, including environmental considerations for each option. Decision urgent due to spatial impact of each option and need for MEP team to begin design work.	1	MS	L
5 Feb	5 Feb	Floor finish – toilets	Slip resistance information on options show all comply with client brief and BS recommendations. Tiles have slightly different thicknesses; however, the sub-base can accommodate all options. Decision not urgent. No cost implications.	3	–	–

Date raised	Last discussed	Item	Status	Priority (1-5)	Required by	Action by
5 Feb	5 Feb	Lobby ceiling and lighting	Concealed cove to be used for extract. Grille sizes and specification for supply air to be agreed. Electrical engineer to put forward lighting options based on architect's sketches. Architect to model preferred ceiling layout based on agreed MEP parameters. Cost consultant has confirmed that initial sketch proposals are achievable within Cost Plan.	2	DS	A
5 Feb	5 Feb	Floor finishes – lobbies	The extent of the tiled finishes in lobbies has been agreed, including deletion of finishes to stair lobbies and the relocation of a number of doors to floors to reduce tiling scope. Architect to adjust finishes accordingly. Changes bring design in line with Cost Plan.		CQ	A

The Design Status Schedule above is representative of the types of topics that might be current during stage 3 of the design of a core for a commercial office building. The above example shows the diversity of topics being developed and demonstrates that the lead designer is clear regarding the direction of each item, who should be doing what, including consideration of cost items. These are not minutes, and to be successful each status note needs to be less than 50 words while capturing the essence of what needs to be done. Crucially, the schedule should be updated and old concluded items deleted. It is a real-time tool not a record of decision-making or who said what for every topic.

Effective communication

Good communication skills are a prerequisite for the complexities of iteratively and intuitively coordinating and collaborating. Those undertaking the lead designer role must be great communicators.

We have moved from letters and phone calls to beyond e-mail and towards texts, social media, blogs, group e-mail, tele-presence and video conferencing. The increasing drive for real-time responses can divert attention and dilute effort away from the real priorities on a project. The lead designer needs to consider how to balance these different types of communication. A good communicator will use the right means at the right time.

The lead designer needs to communicate with diverse parties on a wide-ranging set of subjects and choose what will best facilitate effective communication. These habits should be bedded in by agreeing the Communication Strategy with the project team before the project commences. Members of the design team may be working in different cities and the site may be in a different country, which adds further complexities, such as balancing the benefits of face-to-face time with the costs of travel.

Why is negotiation a core communication skill?

Lead designers need to negotiate effectively on a daily basis. For example, persuading the building services engineer that the plant room strategy needs to be amended or agreeing a different beam size with the structural engineer. The following points provide a better awareness of what is required to be a good negotiator:

- Good preparation is essential. Without all of the facts at your fingertips, it is difficult to negotiate well.
- Make sure the basis of any assumptions are clear. Relying on poor assumptions can impact on the outcomes of a negotiation.
- Listening to what the other party has to say on a specific point is essential. The more you 'dig in' with your own view, the harder it is to close the gap with another party.
- An abrasive or combative approach is more likely to break down negotiations. Conversely, being cooperative and friendly and taking a collaborative stance will lead to successful results.
- Consider how strong a position you are negotiating from and adjust your strategy accordingly.
- Being able to adjust or adapt your strategies in response to the other parties' comments will gain a better outcome.

Project meetings

With various communication tools in existence, it is easy to imagine that meetings are not required. However, a good meeting structure forms the backbone of a successful project, with different types of meetings required for different purposes, to:

- gather knowledge and information
- make decisions
- move the design forward
- review the design (see Chapter 10)
- coordinate
- report on the status of the design.

Meetings and workshops can be used by the lead designer for coordinating purposes and/or for reporting design progress with the client. The lead designer needs to understand that these two concepts are different. The dynamic created by a project meeting with 12 people present is different to a workshop attended by three designers. The lead designer needs to frame the structure and agenda of the meeting accordingly. Trying to resolve a complex design issue in a large meeting can be dangerous because:

- there will too many people present to enable options to be mocked-up
- design development is difficult in a formal environment
- some design team members may comment on items outside their remit or competence (complicating the resolution of items)
- the right designers may not be present or those present may not have the complete picture of the subject.

Figure 5.2: Meetings v workshops

Meetings		Workshops
Formal		Informal
Large numbers		Small numbers
Reporting		Designing
Knowledgeable	V	Experts
Reviewing		Adjusting
Teamwork		Collaboration
Minutes		Design Status Schedule
Client team focus		Design team focus

Design team meetings

In advance of a design team meeting, the lead designer may have an obligation to receive reports from each design team member and should avoid these being read verbatim at the meeting: hot topics only! In certain circumstances, it might be advantageous to meet with a designer prior to the meeting so that the resolution or progress of a challenging hot topic can be reported accordingly rather than lack of action on the topic or the need for a challenging discussion in the wrong environment. The goal of the lead designer at all times should be avoiding discussions in unpredictable environments.

Workshops

If design team meetings should avoid detailed design discussions, the converse is true of design workshops:

- There is no point in designers being present if they are not equipped with the right information. An agenda, or a list of subjects to be discussed, should be issued beforehand.
- Numbers should be kept to a minimum. If necessary – and to keep numbers down – subject matters can be limited. Or, meetings can be rotated so that one week the emphasis is on building services engineering and the next week on structural engineering. This also ensures that those designing at 'the coal face' are involved in the design development.
- Workshops should be weekly: it is better having a short, sharp meeting to discuss a few hot topics. However, if a specific issue is impeding the development of the design, a one-off meeting should be arranged in-between.
- Discussions should be recorded (copies of sketches are adequate – mobile phone cameras are now great for this): future referencing may be required to enable the lead designer to demonstrate that they have coordinated the design. The Design Status Schedule might be used to record workshop issues until they are closed out.
- Collaboration is not possible without the right behaviours. Every designer needs to be briefed on the expectations of each workshop.
- Training might be required to allow more experienced designers and engineers to engage more constructively with the 3D environment.

The successful running of workshops demonstrates that a truly collaborative team is in place and allows design team meetings to be more forward-looking and strategic in their outlook.

Project Strategies

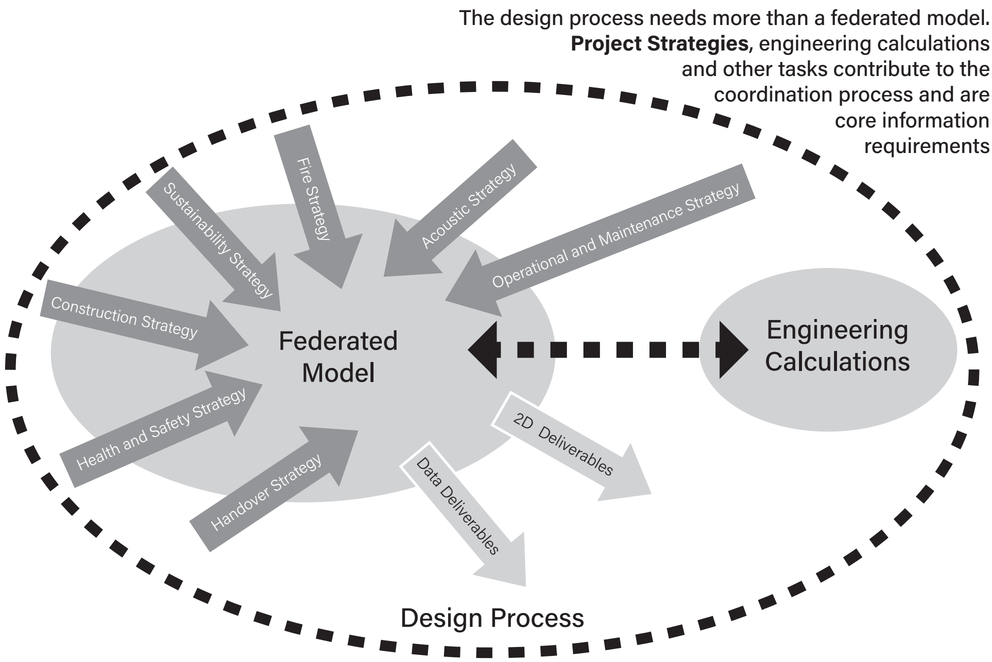
In recent years the built environment industry has focused on the value of BIM. From the lead designer's perspective, BIM is an essential tool. However, many of the specialist consultants involved in the design process do not produce geometry for incorporating into the federated BIM model and require a vehicle for their analysis and expert advice to be set out and considered by the lead designer for coordination purposes. This is the purpose of Project Strategies.

The RIBA Plan of Work incorporates a number of core Project Strategies to remind everyone in the project team of their importance. Many topics need to be considered as the design progresses incrementally, intuitively and iteratively, and Project Strategies can be leveraged for various purposes going beyond those set out in the RIBA Plan of Work. Project Strategies can be used to:

- provide the story behind a particular aspect of the design
- record decision-making for all to see in the future
- expose what would normally be intuitive decisions
- set the pros and cons of different options, along with the design team's recommendations
- consider diverse topics, such as health and safety, sustainability and buildability
- allow specialist subconsultants to engage with the design process
- set out the rationale and reasoning behind certain topics in greater detail
- enable the client to review and sign-off individual topics in detail
- explain how the building works at handover and the logic behind the systems specified.

The increasing number of specialist consultants requires a greater number of Project Strategies, adding to the workload of the lead designer. Successfully implemented, Project Strategies assist the design process and communicate to the project team what is proposed in relation to a particular topic. However, aspects contained in one strategy may contradict those in another, underlining the need for the lead designer to coordinate and align the contents of each strategy.

Figure 5.3: Project Strategies need to be aligned to the federated model



Of greatest interest to the lead designer are cross-cutting themes: issues that might appear in a number of Project Strategies and where contradictory approaches are feasible. When coordinating the Project Strategies, the lead designer might consider:

- The core aspects of the Sustainability Aspirations set in the Initial Project Brief and how they will be approached by the design team in the development of the Sustainability Strategy.
- The high level maintenance and operation aspects that need discussed. For example, will the client accept the use of a cherry-picker for cleaning the façades? If so, will this be rented or purchased and therefore requiring on-site storage?
- Are the core project risks immediately identifiable? Does the Project Budget make adequate allowances to cover these before they are considered in the Cost Plan?
- Is off-site fabrication being promoted for inclusion in the Construction Strategy? If so, how might this work? (Modular construction necessitates a more disciplined design approach.)
- How will the health and safety bar be raised in the Health and Safety Strategy? What can be done to proactively engage the design team in a profoundly different health and safety culture?

Resolving contradictory Project Strategies

Example 1: One section of the brief for a university requires a secure campus whereas another requires the campus to be open and accessible. Accordingly, the security strategy is developed to show gates at every entrance. However, the landscape design illustrates open access. To overcome this, the lead designer agrees with the designers and the client that the majority of gates will be closed at night except for two main gates which will remain open and covered by CCTV 24 hours a day. The Project Strategies are now coordinated and the client signs off the stage 2 Concept Design.

Example 2: The brief for a project requests that all building elevations are accessible by a mobile access platform. As the design develops the design team determines that insufficient land is available on one of the site boundaries to use a mobile platform. The design team proposes a BMU for cleaning this façade. The client agrees with the proposal and the Final Project Brief and Operational and Maintenance Strategy are adjusted accordingly.

One essential point for the lead designer to consider is that Project Strategies are not always conclusive or prescriptive in their recommendations. They may require a decision from a client or design team before their contents are used by the core designers. In these circumstances it is essential that such decisions are recorded and included in a final version of the Project Strategies. Finally, the majority of Project Strategies *are not* intended for construction purposes. As a result, the majority should not proceed beyond stage 3, allowing the design team to filter out any requirements at stage 4. For example, from the fire strategy the architect can add fire ratings to walls and the building services engineer any dampers that are required as they progress their detailed design aspects. When the lead designer is coordinating stage 4 information it is essential to review this information against the relevant strategies.

What are the core Project Strategies on a project?

The core strategies set out in the RIBA Plan of Work 2013 include:

More effective operations: the Operational and Maintenance Strategy

How a building is operated and maintained is playing a more important role in design. A good Operational and Maintenance Strategy reduces whole life costs and is invaluable as part of whole-life thinking, ensuring that in-use health and safety considerations are considered as the building is designed. Crucially, poor consideration of these aspects can create operational difficulties, require additional expenditure in-use or result in a building that is not safe to maintain. At stage 2, the Operational and

Maintenance Strategy should be discussed with the client team's facilities management (FM) team or adviser. This strategy might:

- demonstrate how façades, atria spaces or staircases will be cleaned and maintained
- set out how plant will be replaced and maintained on a day-to-day basis
- ensure that sustainability and health and safety considerations are embedded into the design.

At stage 3, these proposals can be developed further, with more detail added. For example:

- examining the interfaces associated with a BMU on the roof
- considering the location of power and water supplies for mobile access platforms
- preparing illustrations demonstrating how plant is removed from a rooftop plant room.

By the end of stage 3 the Operational and Maintenance Strategy should be robust enough to allow stage 4 information to be produced independently by each designer. The introduction of a specialist subcontractor into the mix may also require aspects of stage 3 to be revisited and the lead designer needs to be alert to these topics.

Considering buildability: the Construction Strategy

See Chapter 9.

Raising the health and safety bar: the Health and Safety Strategy

It is reasonable for the family of any individual playing a role in the built environment industry to expect members of their families to come home safely every day. Often this is not the case. The Health and Safety Strategy in the RIBA Plan of Work aims to raise the health and safety bar from a design perspective, positioning it above and beyond statutory requirements. There are a number of ways that the lead designer can influence the Health and Safety Strategy during the design and drive health and safety innovation. For example:

- acknowledging the significant role that designers play in reducing health and safety risks
- considering how Safety in Design (SiD) can be used to improve health and safety outcomes
- leveraging the Operational and Maintenance Strategy to add value to health and safety considerations

- using digital tools, such as 4D (see p 163) to rehearse the Construction Strategy early in the design process
- embedding a good health and safety culture within the design team.

Safety in Design (SiD)

All accidents and incidents are avoidable. SiD initiatives are created by government health and safety entities or by clients with a strong focus on health and safety. They encourage designers to focus on changing the culture of design processes, promote risk awareness and proactive involvement in health and safety and to change the thinking of designers who may believe that health and safety considerations are the responsibility of others and do not realise the crucial role that designers play in designing out health and safety risks.

Designing sustainably: the Sustainability Strategy

The Sustainability Strategy is of great interest to the lead designer. A number of sustainability targets such as BREEAM Excellent or LEED Gold, or a requirement to adhere to a new standard such as WELL, may have been set in the Sustainability Aspirations. It is easy for the work required to achieve these targets to sit 'outside' the design process, creating challenges when the standards are not met down the line. The lead designer needs to consider all aspects of sustainability and integrate them into the design process. This might include, for example, using the Design Status Schedule to record items that the cost consultant should take cognisance of. This might range from the smallest of items – such as bird boxes – to the largest – such as the installation of a biomass plant, a photovoltaic farm on the roof or a wind turbine.

BREEAM, LEED, WELL

BREEAM (BRE Environmental Assessment Method: www.breeam.com) and LEED (Leadership in Energy and Environmental Design) are environmental certification schemes that rate the sustainability of buildings. The rating systems consider design, construction, operation and maintenance aspects, encouraging clients to be environmentally responsible. On assessment, the more points a building achieved, the higher the rating it is awarded. Clients will typically set the rating required in the Initial Project Brief to allow the design team to design accordingly. WELL (www.wellcertified.com) is a similar standard, which instead places emphasis on the health, happiness, mindfulness and productivity of a building's occupants rather than the building itself.

Efficiently transitioning from construction to use: the Handover Strategy
The Handover Strategy, or the methodology for ensuring that the systems in a building are successfully set up and handed over, is a major consideration on a project.
A successful handover can result in better performance, reduced energy use and the more effective use of a building. Obtaining feedback from previous projects, including Post Occupancy Evaluations, is a crucial part of the briefing process and one that the lead designer should be alert to. However, once a design is under way this topic has negligible impact on the design process.

The lead designer needs to be alert to the detail required to facilitate a successful Handover Strategy, such as ensuring access hatches, or other good means of access, are incorporated in the design for commissioning or considering how the aspects of the design that will impact on the effective use, maintenance and performance of the building might be designed and reviewed by the client team.

How can other strategies add value to the design process?

Other Project Strategies that add value to the design process include:

The Fire Strategy
The Fire Strategy might consider areas not covered in statutory regulations or where relaxations of regulations might be required – for example, a phased evacuation strategy in order to reduce the size of escape stairs. In such situations the fire strategy is a core document for stage 2. Without it the Concept Design will not be robust and therefore able to proceed to stage 3. In some situations, approvals or discussions with the statutory authorities will be required at this early stage in order to determine the likelihood of certain fire engineering approaches being acceptable. It is better to understand that an approach will not be supported early in the design process than spending time coordinating it into the design only for it to be rejected later on in the design.

The Acoustic Strategy
The acoustic strategy might be 'light touch', considering only project-specific acoustic issues such as the glazing specification for a housing scheme next to a railway line, the dry-lining specification between a plant room and office space or the door specification for a recording studio. It can also be more detailed, considering all the core issues on a project, such as whether the partition specified meets the appropriate standards.
The acoustic strategy might include recommendations and the role of the lead designer is ensuring that these are agreed and incorporated into the work of the core designers.
The acoustic strategy should be concluded by stage 3, although the acoustician may advise on certain details during stage 4.

The Toilet Strategy
Sample boards might capture agreement of the finishes in a toilet but many other questions need to be asked and decisions made in order to design a toilet:

- Are the toilets to be designed to BCO (British Council for Offices) or British Standards?
- Are the toilets to be unisex?
- Are manual or sensor-operated taps required?
- How is soap to be dispensed?
- Is the plug to be connected to the tap?
- Is drainage required to the flooring?
- Are waterless urinals acceptable?
- Are paper towels or hand-driers best environmentally?

A strategy document can record the decision-making in relation to these many questions that bridge the brief and the design. Appendices can be used to record evidence – for example, the information used to confirm whether hand-driers or paper towels are better environmentally. A Decision Tree (see p 136) is an effective way of teasing out the quantum of the decisions to be made on a project and particularly those that may need a supporting strategy.

Design checklists: recycling knowledge and experience

Lead designers used to be generalists who understood enough about every system in a building, enabling them to ask the right questions at the right time. The number of detailed Project Strategies required on a project and the increasing number of topics that need to be addressed during the design process, such as sustainability or DfMA, underlines the new complexity of the design process. Simply, no one individual can understand in detail every topic that needs to be considered in the design of a building.

This creates a new challenge for those undertaking the lead designer role, and with no one person holding all of the knowledge in their head the lead designer is running 'blind' in certain situations. Being able to 'know what you don't know' becomes a useful tool for the lead designer and checklists can perform this crucial role. The role of checklists in medicine (see below) acknowledge the notion that experts can get things wrong. Checklists:

- prompt experienced designers and engineers
- act as tools for younger designers so they are considering the pertinent issues when they are progressing the design
- disseminate knowledge to every designer, including those who may be dealing with a topic for the first time
- provide a more robust mechanism for reviewers to check designs against, making sure crucial points are not missed
- avoid intuitive decision-making processes
- allow one designer to understand the drivers of another
- enable the lead designer to check that a tender package contains all the relevant information, making sure the topics that are not included are covered in the Design Status Schedule
- enable designers and the cost consultant to ensure that the Cost Plan includes items that may not be considered in the early stages of the design
- can be used by design managers, cost consultants and others who need to consider the adequacy of design proposals or price risk.

Checklists can be constructed as a list of questions to be asked at a particular point. Some questions might be prompts to ensure that certain matters have been considered. Others may require a simple ‘yes’ or ‘no’ response. Some may want a written response that requires ratification or discussion in order to provide a robust review process, and with this in mind checklists are more effective when constructed as a table, allowing responses to each item to be added, providing a transparent and trackable review process. The use of checklists could be part of a strategic shift in the design of buildings where knowledge is shared for the collective use by others, rather than being retained in the mind of the individual. Checklists might be distilled from guidance, which is considered next.

Checklists in medicine

Atul Gawande pioneered the use of checklists in medicine. His efforts improved clinical outcomes and the number of deaths occurring in surgery significantly reduced where his ideas were implemented. His ideas are set out in his book *The Checklist Manifesto* and his vision can also be gleaned from his TED lecture.

So, how would the checklists work?

An example of the principals, above, applied to a checklist for a door package being issued for tender and/or construction purposes. The checklist has been developed in such a way that the response conveys the decision-making process, allowing issues that have not been considered to be recorded and enabling appropriate allowances to be made.

Figure 5.4: Example of checklist issued for the door systems of a building

Checklist item	Response
Ss_25_30_20: Door Systems	
Has the door strategy, including finishes, sizes, ironmongery specification and other aspects (as below), been presented to and signed-off by the client?	*Principles discussed 12 Jan. Ironmongery options discussed and principles agreed. Final selection of product to be made and presented to client.*
Has the full scope of door requirements been determined for cost purposes? For example, are riser doors and any specialist doors identified?	*12 no. doorsets are required to the building services risers. These have been agreed with the building services engineer but have not been added to the architect's model yet. Budget for doors was included in stage 2 Cost Plan.*
Are doorsets, or doors with separate frames, proposed? Are the doors timber, metal or a combination of both?	*Doorsets are proposed for both steel and timber doors. A combination of timber and steel doors is required as indicated in door schedule.*
What level of specification is proposed, including: ► Door dimensions: height, width? ► Are these standard sizes? ► Finishes, veneer, paint, etc. ► Vision panels, aspect ratio checked? ► Fire ratings? Certificates available? ► Ironmongery specification – concealed closers, finish, supplier, etc.	*Outline specification issued to cost consultant confirming:* ► *Paint grade doors (agreed with client to enable a higher ironmongery specification)* ► *Vision panels to fire escapes as door drawings* ► *Fire rating requirements are shown on the door schedule.* *The cost consultant has reviewed the specification and confirmed that it is aligned to the Cost Plan.*
What information has the cost consultant used for the basis of the Cost Plan? Are the proposals affordable?	*Mark-up of plan provided to cost consultant to confirm door types and enhanced specification requirements.*
How have Building Regulation requirements been determined? Have these been checked against the fire strategy?	*Drawings reviewed against Building Regulations and partition types and fire ratings reviewed against fire rating of doors. Both checks validated the current proposals.*
Have locking arrangements been agreed with the client, including lock suiting or locks for maintenance access?	*Principles agreed and recorded.*

Checklist item	Response
Have discussions been held with a door manufacturer?	*Yes, Manufacturer X has been involved in the design development and is shown in the specification as a potential supplier.*
Is a door schedule available?	*Door schedule has been drafted for inclusion in stage 3 report.*
Does the mechanical engineer require grilles or undercutting to any doors for make-up air or other purposes, i.e. ventilation to rooms?	*The MEP engineer and architect have agreed that four doors need to be undercut to provide make-up air to a number of utility spaces.*
Are there any interfaces with electrical elements, including alarm contacts, PIR or electronic door closers? Do these need enhanced specification requirements, i.e. concealed cableways or notches for sensors? If so, has it been confirmed that these will not impact on the certification of any fire doors?	*Yes, for door contacts in security strategy and hold open doors in fire strategy. Cost allowances incorporated into Cost Plan.*
Have the services requirements been coordinated with the MEP information? Has this information been reviewed? Is it clear who will fit any elements and where the electrical interfaces will be?	*Information has not yet been incorporated into services information. A further check of this item at stage 4 is recommended. Design Status Schedule to be adjusted accordingly.*

Note: the above list is not meant to be definitive, but representative of how knowledge can be best managed. The response side has been completed in a manner that a project architect might respond as part of internal QA processes. Subsequent issues of the Design Status Document can be used by the lead designer to manage issues that have been identified.

Figure 5.5: Example of checklist issued for the façade systems of a building

Checklist item	Response
Ss_25_30: External Wall Systems	
Have the different façade systems on the project been defined? Are these commonly available?	*There are three façade systems: a terracotta tile system by supplier A, a window system by supplier B and a timber system developed by our practice.*
Has testing documentation been obtained from suppliers and checked for its relevance against the project parameters? Are case studies available?	*Yes. We have reviewed the testing documentation from suppliers A and B and confirmed that it suits the project constraints (high winds and coastal environment).* *The timber façade is detailed as per previous practice projects.*
Are any of the façade systems to be specified descriptively (performance specified)? Have details been prepared accordingly?	*No. All items will be prescriptive.* *Note: Shop drawings to be issued by window manufacturer for review.*

Checklist item	Response
Where relevant, have manufacturers confirmed that the proposals can be achieved within normal system constraints? If the system needs adjustment or development, have the costs, timescales and feasibility been determined?	*No requirements beyond standard system requirements needed.*
Where a façade system is assembled from different elements, have these been considered holistically, including from a cost perspective?	*The type A system requires a metal stud back-up wall. The cost consultant has allowed for this in the stage 2 Cost Plan.*
Has the interface with the structural frame been considered, including grids, slab edge conditions and fixing parameters?	*Fixing methodologies have been discussed with possible installers and the structural engineer. Agreement made regarding fixing methodology, including ability to fit brackets into floor zone.*
Does the span in any area exceed the normal span criteria? If so, how are these being dealt with?	*The entrance screen is double height. It has been agreed that a timber column will be provided behind the two mullions to provide the relevant support.*
How have the system zones been determined? Have these been agreed with the design team?	*Yes. All three zones discussed, agreed and recorded.*
Have U values and other insulation criteria and specification been determined? Has the glazing specification been considered, including U values, K values?	*Calculations have been prepared for U values. The mechanical engineer has confirmed that the proposals meet daylighting and overheating criteria.*
Are there any glazing requirements beyond current norms, i.e. large/curved panels or low iron glass?	*No enhanced specifications required.*
Has the interface between the different systems been considered?	*Interface details between the three systems have been developed.*
Have non-system elements, such as copes, flashings and other items, been considered?	*Key details discussed with installers and Cost Plan allowances checked.*
Are there any special features or requirements that might not be clear to the cost consultant from the information issued? If so, how has the relevant information been conveyed?	*Type B windows have a deep flashing. The cost consultant has discussed the sketch of this with a number of installers.*
Has the specification of all of the door elements been considered, including costs, i.e. fire escape, entrance, revolving or other requirements including likely suppliers and specifications?	*Outline information including specification issued to revolving door companies to allow Cost Plan to be tested. Allowances made for automated door openers to adjacent doors.*
Have finishes been considered and any implications determined?	*Anodised finish reviewed including supplier options and manufacturing limitations.*

The elements driving the costs of a building façade are diverse. The above checklist considers the façade holistically. It is recommended that the lead designer has a checklist for each façade type typically used in the practice so that the nuances and interface challenges of each are properly understood and checked on every project.

Guidance: enabling robust designs

Chapter 4 dwells on the challenges for the lead designer when the design team works intuitively. Intuitive design processes rely on the knowledge of the individual the day they are designing rather than the collective knowledge of the design team, the practice, the client team or the broader built environment industry. Checklists can help manage an intuitive design process; however, to be successful they need to be succinct. Guidance provides further background information to a particular subject which can be essential in many circumstances.

Individuals might possess a great deal of knowledge and believe that they 'have all the answers.' In reality, they might not be abreast of recent developments in a topic. For example, the architect might not be aware of changes to regulations that impact on the design of a core. Simply, they do not know what they do not know. The lead designer can prepare guidance for each building system possibly developed using Decision Trees (next tool) and/or checklists but then expanded to incorporate detail on the topic, including how interfaces should be managed, the design dependencies to be navigated and the decisions required. Guidance:

- connects designers, alerting them to interface and interdependency issues
- explains the logic behind a particular methodology or material, preventing the design team from reinventing the wheel
- allows the reasons behind certain design approaches to be easily explained and communicated to the client
- captures knowledge from the design team, suppliers and specialist suppliers, including frequently asked questions, hot topics and issues arising in the design process
- flags information typically missed in tender and/or construction information
- avoids knee-jerk decisions based on poor information
- promotes more robust decision-making processes, identifying the client's decisions required at each stage
- encourages greater standardisation of design approaches, or rather minimising the need to redesign every aspect of a building every time
- disseminates knowledge of a particular topic: how DfMA impacts on the Concept Design or how a particular sustainability topic impacts on the Developed Design
- sets out options that need to be discussed and considered with the client team in relation to a particular topic

- acts as a bridge between manufacturers' information and a practice's approach to a topic – for example, collating and comparing product information from different manufacturers and suppliers
- links different information sources
- shares knowledge with everyone
- provides guidance on a particular aspect of design that may be not available elsewhere – for example, the topics to be considered when designing an office building entrance lobby
- advises on standards or regulations, helping designers unfamiliar with the requirements – for example, the Building Regulations to consider when designing an office building.

The preparation of guidance is core to a practice's knowledge management strategy and might be defined as Research and Development. Guidance can be industry-wide, might be produced by a practice to reinforce a particular aspect of design or way of working, might be produced specifically for a project and signed-off by a client (under the wrapper of a Project Strategy) or might be produced for a particular client who wishes to undertake an aspect of the design in a particular way across a number of projects. The key to successful guidance is devising a method of making everyone aware that it exists and making it easily accessible. This might be done by:

- making it easily accessible and searchable
- linking it to checklists, Decision Trees or workflow diagrams
- preparing a thought leadership article and issuing it to clients or a practice blog
- having a 'champion' for each topic, accountable for keeping guidance relevant and up to date, as well as spreading awareness of its existence and providing updates via CPD
- adding knowledge to BIM objects where it is easily accessible.

A core challenge and risk with guidance is keeping it up to date. Best practice moves on, materials and systems are refined or new ones invented, regulations change and client opinions move with industry trends. Poor guidance can defeat its purpose if it leads to designs that subsequently have to be altered. Conversely, well-produced and managed guidance acts as a single source of knowledge, avoiding everyone having to get up to speed on every subject. This is crucial as we move away from generalist knowledge to subject matter experts. The key to good guidance is restricting it to the essential subjects and avoiding repeating information that exists elsewhere.

Flat roofs: guidance

There are many approaches to designing flat roofs, with different manufacturers advocating their systems over others. Early flat roof systems failed at the end of their life, resulting in clients being wary of using them, yet in many situations they are preferable and modern systems bear no resemblance to their predecessors. Regardless, the lead designer needs to consider the differences between different solutions and what approach might be best. Flat roof guidance might consider:

- the systems available and which are suitable in different situations
- an analysis of different manufacturers' systems and their pros and cons
- details of system installers
- any certification that might be relied on to confirm a system's suitability and robustness
- a list of projects where different systems have been successfully used
- design considerations, such as where to place or how to detail a gulley
- typical details including issues to be considered and ways of dealing with them
- other considerations, such as buildability, overflows or frequently encountered scenarios
- interfaces and interdependencies to ensure that they are considered at the appropriate time.

Decision-making

Chapter 4 emphasised the intuitive nature of the design process and the need to identify the different and diverse aspects of the design that need to be considered by the lead designer and the design team. Decision-making tools are a useful means of flushing out the different aspects of the design that need to be considered by the client and/or design team. Checklists and guidelines can help steer decision-making but given that thousands of decisions are made on a project, decision-making tools can be more effective in unpicking the decisions to be made on a project, allowing many to be made earlier or eliminated altogether. Decision-making tools include:

- the Consequences Model
- the Energy Model
- the Black Swan Model
- the Hersey–Blanchard Model
- Decision Trees.

There are many books and articles published on decision-making that can help lead designers improve this aspect of the design process.

Decision Trees

The lead designer can develop a Decision Tree in relation to a particular system of the building, such as a cladding system. Or, a Decision Tree can be used to tease out issues in relation to a particular area or aspect of the building – for example, an entrance area. The lead designer might complete the Decision Tree by:

- using their experience and knowledge from other projects
- speaking to suppliers and manufacturers
- consulting with other designers, including the architect and engineers
- liaising with specialist subconsultants to determine any specific and stand-out requirements
- liaising with the client team or a number of clients
- visiting other similar completed projects to unpick the topics to be addressed
- discussing future trends with industry experts.

A completed Decision Tree can be used to:

- determine items requiring client decisions
- select the right stage to discuss each aspect of the design
- prompt discussions at design workshops
- determine products required for an element of the building
- establish workflow
- determine multidisciplinary interfaces and interdependencies
- flush out aspects requiring Research and Development or preparation of guidance.

The lead designer can use Decision Trees to discuss different aspects of the design with the design team, perhaps using a specific task team Design Status Schedule to record the information required by each designer and the interface and interdependency issues to be considered. For example, on the basis of the cladding example in Figure 5.6 a workshop using the cladding Decision Tree might reveal:

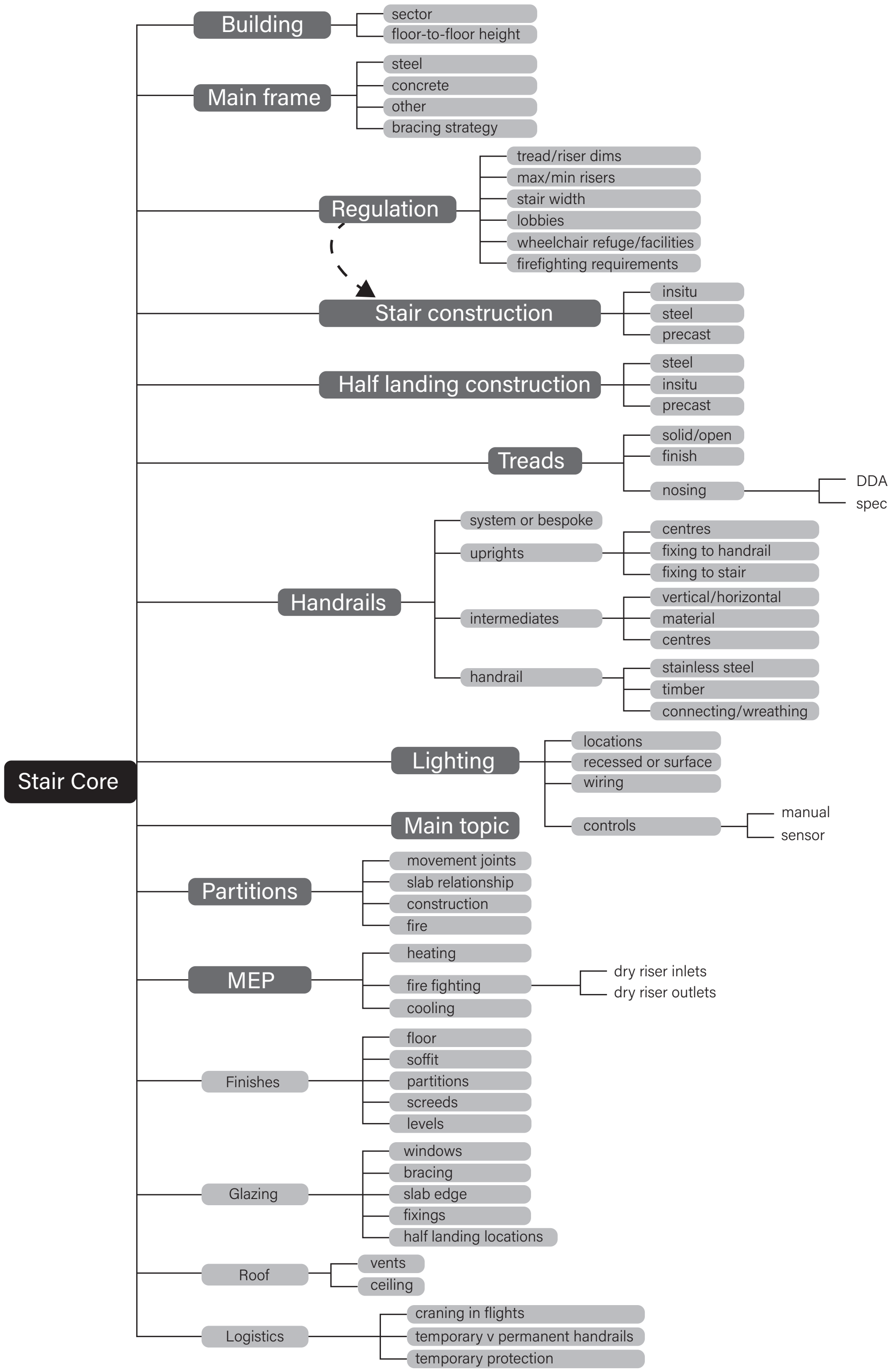
- the importance of determining the finish to the aluminium with the planners
- the wish to resolve the glazing specification needs
- the need to resolve a number of interfaces between building engineering items and the architecture – for example, door contacts or power requirements.

Decision Trees are a good communication tool and might be updated following peer review or a task, design or client team discussion. Decision Trees are also an effective way of conveying the topics to be considered during the design process to the next generation of lead designers.

Artificial Intelligence (AI)

Algorithms (see p 142) are central to rules-based design processes. Artificial Intelligence (AI) progresses beyond this with AI systems making decisions that go beyond, mimicking intuitive human decision-making. There are many subsets of AI, including machine learning. Decision Trees are one of the common tools used by data scientists to help define the basis of AI tools. While AI tools are beginning to emerge, the lack of machine-readable design information at scale will impede the development of useable AI tools in the short term.

Figure 5.6: Unlocking decision-making



Workflow diagrams

The architect's 2D geometric information has formed the backbone of the design process for many years, with the progression from drawing board to CAD maintaining this status quo. BIM and the use of digital technologies change this, requiring greater consideration of the workflows of each designer to redefine the design process. In a digital world it is possible to:

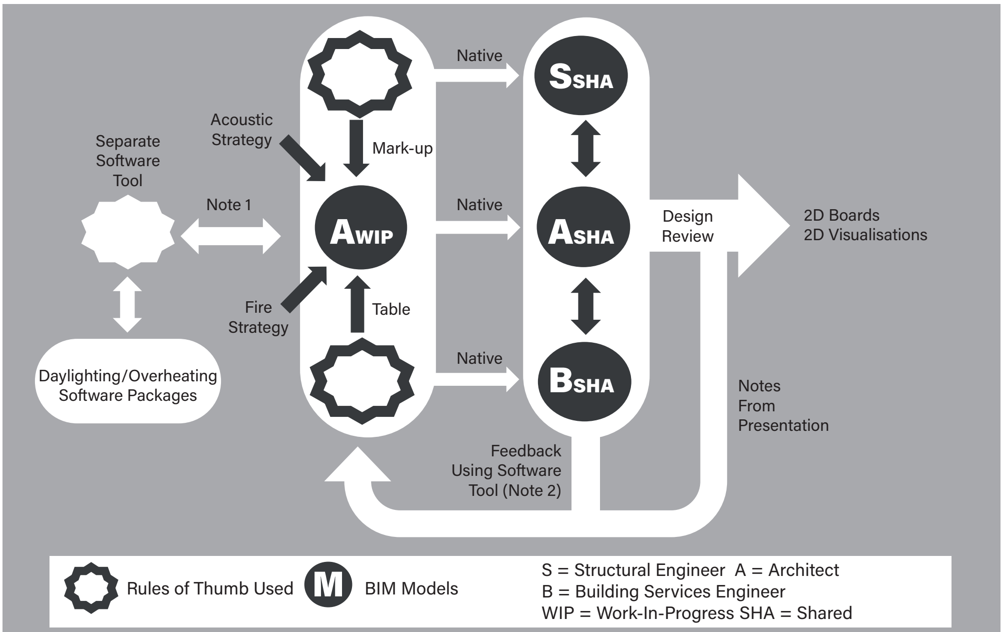
- link engineering analysis software directly to the engineering models, speeding up analysis
- connect objects in the architectural model to a specification
- create datasets that allow different building engineering equipment, such as pumps or air handling units, to be assessed quicker
- import 3D scans of existing buildings
- link the Cost Plan to the federated model (5D)
- rehearse the construction process using the design team information (4D).

Simply, the connections between each designer's geometry, data and analysis are getting better and better. The Holy Grail is the point where designs can be iterated in real time. For example, the architect is able to assess the daylighting results for different façade systems as they are designed. Until this point is reached, understanding what is connected, what can be better connected and what aspects remain standalone becomes crucial to the design process, requiring attention from the lead designer. Connected information allows faster or fewer iterations of the design. A core topic for the connected agenda is interoperability. Many software packages are used for creating geometry, storing data and undertaking analysis. If the output of one package cannot be used as an input of another, connectivity is difficult to achieve. Interoperability therefore becomes a core workflow issue.

Workflow diagrams help the lead designer to understand how the building engineering teams work and can help eliminate waste in the design process. Figure 5.7 shows a simple workflow diagram aimed at understanding how different software packages impact on design workflow as well as the design review process. As an example, consider that in CAD it was commonplace for the architect to 'draw' the structure in the architectural file to move the design along. Coordination in BIM and the connection to structural analysis packages becomes more effective when this structure is modelled by the engineer. Deciding when the architectural model is sufficiently robust to allow the engineer to undertake this task therefore becomes a core challenge for the lead designer.

Simply, BIM workflow is different to CAD workflow and with new workflow comes new terms such as real-time environments or the need to avoid post-production tasks in 3D to 2D workflow (see Figure below).

Figure 5.7: Workflow diagram



Note 1 : Two different softwares being used – set-up to be discussed
Note 2: Not everyone (including client) familiar with proposed tool – training session to be arranged

Workflow diagrams can be used to explore the different tools being used by the design team including sketching, spreadsheets, software packages, BIM tools as well as the deliverables required. These might include sketches, 2D outputs from the federated model or native and IFC files. Once produced the lead designer can use workflow diagrams for examining issues in greater detail or to look at areas that might be more efficient if a different methodology is used or the areas where the design process might be automated. They are also a useful means of playing back the design process to the design team and to check the Design Programme.

Interoperability

Interoperability is the ability of one software system to exchange and make use of information from another. Good interoperability enables the output from one software package to be used by another and will lead to automated design processes as the use of scripts increases. Lack of operability impedes the use of diverse software products, impeding innovation. The lead designer needs to consider the software used by each design team member, including the relevant version, and whether any interoperability issues are likely to arise before concluding the software to be used on a project. To do so may require some testing to be carried out or feedback obtained from those who have connected the proposed tools.

IFC (Industry Foundation Classes) is an open file formation specification internationally promoted by BuildingSMART to assist interoperability between different software packages. See https://www.buildingsmart.org

BIM uses

Setting the BIM uses in the BIM Execution Plan is crucial to good workflow management. If the federated model is to be used for a specific purpose this needs to be considered and planned for. Penn State guidance (www.bim.psu.edu/Uses/) sets out 25 BIM uses.

Real-time environments

Digital tools are transforming the design process with new workflows nudging closer to the Holy Grail of real-time environments where geometry, data and analysis are connected. In such systems the impact of change can be assessed immediately – for example, the energy impact of a different façade or the impacts on lighting levels of a darker floor finish. New workflows are crucial in connecting the different parts of the design process together and moving towards real-time design processes.

Algorithms

Algorithms can be used to create graphs for more complex geometries or for generative design. However, they can also be useful for considering how to automate aspects of the design process. For example, the process for creating a door schedule from the datasets in a BIM model might be conceived as an algorithm by a technically orientated architect and then scripted or coded by someone else. Simply, algorithms can be used to make the design process more efficient.

Parametric design

In a BIM environment variable parameters can be added to objects, enabling them to be quickly edited – for example, the width of a staircase or the height of a door. While this can assist the design process, it can also add complexities. For example, a parametric door would have infinite options when the lead designer may wish just a few options geared to standard manufacturing sizes. More complex parametric design uses visual scripting graphs where more complex geometries can be created and varied. This can also be called rules-based design.

Generative design

Generative design takes rules-based design to the next level, allowing thousands of options to be rapidly created around set constraints using genetic algorithms, machine learning and large scripting graphs with nodes that use more complex codes such as Python. Options can then be evaluated using data analytics and iterated and evolved faster than traditional design processes. The balance between the machine and the intuitive oversight of the designer is set to be one of the core debates of the next decade.

Post-production

With more work undertaken in 3D, the goal is to create design processes that avoid post-production workflow once 3D information has been pushed into other environments – for example, adjusting a render in one environment or adding dimensions to a 2D drawing. Post-production work adds waste to the design process and creates risk due to the need to manually change information outside the model. Eliminating post-production work becomes crucial to the workflow of the future, although this may become a moot point once the need for 2D information has been eliminated or 2D becomes solely a view taken from the 3D model.

This chapter:

- Considered specific tools to assist in the day-to-day management of the design process
- Underlined the importance of considering better design decision-making processes and the tools to facilitate this
- Proposed that connecting new design processes to better knowledge management tools is crucial if designs are to be more robust and efficiently produced
- Set out the tools useful for connecting the digital tools of the design team more effectively together

CHAPTER 6
Delivering design on time

Introduction

A core challenge for the lead designer is ensuring that the design team's work is delivered on time. Each project stage has different drivers and demands, each site and brief its own challenges. Tweaking the order of the tasks to be undertaken from one stage to the next, or the nuances of their timing to deal with project-specific constraints, can result in information not being available to manage interfaces or interdependencies.

The periods for the three stages of the design – stage 2: Concept Design, stage 3: Developed Design and stage 4: Technical Design – sit inside a Project Programme that looks at the strategic timing for the project. The primary goal of this is to determine when the project will be complete, ready for the client to use the building. The construction team needs to prepare a programme to control and monitor the manufacturing and assembly or construction of a building. The lead designer must be able to navigate and understand these programmes, particularly the Project Programme which acts as the basis for preparing the Design Programmes for each stage. This chapter considers these programmes, their relationships and the topics that the lead designer needs to be aware of.

To put some order to what can seem like a random process, the lead designer needs to prepare a Design Programme for each stage of a project. The core purpose of a Design Programme is to summarise the 'story' of the design process for a project. The Design Programme at stage 2 needs to be flexible to deal with the complexities of iterations; however, the stage 4 Design Programme can be more specific and geared to deadlines, as well as being used to manage interfaces and interdependencies. The Design Programme is a core tool for the lead designer, allowing them to respond to the progressive fixity and increasing level of detail of the design, and the unique challenges generated by every site, the iterative nature of the design process and the unpredictable contributions from clients and stakeholders.

This chapter provides the tips and tools required to prepare a Design Programme and looks at how to deal with the complexities of each design stage and how to deliver the right information by the right designer at the right time. To be efficient, Design Programmes need to be succinct and aligned to other design management tools. This chapter considers the crucial relationship between the Design Programme and the design management tools set out in Chapter 5.

To make matters more complex, the transition towards new workflow driven by increasingly intelligent design tools and the advent of modern methods of construction requires a major overhaul of Design Programme templates that have been used over the years.

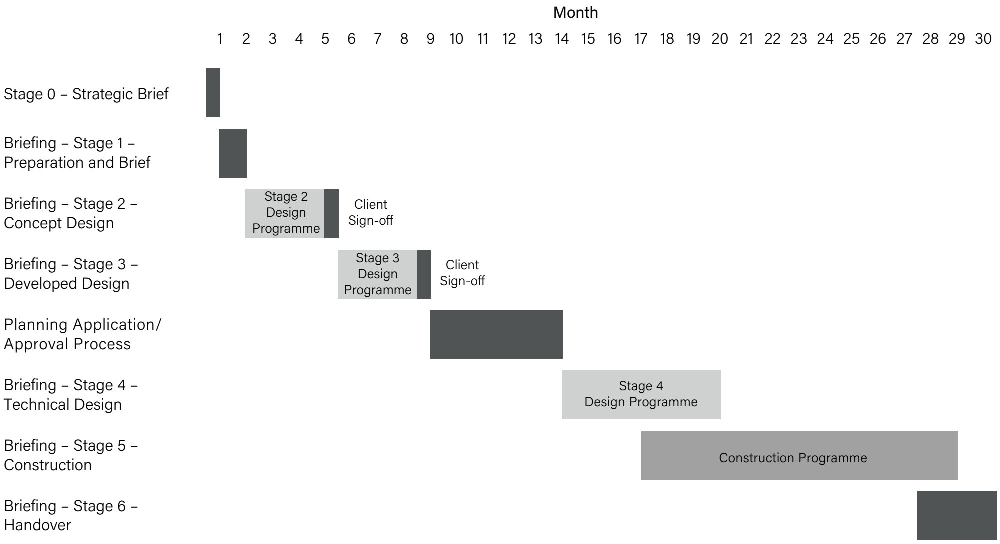
What purpose does the Project Programme serve?

The Project Programme sets the timescales for a project from inception to completion. It is set by the client team and drives the timescales for each stage. It therefore sets the boundaries for the Design Programme at each design stage. On any project, time is limited and there are increasing demands to deliver projects faster. For example, the UK government in its 2011 Construction Strategy set the goal of reducing time by 50%: a significant reduction. With the time for design and construction split broadly 50:50, there are increasing demands for the lead designer to look at opportunities to design faster without increasing design risks.

The Project Programme is produced by the client team. By setting the commencement and completion dates, the timescale for the project is set. The Project Programme is used to:

- set the overall time frame for the project: from inception to completion
- determine the time available for each stage, including briefing, design and construction
- show key gateways, milestone and sign-off dates
- overlay procurement activity on to the design process
- map out the dates for the planning application and other statutory consents
- illustrate key stakeholder meeting dates.

Figure 6.1: A Project Programme illustrating Design and Construction Programme durations



The Project Programme

This figure illustrates how the three Design Programmes and the Construction Programme sit inside the Project Programme. The Project Programme illustrates how a typical project works. A period of time is required to determine that building is required and to develop the Initial Project Brief (stages 0 and 1). The design journey begins and stages 2 are 3 are undertaken before the scheme is signed-off and a Planning Application submitted. Stage 4 and procurement exercises can be undertaken at different times; however, in this example, they take place once Planning Consent has been granted. As illustrated, it is commonplace for stages 4, 5 and 6 to overlap.

The client team will prepare the Project Programme using their experience from similar projects.

In preparing the Project Programme certain stages and/or tasks may need to be compressed or overlapped in order to achieve the required completion date or to comply with specific project milestones – for example, the date for a funding application or a scheduled board meeting. When the client wishes a building to be delivered faster, it will inevitably impact on the design process and require the design team to take risks. The lead designer needs to understand the rationale behind the Project Programme and how the different periods have been set. For example:

- Has the briefing period been reduced?
- Are the design stages shorter than what is typically set?

- Are the design stages overlapping with sign-off periods?
- Does stage 3 and/or 4 overlap with the planning application approval period?
- Is it necessary to proceed from stage 2 to 3 without key stakeholder contributions?

Figure 6.2: The impact of procurement on design time

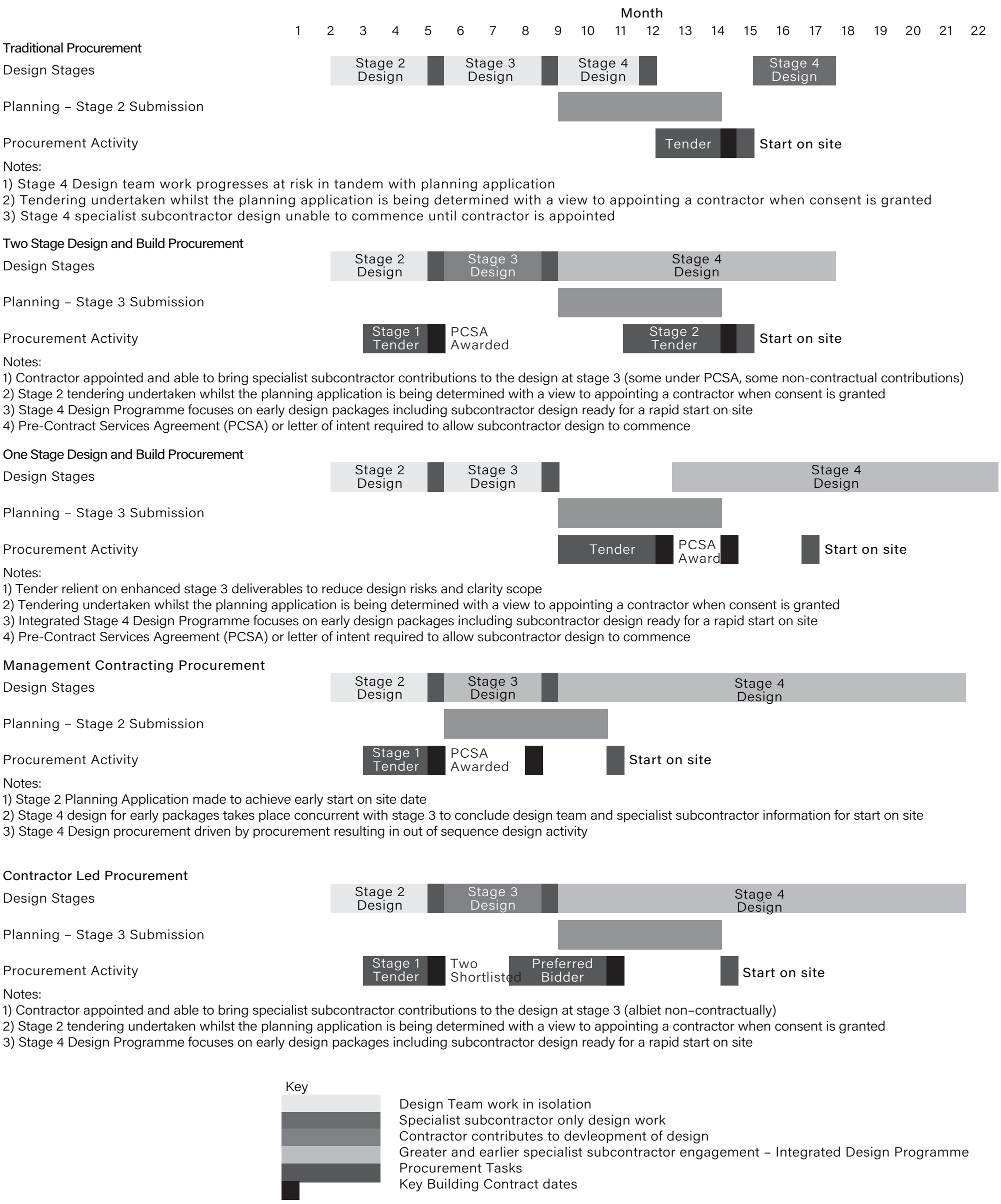
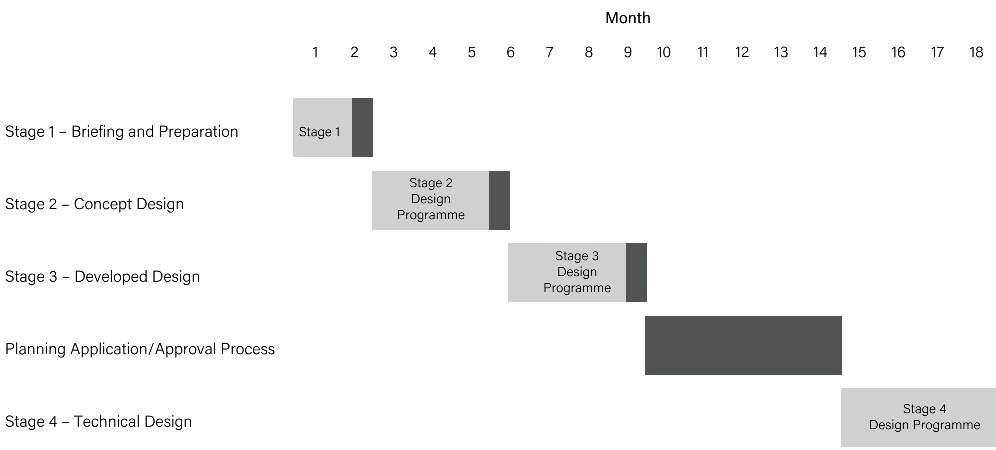


Figure 6.3 illustrates the typical periods shown in Project Programmes for traditional stage 2 and 3 design processes with Figure 6.4 illustrating a compressed programme. The risks associated with this shorter programme include:

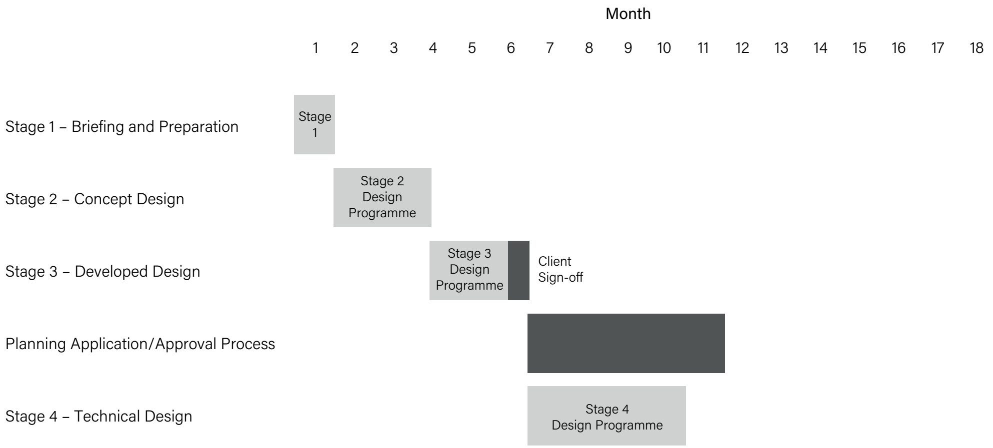
- A reduced briefing period might result in an incomplete or ill-considered brief with many questions asked during stage 2 or challenges fitting the brief on the site encountered due to Feasibility Studies not being undertaken.
- Shortening the design stages may not allow enough iterations of the design, resulting in information that has not been adequately thought through or uncoordinated project information, including Project Strategies.
- Sign-off periods overlapping with the next design stage, resulting in the design team responding to the client's review, diverting the design team from the task at hand.
- Planners requesting changes once the Detailed Design has been completed. Will the client push these through the change control process with the design team being given additional fees and time to make the necessary amendments?

Figure 6.3: Reduced risk Design Programme



The above programme allows sufficient periods of time for different iterations of the design, client sign-off periods after the Concept Design: to allow the client to review and sign-off proposals, with stage 4 taking place after the Planning Consent has been granted, allowing any conditions to be addressed during stage 4.

Figure 6.4: Faster Design Programme with increased risk



Although this Design Programme is seven months shorter than the duration in Figure 6.3, the stage 1 briefing period and the stage 2 and 3 design periods have been reduced, minimising the opportunities to iterate the design and coordinate. The client review period for stage 2 has been removed, creating further design risk, and the stage 4 design period overlaps with the planning approval period, creating the risk of potential for rework to deal with conditions placed on the Planning Consent.

The lead designer needs to be alert to these issues, making sure that the PSAs have been reviewed with these topics in mind. Where amendments are not possible and residual risks remain, the lead designer should ensure that the design team is aware of these and is happy to proceed, adding additional hold points to the Design Programme or using other measures, such as robust Change Control Procedures, to manage these risks.

The issues driving the Design Programme

Understanding the iterative nature of the design process is core to developing a good Design Programme. Iterations are driven by external constraints and differing nature of design from project to project that make it difficult to predict exactly when aspects of the design will progress. Simply, a Design Programme with many lines of activity is doomed to fail: it adds structure to a process that needs flexibility. The three RIBA design stages iterate in different ways.

- During stage 2 major and many iterations are required to get spatial adjacencies right and to get the correct strategies for the engineering embedded into the architect's geometry.

- During stage 3 the design team coordinates its designs with iterations occurring as a result of engineering analysis, coordination tasks and refinement of the building's envelope.
- During stage 4 the final details, and the contribution of specialist subcontractors, will require fine tuning iterations of the detailed aspects of the design.

To deal with the diverse challenges of iteration, it is crucial for Design Programmes to avoid detailed lists of tasks that logically flow from one to the next. Programming this way serves no purpose: it implies that the design progress can be controlled in detail when the reality is that some tasks may need to be repeated or undertaken at later in a stage. **If the timing of a design task cannot be predicted with certainty, it cannot be programmed as a finite item in a Design Programme. This is the core difference between a Design Programme and the Project or Construction Programme.**

The Design Programme:

- dovetails with the key dates in the Project Programme, including meeting or milestone dates
- considers any unique design tasks on a project and when they will be dealt with
- deals with the iterative nature of design by creating simple timelines and managing these using the Design Status Schedule
- acknowledges that designs are presented to, and reviewed by, many people whose comments cannot be predicted
- tells the story of how the design will be undertaken
- includes meeting dates with the client, design and construction teams and any project stakeholders
- overlays the requirements of the Procurement Strategy, including the time frames for integrating the design work of specialist subcontractors with design responsibilities.

Those undertaking the lead designer role are advised to have their own Design Programme templates. These might vary for different sectors, scales and complexity. They can be refined over a number of projects as they are adjusted to reflect the issues encountered. This approach also gives the lead designer the information necessary to respond to the client team's Project Programme at the outset.

To create a robust Design Programme the lead designer needs to:

- reconcile the Design Programme with the Project Programme
- map out the client and stakeholder engagement and review timescales
- consider how to manage the iterative nature of the design process
- overlay any procurement tasks on to the Design Programme
- consider likely forms of construction and their impact on the Design Programme
- reflect on how new workflows will impact on the design process.

What should a stage 2 programme contain?

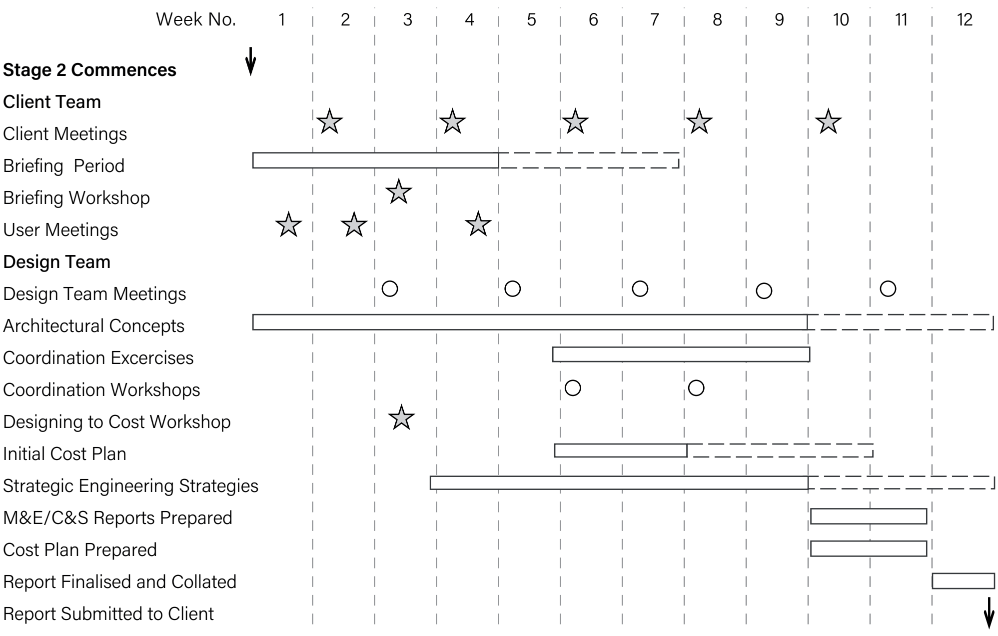
Stage 2 contains the biggest iterations of the design. It may take one day or several weeks for the architect to create an idea that captures the client's imagination. The client may wish to see a number of options progressed for greater consideration and when the designer/client relationship goes well stakeholders may have comments that require detailed changes to the design. The Design Programme needs to be flexible to allow time for these unprogrammable and unpredictable design transactions to take place. The Design Programme for this stage needs to allow periods for adjusting the design in line with:

- comments made at client presentations or user meetings
- comments from third parties, such as planners or utility companies
- the analysis and conclusion of strategic coordination exercises
- the development of building services elements (i.e. plant room and riser requirements).

Figure 6.5 illustrates what a typical stage 2 programme should look like. This example makes it clear that the precise timing of certain tasks, such as incorporating engineering principles into the design, cannot be predicted other than in broad terms. The programme shows the importance of setting design review dates and the need to consider the timing for developing the Cost Plan or other tasks that might be undertaken in isolation, such as developing the energy strategy. By creating a 'looser' Design Programme, the lead designer provides a platform for developing a world-class design, allowing the design team to engage when a clear concept is emerging.

Recognising the challenges of iteration, the tools outlined in Chapter 5 should be used in conjunction with the Design Programme in order to manage the design process and to demonstrate to the client team that the design is progressing as planned.

Figure 6.5: Typical stage 2 Design Programme



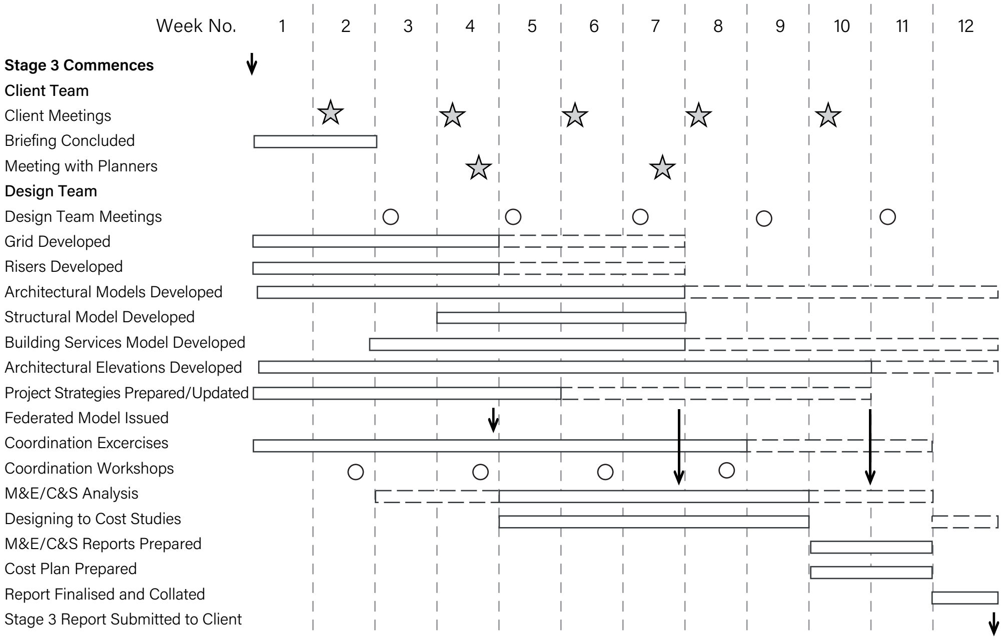
How should the Design Programme for stage 3 vary from the stage 2 programme?

When the Concept Design has been signed-off by the client, the more volatile iterations of the design will be complete. Iterations at stage 3 will still be required; however, they will be more predictable and therefore the Design Programme can be more rigid. The Design Programme at stage 3 should focus on concluding the coordination of the design before the detail is layered in at stage 4. At stage 3 the following activities will take place:

- Conclusion of the structural grid following coordination exercises.
- Engineering analysis where rules of thumb have been used at stage 2: validation through engineering.
- More detailed cost exercises, particularly for unique aspects of the design, such as the use of new materials or a new form of construction.
- Development and coordination of the Project Strategies.

Figure 6.6 illustrates how a stage 3 Design Programme differs from a stage 2 one. As the design will be 'settling down', the number of iterative items is reduced, allowing more detailed programme bars to be added to manage interdependencies.

Figure 6.6: Typical stage 3 Design Programme



What drives the development of a stage 4 Design Programme?

If stage 3 has been undertaken successfully, the majority of design work at stage 4 can be undertaken independently by each designer, although minor iterations of the design are inevitable. The stage 4 Design Programme moves emphasis towards the detailed considerations of interfaces and interdependencies. The timing of the design work of the design team and the specialist subcontractors will be sliced and diced depending on the Procurement Strategy. For example:

- On projects using traditional procurement, the design team must produce design intent information for any (descriptive) CDP packages for inclusion in their tender package. If this information is not robust the development of the specialist subcontractor information may impact on construction information at interfaces requiring adjustments and instructions to this work.
- At the other end of the spectrum, contractor-led procurement allows the work of the design team and the specialist subcontractors to be undertaken in tandem with key interfaces to be developed collaboratively and interdependencies to be managed efficiently.

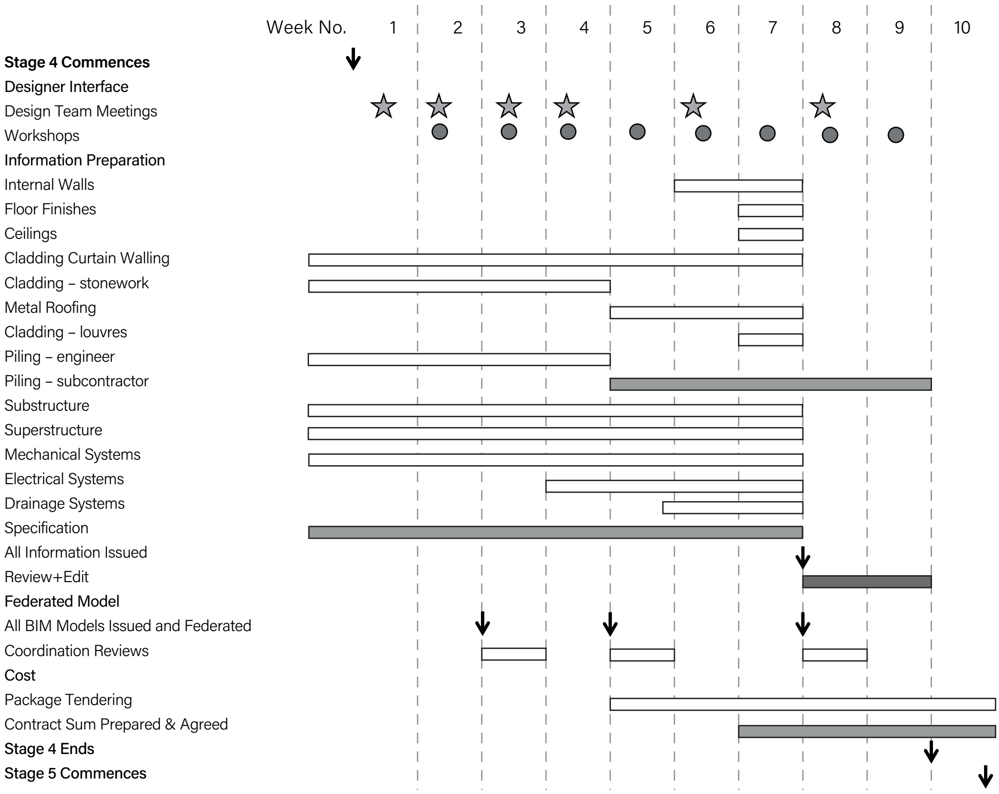
- The Design Programme on management contracts is set by working backwards from construction and procurement timescales, requiring aspects of the design to be undertaken out of sequence by both the design team and specialist subcontractors, creating significant design challenges for the lead designer.
- On Design and Build projects, high-risk packages – such as the building services or cladding – might be developed early, along with those required to enable an early start on-site, requiring early specialist subcontractor input for these aspects.

The stage 4 Design Programme is more akin to an Information Release Schedule (IRS), setting out the dates that information for specific packages will be released for tendering and/or construction purposes (see Figures 6.7 to 6.11, inclusive). It is crucial for the lead designer to review these dates and to understand the implications on any interfaces and interdependencies. For example:

- Is information required from one designer in order to conclude construction information for another? For example, are fixing slots for cladding brackets, recesses for door thresholds, the setting out for BMU plinths or notches to suit waterproofing systems ready for incorporating in the structural engineer's construction information?
- Is the information necessary to develop and conclude the reflected ceiling plans available, including the ceiling manufacturer, perimeter margin details, grille and lighting requirements supplier information and details on sprinklers, smoke detectors and other services?

The lead designer can use the design status tracker to manage and drive residual design items to conclusion. On some forms of procurement this schedule might be used to identify risk. On others it might be used to highlight design intent challenges, agreement on how interfaces will be designed or recording the timing and order of the information required. The detail involved at stage 4 benefits from tools such as checklists to ensure that no issue is left unconsidered due to the intuitive judgement of one designer resulting in a small but crucial detail being missed.

Figure 6.7: Stage 4 Design Programme – two-stage Design and Build



Notes:

1 – 10 week design period has been structured to allow an early start on-site yet allowing the Contract Sum to be based on as much information as possible.

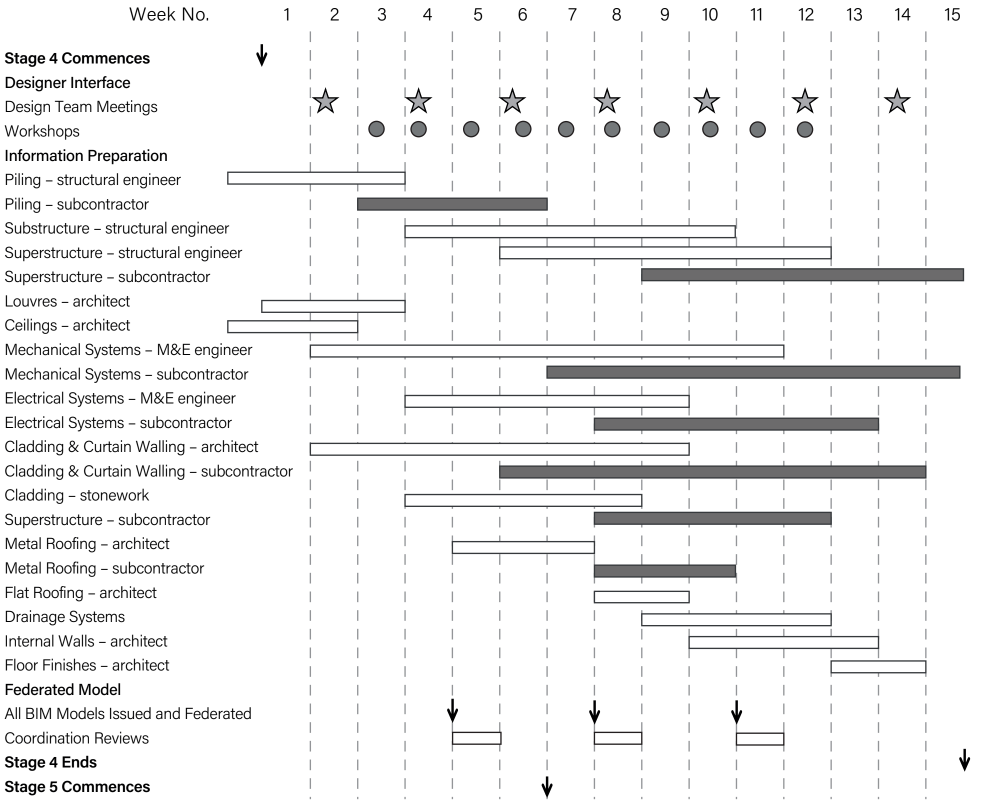
2 – Single review period shown at end including a final BIM coordination review although there is not much time available for a comprehensive review and tenders have been issued. The review allows risk allowances to be determined.

3 – Design information is focused on initial construction packages (to construction status) as well as those covering risk. The specification is highlighted as it will need to cover aspects that are not drawn in detail prior to the award.

4 – Everyone is working concurrently and design dependencies will be more difficult for the lead designer to manage. Design team meetings (as well as workshops) are shown as weekly in the early weeks to provide additional management of these issues.

5 – The Design Programme shows only the design team information produced for agreeing the Contract Sum. A separate and integrated Design Programme would be prepared after the award of the Building Contract covering the remaining design team aspects and the specialist subcontractor design elements. An early award of the piling package has been undertaken to allow the specialist subcontractors design work to be concluded to allow a start on-site immediately following agreement of the Contract Sum.

Figure 6.8: Stage 4 Design Programme – contractor-led



Notes:

1 – Review of information is incremental and by element and is not shown.

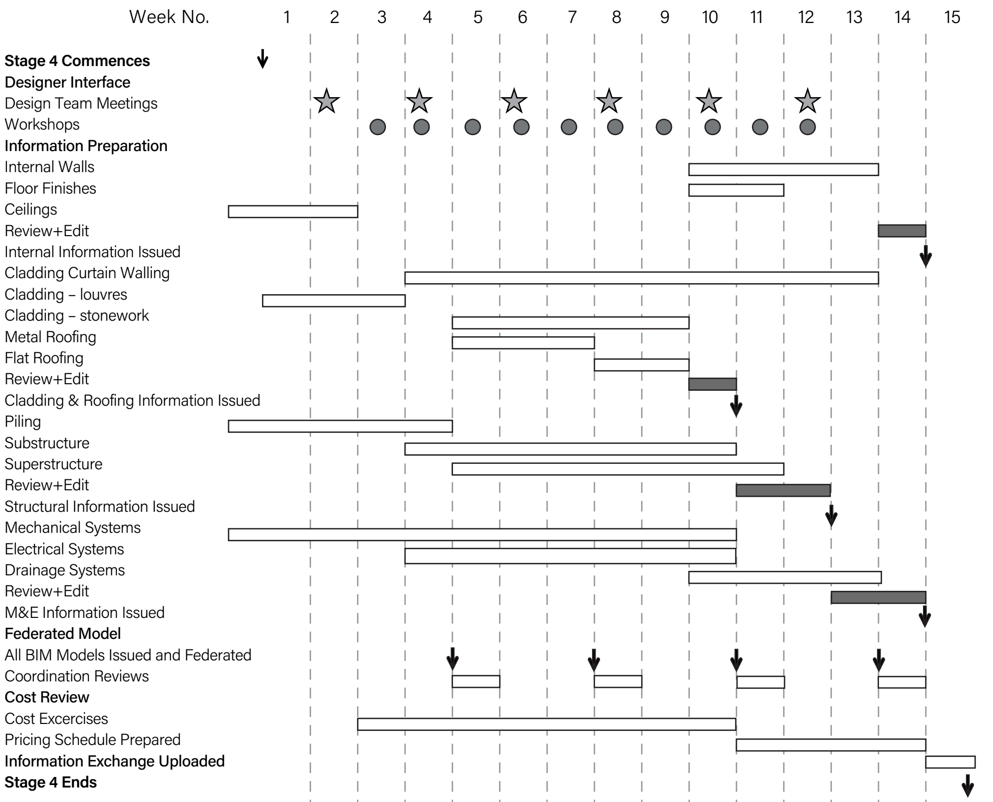
2 – Cost activities removed. The contractor may undertake these but they do not fundamentally alter the lead designer's work and as such they are not included in the Design Programme.

3 – Programme shows design work of design team and specialist subcontractors and generally follows construction activity.

4 – Construction (stage 5) commences on completion of piling information.

5 – For clarity, not all building aspects are shown.

Figure 6.9: Stage 4 Design Programme – traditional



Notes:

1 – The Review periods will depend on who is reviewing – In this instance it is assumed that it is solely the lead designer – The architectural reviews are reduced to reflect the practices internal processes.

2 – Cost excercies and a stage 4 cost report are shown – On many projects pre-tender estimates are not undertaken.

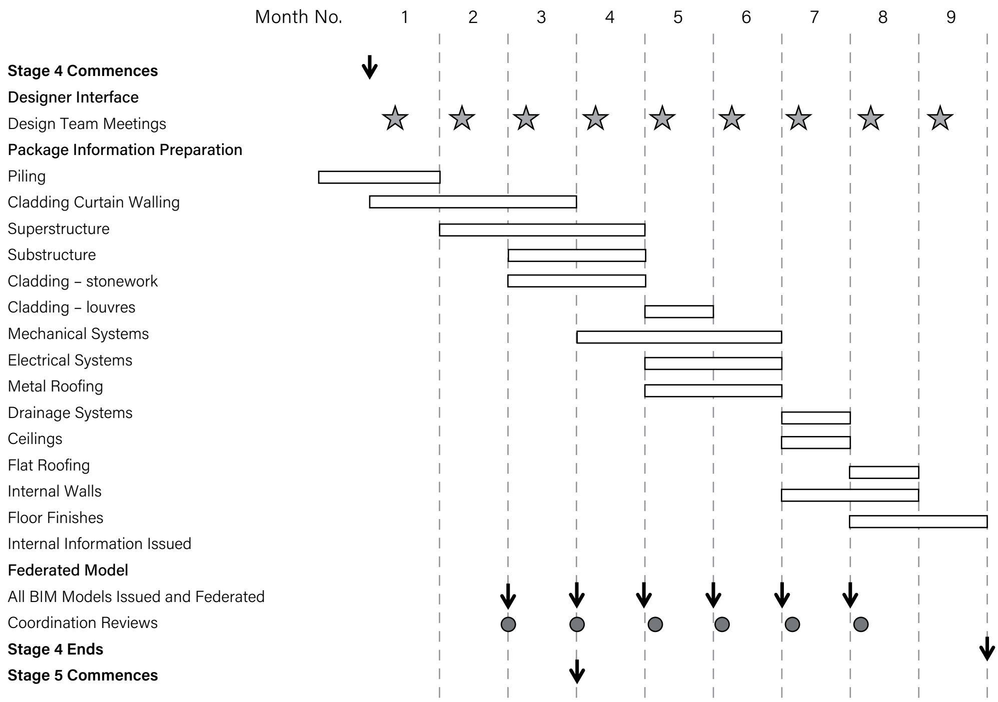
3 – The architect is producing ceiling and louvre information first to allow M&E information to progress and then is focusing on the cladding packages where the greatest amount of coordination is required. The architectural team are programmed to complete the internal packages after that.

4 – The completion of information is staggered to allow the lead designer adequate time to review each 'package.'

5 – The Design Programme shows only the design team information produced for tender.

6 – There is no overlap with stage 5. The tendering process can begin when stage 4 ends.

Figure 6.10: Stage 4 Design Programme – management contracting



Notes:

1 – The Review and issue periods are not indicated for clarity. Each package is reviewed as it is completed and before it is issued for tender. The same principle applies to cost infromation.

2 – Periods shown are in months to reflect the longer design period driven by the procurement programme.

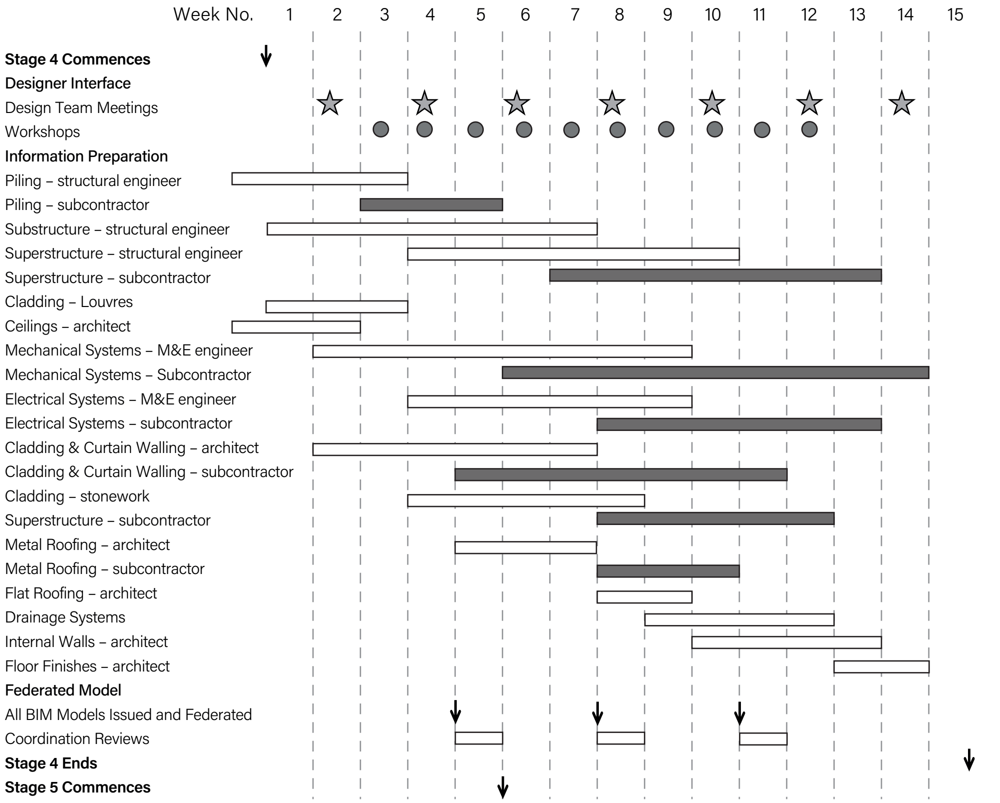
3 – Workshops are to be arranged on a package basis and are not indicated.

4 – Package Information organised by release date (end of the design activity bar). This is when information is released to the cost consultant and contractor for tendering of the package.

5 – Stage 5 commences after the piling package has been tendered and awarded.

6 – For clarity, not all building aspects are shown.

Figure 6.11: Stage 4 Design Programme – one-stage Design and Build



Notes:

1 – Review of information is incremental and by element and is not shown.

2 – The Building Contract was awarded immediately prior to stage 4 commencing and cost activities have therefore been removed. The contractor may undertake these but they do not fundamentally alter the lead designer's work and as such they are not included in the Design Programme.

3 – Programme shows design work of design team and specialist subcontractors and generally follows construction activity.

4 – Construction (stage 5) commences on completion of piling information.

5 – The programme is similar to the contractor-led programme, the exception being that the early packages for site are compressed (design team and specialist subcontractor) to facilitate a prompt start on-site.

6 – For clarity, not all building aspects are shown.

Other tools to use in conjunction with a Design Programme

Chapter 5 considered the lead designer's toolkit. A number of these tools are essential to use in conjunction with the Design Programme if a design is to progress as planned. These include:

Design Status Schedule

The Design Status Schedule can perform a number of functions (covered further on p 114) and has different purposes at different stages of the design. Its primary functions are to act as a bridge between the information in the 'designer's head', the current design information and as a means for the lead designer to convey all aspects of the developing design to the relevant parties.

Progress reports

It is essential that progress reports contain a commentary in relation to the Design Programme, focusing on the tasks that are behind programme or have not taken place rather than emphasising tasks that have been completed as planned. Topics in a progress report might include the status of:

- specialist consultant appointments: are any holding up the design?
- hot topics and how they are being driven to conclusion
- comments from planners and how they are being dealt with
- how user group comments are being closed out and any impacts on the design process
- interfaces or interdependencies that are causing concern
- discussions with suppliers or specialist subcontractors
- responses from utilities companies.

The progress report is the ideal means for the lead designer to demonstrate that they understand all the design issues on a project and are effectively managing them and directing the work of the design team.

Workflow

As more and more innovation is layered into projects, more traditional design processes are being transformed. The workflow diagrams set out in the previous chapter are a crucial means of the lead designer ensuring that the Design Programme reflects new ways of working and the collective agreement of the project team to the digital tools that will be used on a project.

How does the Procurement Strategy impact on the Design Programme?

The impact of procurement on the Design Programme at stage 4 is considered above. A common misconception is that different Procurement Strategys radically change the design process at stage 2 or 3. They do not. Procurement requires adjustments to the design process in the early design stages:

- Appointing the construction team early results in a more rigorous and robust Construction Strategy at stage 2, and may result in the lead designer to delve into design detail that may not be relevant to the stage.
- Allows the contractor's supply chain, including suppliers and specialist subcontractors, to contribute earlier to the design process.
- Requires additional deliverables at stage 3 to ensure a more robust set of Contractor's Proposals and in order to define the scope of work in greater detail.

The lead designer needs to consider these tweaks and adjust the contents of the Design Programme for each stage accordingly.

The Construction Programme

The Construction Programme is the main tool for ensuring that construction is completed on time. It sets the duration and sequencing for each construction activity and defines the critical path for the project (see p 163). For example, dry-lining cannot commence until the slabs above and below are completed and the building is wind- and weather-tight.

Although stages 4 and 5 are independent of the majority of Procurement Strategys, they occur concurrently. On some Procurement Strategys, such as management contracting, there is a substantial overlap between design and construction, requiring the lead designer to consider how to deal with items being designed out of sequence. For example, the stairs might be constructed on-site months before balustrading information is released for tender.

The Construction Programme is also used to determine whether construction is progressing as planned by reviewing progress on-site every month. With a traditional Procurement Strategy the contract administrator needs to understand the logic and detail of the Construction Programme and may need to rely on its contents, and in particular against the programme the critical path, when determining any claims for extensions of time. A review of the Construction Programme by the lead designer is useful as it may:

- identify a construction sequence that is not possible, due to the way that a specific area is detailed

- flag that insufficient lead-in periods have been taken into account to order and deliver key specified components for the building
- suggest that more time is required to develop and finalise specialist subcontractor design information and/or the time required for off-site manufacturing.

A Construction Programme is prepared using 'frozen' information and once the programmer has established the quantities of work for each element and area of the building they will use their knowledge, experience and/or historical data from completed projects to prepare the Programme. From the construction team's perspective, the programme serves a number of purposes:

1. It enables the construction team to demonstrate and be confident that the building can be constructed in the period allocated in the Project Programme.
2. It can be issued to the subcontractors, pricing the works to allow them to consider their own preliminary costs, the number of installation teams and the management that will be required on-site and for them to ratify that the periods allocated to them are adequate.
3. It allows the critical path to be identified.

4D BIM

Increasingly, the construction team is using the design team's model to visualise the construction sequencing. 4D BIM achieves this by connecting the Construction Programme to the objects in the BIM model, allowing the virtual constructing of the building. This process allows the construction team to understand the sequencing more clearly and can be used to communicate the process more effectively to clients and other stakeholders. Crucially, it allows health and safety and other logistic details – such as the location of access points, site facilities or crane locations – to be rehearsed and optimised in greater detail.

What is the critical path?

The critical path determines the fastest construction methodology for a project and is the point beyond which additional measures, such as additional shifts (evening or weekends) would be required to compress the Construction Programme further.
By default, the delay of any activity on the critical path will cause a delay to the overall completion date unless they and/or any subsequent activity is accelerated, which may of course incur additional costs. Activities that are not on the critical path may be delayed but can be re-sequenced without impacting the completion date.

How will Design Programmes change in the future?

BIM workflow allows the engineering teams to more efficiently leverage the architectural model for the development of their geometric information as well as for analysis purposes. As the architect's model is able to be used more dynamically (rather than the static use of CAD reference files) by engineering analysis software, the workflow and interoperability between the various models and analysis software becomes crucial to new innovative Design Programmes. Workflow diagrams can be prepared when developing the design team's BIM Execution Plan to help conclude the software to be used on a project and how this might be better connected. In the future, real-time analysis will result in game-changing adjustments to the design process. Perhaps a design stage will be omitted as more intelligent construction-ready objects are incorporated into the early design stages?

The lead designer needs to be alert to these developments, regularly considering whether new tools or techniques can justify a reduction of the times set in their Design Programme templates and how the design team might work more effectively to achieve faster, cheaper, better, safer and greener designs.

This chapter:

- ► Described how the Project Programme acts as the framework for the project stages, including the design and construction stages
- ► Noted that Design Programmes need specific considerations and inclusions and to be aligned to other tools if they are to be employed effectively
- ► Set out the challenges in creating a Construction Programme and the aspects that the lead designer should consider

CHAPTER 7
DESIGNING TO COST

Introduction

Designing to cost is the biggest challenge for the lead designer. Managing cost is central to the design process and although cost exercises may not influence coordination tasks, the lead designer's efforts will have been in vain if the coordinated design exceeds the client's Project Budget. The first task for the lead designer is therefore understanding the client's views on cost and the cost goals for the project.

Every project must start with a Project Budget set by the client team, followed by a Cost Plan prepared by the cost consultant in the design team and end with a Contract Sum in the Building Contract agreed between the client and the construction team. The biggest hurdle to successfully managing cost on a project is handing over the cost baton from the cost consultant to the construction team. Every project is presented with this transition challenge, regardless of the Procurement Strategy. It is important to understand where the handing over of this baton can go wrong, so that those undertaking the lead designer role can be alert to these issues.

Historically, the costing process was undertaken reactively: a Cost Plan produced in response to a near completed stage design. While the client team continues to see the cost consultant as their 'banker', the design team can be diligent and demonstrate that they are treating the client's money as their own, with the lead designer facilitating designing to cost measures to deliver on cost. This chapter considers what those might be.

For various reasons the brief might need altering as the design progresses. Regardless of the reason, once the Concept Design has been set, Change Control Procedures should be put in place by the client team to allow the implications of changes to be considered and, if necessary, instructed. The lead designer needs to be aware of Change Control Procedures on behalf of the design team.

Client teams are increasingly embracing whole-life costs and topics, such as the circular economy. Although there is not necessarily a correlation between capital costs and reduced operational costs, it is fair to say that carefully increased capital costs will reduce maintenance requirements. In many instances ownership changes at the building handover and there is no incentive to design for reduced maintenance costs. Clients who are the end user and control all costs are moving to a more considered approach, providing the case studies for others to consider.

The final section of this chapter considers how digital tools will continue to evolve and further transform designing to cost processes.

Cost from a client's perspective

Any project must be designed in line with the Project Budget set by the client team and any design process must consider how to respect the budget that has been set. A core initial task of the lead designer is therefore understanding the client's budget. Is it tight, requiring a lot of consideration during the design process? Is it in line with sector norms, meaning the designers can design as they usually do? Or is it generous, allowing new forms or materials – that might normally be unaffordable – to be considered?

Some clients may not wish cost considerations to impede creativity. Others are frugal, being happiest when a project is delivered below budget. Behaviour geared to the latter, when the client wishes the former, will result in poor cost outcomes, resulting in re-work and in some instances aborted projects. It is crucial that the design team understands the project cost dynamic and the client's views on cost at the outset, allowing the lead designer to steer the design process accordingly.

Although some Procurement Strategys resolve client goals for time and cost goals, quality can remain at large on a project. The client team needs to consider the prescriptive to descriptive journey for products. It may wish certain products or approaches to be standardised across the estate, might ask the design team to specify agnostically to allow the construction team to leverage its supply chain or allow specialist subcontractors to propose innovative solutions. As set out in Chapter 5, this variable journey can impede designing to cost initiatives.

The cost challenges on a project

Predicting the cost of a building is challenging. Every building is unique, even where the same design is repeated. For example, the same school design will require different foundations, drainage and power connections, or different landscaping requirements in response to comments from planners. Furthermore, the cost of transporting materials or obtaining labour can vary from one location to another.

The lead designer can assist the design process by considering how to design to cost. The Design Status Schedule can record any assumptions that the cost consultant has made in the preparation of the Cost Plan. This schedule can also be used to match early specification aspirations to the Cost Plan. For example, there is no point in the architect considering oversized timber-veneered doors with fire-rated glass panels and full-height offset stainless steel handles if the Cost Plan allows for paint grade doors with standard ironmongery.

Why is the Project Budget crucial to the design team?

The Project Budget is produced by the cost consultant using historical data or their knowledge and experience of market rates for carrying out similar projects. The Project Budget should be available when the lead designer is assembling the design team, as should any designing to cost obligations contained in the PSAs (see p 169).

The first task for the lead designer is reviewing the Project Budget, ascertaining how robust it is and whether it presents any particular challenges. It always merits further analysis.

If the design team has concerns regarding the Project Budget and/or the client's attitude to cost, they should be flagged and addressed during the appointment process. For example, an ambitious Project Budget (one that appears to be difficult to achieve or verging on unrealistic) aligned to designing to cost obligations in the Schedules of Services included in the PSAs (i.e., the need to redesign if tenders are over budget) should make the design team pause before they proceed.

Simply, if the Project Budget is unachievable the design team will never be able to produce a Cost Plan that matches the client's aspirations. The lead designer needs to recognise that while it is possible to hone the specification for a building, cost is ultimately dictated by the area of a building. Where a building is significantly over budget it is folly to believe that this can be dealt with by specification alone. A properly set Project Budget should already have flushed out this point.

The Project Budget should include allowances for:

- professional fees
- VAT
- planning fees
- utility costs
- estimated construction cost
- contingencies
- inflation.

The estimated construction cost of the building will be based on sector norms, the quality aspirations set in the brief (including the level of specification), any site-specific risks or abnormal requirements (such as poor ground conditions), trends in tender pricing, and will be based on the functional requirements with an uplift for the nett:gross ratio.

Figure 7.1: Project Budget v Cost Plan

Client team's **estimated construction cost in Project Budget**

=

Design team's **Cost Plan**

Why is the Cost Plan a crucial tool for the lead designer?

The Cost Plan is a core document from the lead designer's perspective. It demonstrates that the design proposals are progressing in line with the Project Budget. The Cost Plan used to be produced at the *end* of a stage. In this scenario, if the Cost Plan exceeded the Project Budget the design had to be adjusted until it was in line with the Project Budget, creating further, potentially significant, iterations of the design process. Not only did this result in delays to the Design Programme, it was an extremely inefficient way of working.

Designing to cost initiatives put the right checks and balances in place as the design progresses, allowing cost decisions to be made incrementally for inclusion in the Cost Plan as part of the iterative design process.

Designing to cost obligations in Professional Services Agreements

Many bespoke agreements create an onus on the designers to redesign at no extra cost should the Cost Plan be exceeded or the contractor's tenders returned over budget. While the cost consultant will have liabilities to ensure that the Cost Plan is accurate, if the designers are not to be paid to redesign, they should consider the interface with the cost consultant more closely. The lead designer might request additional duties, processes or procedures that will help them work more effectively with the cost consultant to design to cost. For example, reducing elemental costs for aspects of the design earlier in the design process.

How does the procurement process impact cost control?

The procurement process has minimal influence on the design process and should arguably make little difference to the out-turn cost; however, it is a matter of record that different Procurement Strategys influence the Contract Sum in different ways. The impact of procurement on the costing aspects of the design process is considered in greater detail in Figure 7.2 overleaf.

Figure 7.2: Procurement: transferring the cost baton

Procurement Strategy	Stage 2	Stage 3	Stage 4	Notes
Traditional	1	1	○	No interface with the construction team. Construction team's cost unknown until tenders are opened during stage 4.
Two-stage Design and Build	2	● 3,4	○	Cost Plan developed in conjunction with selected construction team.
Construction team Led	5	5	○	Construction team's costs known early at the end of stage 2. However, construction team may not have sight of the Project Budget to inform the stage 2 design process.
One-stage Design and Build	1	1	○	No interface with the construction team. Construction team's cost unknown until tenders are opened during stage 4.
Management Contracting	2	● 3,4	3,4	Cost Plan developed in conjunction with selected construction team but costs unknown until project is completed.
Construction Management	2	● 3,4	3,4	Cost Plan developed in conjunction with selected construction team but costs unknown until project is completed.
PFI	5	5	○	Construction team's costs known early at the end of stage 2. However, construction team may not have sight of the Project Budget to inform the stage 2 design process.

Key

○ Point where costs are fixed (Building Contract awarded).

● Point where the construction team agrees the Cost Plan.

1. No interface with the construction team regarding costs.
2. Early appointment can allow discussion with the client and design team cost consultants regarding preliminaries and other project-wide costs.
3. Construction team can discuss core rates with its supply chain – for example, costs for air handling units, dry-lining or other items with large quantities.
4. Construction team can involve its supply chain and facilitate meetings between specialist subcontractors and the design team to progress core aspects of the design.
5. Costs and design developed in tandem by the contractor's design team and specialist subcontractors.

Getting the Cost Plan right – what can the lead designer do at stage 2?

There are a number of designing to cost measures the lead designer can implement to ensure that the Cost Plan is as accurate as possible from its first iteration.

Sector and precedent information

Historical data is available industry-wide, and cost consultants will also have access to accurate historical data from projects against which they can benchmark. This will range from the cost per square metre for a building type to the cost per square metre rate for a specific element of the building. This data can be adjusted by the cost consultant to take cognisance of site abnormals, regional issues (for example, costs tend to be higher in London) and market trends (are tender prices rising or falling?). This information is a valuable design tool as it informs the design team about where money is typically spent and what level of specification occurs in a sector for items such as doors, toilets or the building services specification. Visits to project precedents can convey aspects of a sector to a client and can also help initial discussions regarding finishes and fittings.

Elemental costs

Stage 2 Cost Plans are frequently based on whole building square metre rates from similar building types. As this way of assembling a Cost Plan is not based on specific measurements of the proposed design there is some inaccuracy – this approach requires higher contingencies to be set. For example, the cost consultant might have taken the gross area and applied a rate for partitions to this figure. This will be less accurate than measuring the actual partitions shown on the architect's information.
If the designers have duties to redesign if the project is over budget, they should agree when aspects of the design should be measured elementally. Just as coordination needs to occur incrementally, it may be that critical items, such as the elevations, are measured elementally at stage 2, with the interior aspects being considered at stage 3.

Net v gross areas

As brief areas are typically given as net, the net:gross ratio is a crucial metric from the lead designer's perspective. For example, if this figure is 75% on a project and buildings in the sector typically have figures of 80%, then this design will be over budget and the plan will have to be made more efficient. More importantly, if the wrong net:gross assumptions are made in the Project Budget, the design team will find it difficult, if not impossible, to design to budget.

Getting on top of the façade costs

A building's façade accounts for a significant proportion of the Cost Plan total. This topic is complicated because there are an infinite number of approaches. The balance between the area of the façade and its specification is important for the lead designer to understand. If standard industry cost allowances are included in the Project Budget, the architect cannot push both geometry and specification, and it would be prudent to undertake early cost exercises on the façade to gain an understanding of its affordability in advance. Where a bespoke system is proposed or the architect and cost consultant are working with products with which they are not familiar, the lead designer must provide additional focus. For example, the supplier of a terracotta façade system might not point out that the back-up wall costs are excluded from the costs provided or a specialist subcontractor might provide costs that do not take cognisance of the likely glass specification or the finishes to aluminium panels.

Building services design

The building services systems also contribute significantly to the Cost Plan. If systems that are not typically specified in a given sector are specified or typical systems are specified to a higher level of specification it can have a significant impact on the Cost Plan. Such items might include:

- additional HV/LV requirements dictated by power companies
- complex lighting control system v simple (i.e. light switches)
- additional energy sources, such as photovoltaic panels
- dry riser inlet and outlet boxes where normally the valves are exposed
- the need for emergency generators or uninterruptible power supplies
- the need for a BMS system in a building that typically does not utilise one
- greywater systems for reducing water consumption
- expensive light fittings to staircases or toilets.

To get an early understanding of the building services systems, it is useful for the lead designer to meet the building services engineer and the cost consultant to understand what allowances and assumptions have been made in the Project Budget, and to review these against case studies for other buildings.

Checklists can be a useful tool for getting a handle on the building services and the different topics that need to be considered, including the level of specification for light fittings and other visible building services components.

Unique elements of design and market testing

If there are elements of the design that are innovative or unique, it is sensible for early discussions to be held with the suppliers or specialist subcontractors who might supply. Such discussions allow health and safety, buildability, prelims and other aspects to be properly addressed. They allow the design to be fine-tuned in line with feedback from the specialist subcontractor and enable the cost consultant to gain more accurate costing information on the specific design solutions that are being considered. Such items can be flagged in the Design Status Schedule in the first instance to allow appropriate allowances to be made.

Level of specification

Certain architectural practices may have specific materials, manufacturers or suppliers, standard details or construction methodologies they use and have better historical data than the cost consultant, particularly where the practice has undertaken a number of buildings in the same sector. Where a cost consultant is working with a new design team, a useful exercise is looking at the Cost Plans from previous projects for clues to where a particular design team spend money. The timing of providing specification information to the cost consultant is crucial, as this can impact significantly on cost. Too much information too early can be counterproductive; however, the Design Status Schedule can be used to record strategic specification discussions early in the design process. The schedule, for example, might record the specification for:

- Entrance doors. Are they manual? Are revolving doors proposed? Are larger than normal sizes proposed, increasing the cost of controlling the doors? Has the means of disabled access been considered?
- Internal doors. Are they steel or timber? Are doorsets proposed? If timber, what is the finish? Are they hardwood, softwood for painting or laminate? Are they standard heights and widths? What ironmongery is proposed?
- Floor finishes. Floor finishes and build-ups can vary enormously. For example, there is a vast range of hardwood floors or carpets available on the market. What level of specification is the client expecting and does this match the architects aspirations?

A high level of specification for every aspect can lead to cost over-runs. By facilitating a workshop to review specification early in the design process, the lead designer is not asking items to be designed but attempting to tease out requirements and checking that these are aligned to the Cost Plan. Crucially, there is no point in the architect presenting an expensive hardwood flooring system with underfloor heating to the client team if the cost consultant has based the Cost Plan on carpets and radiators. The specification journey is therefore a core designing to cost consideration.

Setting the right contingency

To take cognisance of unforeseen items, a contingency is included in the Cost Plan. The amount of contingency is dictated by various factors including:

- the complexities of the building type and the brief
- aspects unique to the site, including the requirements for new utilities
- project risks, such as adjacent buildings or working within an existing building
- market factors, including exchange rates, material costs and tender prices
- the experience of the design team, including their previous working relationship with the cost consultant.

Although the client and cost consultant typically consider the contingency, the lead designer needs to be alert to what has been allowed for; inappropriate contingencies can result in the design being over budget at the next stage requiring re-design work and further iterations. To compensate for the lack of detail in the early stages, it is common to include a higher contingency in the Cost Plan in the early stages. The contingency can be reduced as risks are managed and greater detail is considered.

Using digital tools

5D BIM (cost) connects the design team's model to the Cost Plan, which is in turn linked to their cost databases or external cost data sources. To be effective, this methodology requires the cost consultant to agree the reporting methodology with the client. This allows a template that enables the client's requirements to be met. Different costing software packages work in slightly different ways and the cost consultant needs to consider how the design team is modelling to ensure that the right quantities are taken from the model. When it is properly set up, perhaps honed over a number of projects, 5D BIM becomes an essential designing to cost tool. Conversely, 5D BIM still needs clarity regarding market rates, the level of specification and other cost drivers, and it cannot be used in isolation.

Cost dashboards

A cost dashboard is a display that appears on the design team's monitors as design progresses. For example, the architect can be provided with 'real-time' cost advice on the façade. Is it progressing in line with the Cost Plan? Is it over budget? What is the impact of different materials or massing options? As a result, the design team is able to be more proactive and can gain a better understanding of what impacts on the cost of a building.

A final thought on Cost Plans

Cost consultants are not mind readers. Providing the right information to the cost consultant at the right time will result in a more accurate Cost Plan. A cost consultant working regularly with the same design team will learn the specifications they typically use, minimising guesswork.

What changes at stage 3?

If the Cost Plan has been effectively set up at stage 2, little should change at stage 3, as the key cost drivers should have been considered, including core specification considerations. However, as the design is validated through engineering, it is inevitable that further tweaks will be made to specification and the lead designer needs to be mindful of changes that are made. At stage 3 the lead designer might consider the:

- building services systems in greater detail – for example, the type of light fittings or detailed items such as sprinkler heads or dry riser boxes
- build up of systems, beyond the visible finishes, in greater detail, requiring a resetting of budget allowances
- detailing of the façade. Windows might have different flashings or reveals and more expensive finishes, such as a specialist anodising, or a more expensive brick might be considered.

Design development

Many designers use the term 'it was design development' to substantiate an update or change to the design. Such changes should be relevant solely to the design tasks of a stage. For example, if the architect is rearranging a number of rooms at stage 3 they are revisiting the stage 2 design not developing the signed off stage 2 design. This type of of re-design should be dealt with accordingly using change control. Similarly, if the building services engineer requests that a riser be relocated or tweaked in size at stage 4, it is a task that should have been undertaken at stage 3, if not stage 2. The lead designer needs to look out for these situations, as they may impact every designer and may not have the client's support. The intent is not to stifle new ideas that might have significant benefits to the project but to make sure that the impact on the design team, the Design Programme and the Cost Plan are all clearly understood before any change is implemented.

What happens at stage 4?

If the measures outlined above have been followed there is not much more that the design team or cost consultant can do at stage 4. Every building system should have adequate allowances made and a project contingency, albeit reduced, should still be in place. The greatest risk is transferring the cost risk to the contractor. This is considered below on p 177.

New Rules of Measurement (NRM)

The RICS NRM documents set the basis for consistently measuring quantities for the purpose of preparing a Cost Plan enabling accurate cost advice to be given to clients. NRM guidance includes direction on how to quantify non-measurable items, such as preliminaries, profit and overhead, and other costs such as design and/or project team costs, inflation, risk or fees associated with statutory requirements. Using the NRM documents does not just give the client greater certainty; it allows those receiving Bill of Quantities or Pricing Schedules to be certain that all aspects of the project have been considered and included.

Bill of Quantities (BoQ)

A BoQ is more detailed than a Cost Plan. A BoQ contains a detailed and itemised list of all the work to be undertaken with quantities measured in number, length, area, volume, weight or time. It is prepared to give the contractor detailed quantities to price, acting as a 'level playing field' as each contractor prices the same document (rather than each contractor having to take off quantities from the project information). With the rise of Design and Build procurement, the use of BoQs has declined due to the costs and timescales for preparing them and to ensure that the quantity risk rests with the contractor. They have been replaced by simpler Pricing Schedules that each contractor prices for comparative purposes. With the increase of 5D technologies, the use of BoQs is on the rise again – with proper setting-up time they can be efficiently developed from the design team's information.

Reviewing and monitoring the Cost Plan

Even with designing to cost measures implemented, it is still essential that each version of the Cost Plan is issued to the design team in *draft* form for review before it is issued to the client team. This allows the lead designer to be satisfied that the correct assumptions have been made, and in some instances the design may need to be adjusted so that the Cost Plan is aligned to the Project Budget. To underline the importance of this draft issue, the date for its issue should be included in the Design Programme along with the periods for its review by the design team.

Some cost consultants will be tempted to issue the Cost Plan to the client *before* they issue it to the design team. This can be disruptive to the design process and the cost consultant needs to understand that the Plan is part of the iterative design process and that designers need to be given the opportunity to design to cost. By employing the cost consultant, the lead designer can have more frank discussions regarding the impact of different design solutions, eliminating options that are unaffordable early in the design process.

What happens if the Cost Plan is over budget?

If the lead designer has ensured that the above measures have been taken, each iteration of the design and the corresponding Cost Plan should align with the client's Project Budget. If this is not the case, it needs to be remembered that when a design has been produced, savings can only be made by making the building smaller (larger savings) or reducing specification (smaller savings). Each design team member might rehearse what aspects might create savings, particularly if they have a duty to redesign in the event of cost over-runs.

Why can the contractor's costs vary significantly from the Cost Plan?

There is no single reason why the construction team's cost might exceed the Cost Plan. Examples include:

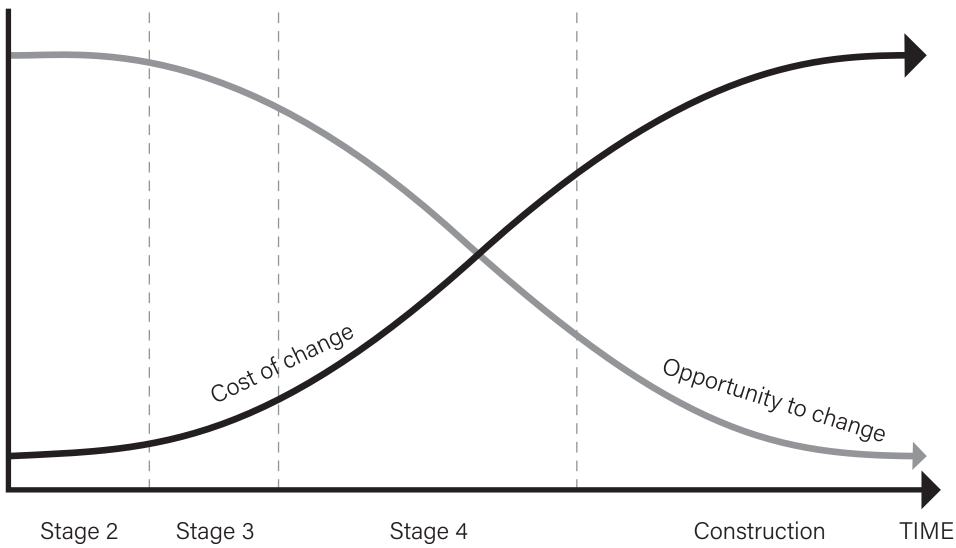
- raw material cost increases above inflation that have not been incorporated into the Cost Plan
- the cost of overseas products increasing due to currency fluctuations
- increased preliminary costs due to complex site logistics that were not considered in the Cost Plan
- labour cost increases due to overheating of demand in the industry
- aspects of the final specification not being included in early cost discussions with specialists

- increase in tender numbers, resulting in less competition in the industry
- lack of suitable, or busy, construction teams and/or specialist subcontractors in a specific area
- the construction team's attitude to risk.

Change Control Procedures

Successful change control is fundamental to the financial management of a project. Change is best managed by the client team, who is best placed to coordinate the impact of proposed changes with the client, designers and cost consultant. A well-managed Change Control Procedure will ensure that change is properly considered and instructed *before* it is implemented and will also ensure that designers are recompensed for amending their designs where this is appropriate. It is essential that Change Control Procedures are agreed at the start of a project and included in the Project Execution Plan.

Figure 7.3: The cost of and opportunity to change



As the design progresses, the ability to easily change the design decreases as more information is produced. Initially restricted to the design costs, the cost of change increases significantly once materials or products are ordered and begin to be manufactured and constructed.

What is Value Management and how does it differ from Value Engineering?

Value Management (VM) processes add greatest value when they are considered at the outset of a project. For example, different user groups may determine their own needs and a VM exercise might dictate that certain aspects (for example, staff rest rooms) are best shared between departments or collected into a single space. VM exercises can ensure that each aspect of the design is robustly tested, making sure that it is adding value to the project.

VM's subset, Value Engineering (VE), works similarly, but the term has been hijacked and is frequently used when the design team is redesigning the building to bring it bring in line with the Cost Plan. If the specification of items or the area of the building needs to be *reduced* to resolve budgetary issues, the term is not appropriate. However, if the same area and specification are achieved by using a different design approach or methodology that may have been suggested by one of the specialist subcontractors, then this is true VE: achieving the same for less.

When tenders are returned cost exercises may be required to get the building back on budget and these might be a mixture of design team items (e.g. reducing the lighting control system, amending the lift interiors or changing a specific finish) that can be costed by the construction team or VE items that the specialist subcontractor might propose. The two should be differentiated.

In some instances, VE should be treated cautiously. It can sometimes result in knee-jerk changes to specifications that have not been carefully considered and thought through.

Rising to the whole-life cost challenge

The Project Budget represents only a fraction of the costs associated with the life of a building. Clients who own and maintain their buildings are becoming more aware of the extent to which capital expenditure sets the operational costs for the whole life of a building and are beginning to consider both more holistically. Sustainability objectives also drive such considerations: a building that has a considered maintenance strategy will inevitably use less energy and/or carbon.

Figure 7.4: TOTex

CAPex (Capital Expenditure)

+

OPex (Operational Expenditure)

=

TOTex (Total Expenditure)

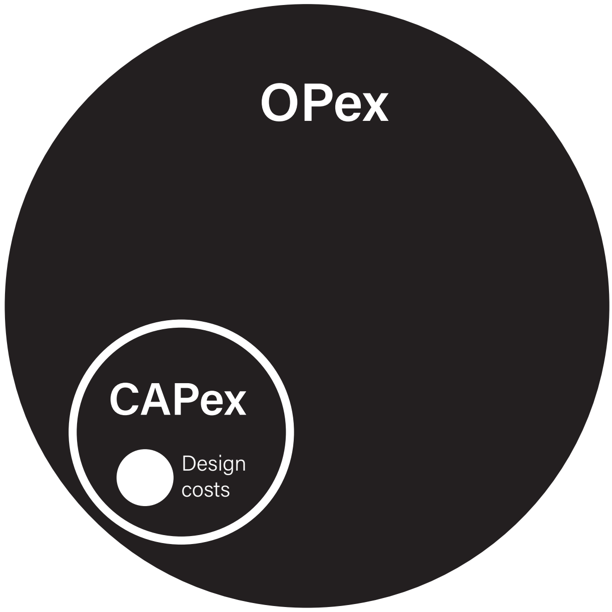
In Chapter 5 the benefits of preparing an Operational and Maintenance Strategy at stage 2 and the updating of this at stage 3 were considered, along with the additional benefits of achieving improved health and safety outcomes. Many lifecycle considerations impact on cost and the lead designer needs to make sure that these are considered as the Maintenance and Operational Strategy is developed. The same principle applies to any Project Strategy. On Public Finance Initiative (PFI) Procurement Strategys, the facilities management (FM) contractor is part of the tendering consortium, and as FM costs constitute a substantial component of the overall costs it is common for more rigorous assessments of lifecycle costs to be considered. For example:

- different floor finishes with different lifespans and cleaning regimes might be considered
- more robust paint specifications might be considered for corridors
- how high-level light fittings are accessed for bulb replacement will be a core consideration
- protection to corners in heavily trafficked areas might be specified
- maintenance-free soft or hard landscaping might be specified rather than grass that needs cutting.

Whole-life costs

Whole-life cost or lifecycle cost includes the CAPex and OPex costs (see above) for a building, giving the total cost for owning an asset, or building, for its lifespan. Commonly referred to as the 'cradle to grave' costs, whole-life costs incorporate any financial transactions, including land acquisition, design, planning and construction costs, interest, depreciation and other funding costs, through to costs for operations, repair, maintenance, upgrade, replacements and the value of the building at the end of its life. increasingly, environmental and social costs, and topics such as the circular economy, are increasingly considered as part of whole-life thinking.

Figure 7.5: TOTex costs – the ratio of design, CAPex and OPex costs



By considering the Operational and Maintenance Strategy early in the design process, the lead designer can ensure that maintenance and related topics are embedded into the design, avoiding redesign and cost over-runs at a later stage.

How will predicting the cost of buildings change in the future?

5D tools speed up the production and accuracy of Cost Plans, allowing the cost consultant to focus on project-specific issues. The re-emergence of Bills of Quantities points towards the design team's information being used for new purposes – in the future it is likely that BoMs or MTOs will be used to extract more granular information from the design team's model. As well as providing more accurate information for estimating purposes and helping to facilitate DfMA (see p 214), these tools address waste issues. For example, certain software packages can optimise the timber to be ordered on a project, minimising waste and reducing material costs.

Bill of Material (BoM)

A Bill of Material is a list of the raw materials, products, components, sub-components or sub-assemblies required to manufacture a product. The difference between a BoQ and and BoM is that a BoQ generally includes labour rates and does not typically list the specific material required.

Material Take Off (MTO)

An MTO is similar to a BoM except weight is added. This allows the weights of sub-assemblies and other aspects to be calculated, which is crucial for determining transportation or craneage requirements or limitations on-site.

This chapter:

- Underlined the importance of the lead designer considering the client's attitude to cost and the cost challenges on a project
- Set out specifically how the lead designer can steer the design team using designing to cost techniques, including how digital tools such as 5D might redefine the cost management process and add value to the design process
- Set out the difficulties of moving from the cost consultant's Cost Plan to the construction team's pricing mechanisms and how procurement impacts this process
- Noted the importance of using a stringent change control process once the Concept Design has been agreed by the client and how Value Engineering and Value Management should be considered
- Looks at whole-life costs and how these are changing the cost dynamic, along with new topics such as the circular economy
- Considers how cost management techniques will evolve in the future

CHAPTER 8

The increased complexity of information

Introduction

The increasing complexity of the information journey merits a chapter in this book for the lead designer to consider. The biggest hurdle to efficiency is continuity of information outputs, such as drawings and reports, with resistance to digital resulting in many clinging on to analogue information requirements bedded into traditional contracts aligned to time-consuming 2D information portals. There is a great deal of information required on any project – a crucial task is determining these requirements and who must produce each piece of information. This chapter considers the complexity of information requirements.

The challenge starts by considering who is best placed to define the information requirements. Is it the client team, the design team or the construction team? Or, should they be set by industry? For the design stages, is the lead designer best placed to set the deliverables to encourage innovation or should clients determine what they want? There is no clear option and a collaborative approach may be required to determine the optimum solution.

Information is of great interest to the lead designer and the complexity of the information landscape must be understood in order to determine the information required to kick-start the design process and the information requirements that need to be pushed out at the end, while also innovating in the way information is used during the design process. The diversity of the design stages, a changing design process including new workflow, the need to define if the design team are designing descriptively or prescriptively at stage 4 and the need to clarify the tasks that underpin the design process compound this challenge. Furthermore, digital and traditional deliverables are requested as designers and those defining contracts wrestle with how to define digital deliverables in legally coherent ways. Change is occurring at a significant pace and these changes present a number of challenges for the lead designer. With many designers finding it difficult adapting to, or resisting, digital ways of working getting them to absorb and learn new design team processes is hard enough before the broader project team changes noted above can be considered.

A number of documents are required to bring clarity to the information challenge. These include the EIRs, the Responsibility Matrix and a Schedule of Services. This chapter concludes with these crucial topics and their interrelationship. To make matters more challenging, information innovation from the design team's perspective is different to project information innovation. The design team's new information workflow includes plugging the architect's information into VR (virtual reality), connecting the engineer's disparate data sources to the models, and analysis software, and the provision of cost advice driven from the design team's model. In this more complex information environment, granular detail becomes important and needs to be set by the lead designer in order to bring clarity to faster and better design processes.

What information is required?

Information is required on projects for a number of purposes, to:

- communicate the design proposals to the client team
- facilitate client decision-making
- allow collaboration, coordination and communication between design team members
- enable statutory consents to be made, including consultations with stakeholders
- provide accurate detail on the site and the utilities to which it connects
- enable comments to be made on the design proposals
- enable discussions with product suppliers and specialist subcontractors
- allow a construction team to tender for the work
- suit the requirements of different Procurement Strategys
- enable specialist subcontractors to complete the design
- allow the construction team to construct the design
- promote the proposals to potential tenants or purchasers.

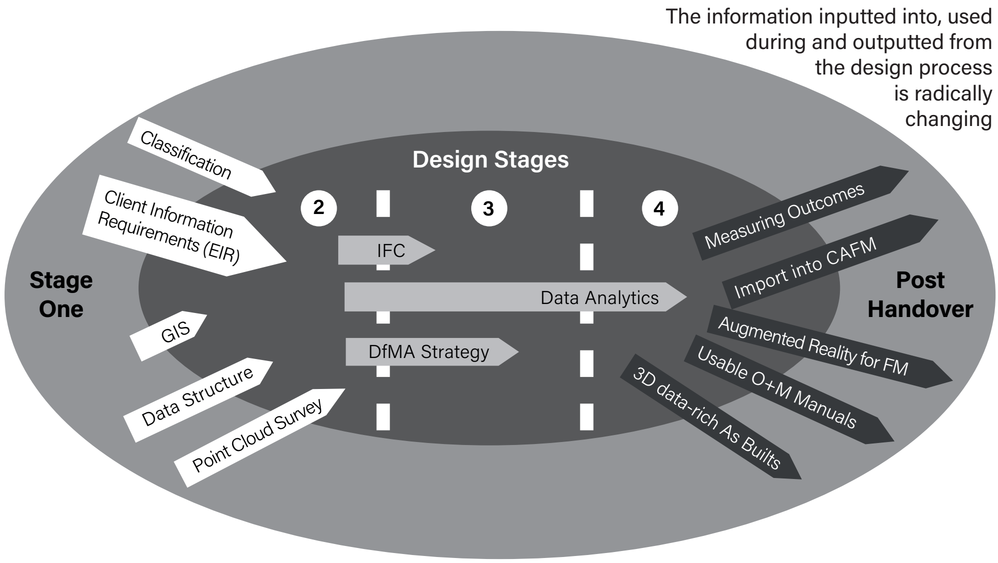
This list is not comprehensive. It effectively illustrates the diverse uses of the information issued by the design team to other project team members, including the client or external stakeholders. Within the design team thousands of information requirements are required to progress the design and one of the challenges for the lead designer is to ensure that the right information is available at the right time. Information requirements are traditionally framed around geometry; however, the shift from CAD to BIM allows data to be considered. Data creates many new possibilities, with interoperability (p 141) and workflow considerations (p 161) central to unlocking innovation and better data connectivity. BIM also transforms geometry, which can be viewed and delivered in different ways.

Defining the information requirements is only part of the picture. In the majority of situations the information prepared and issued by one party is used by the next for a different purpose, yet this topic is not frequently discussed. There is a need for an industry-wide initiative to bring clarity to this subject with the transition towards a digital world making this a necessity. A great deal of information is produced as designers use their reasonable skills and care to carry out the design. It would be impossible to capture all this information, which is why it is common to clarify only the information issued at the end of a stage.

The project information ecosystem

When the depth of digital information possibilities is revealed, it becomes clear that the facilitation of real-time 3D, data-rich, intelligent digital project ecosystems, where information is automatically exchanged, is an imperative. In such an environment, GIS systems and big data aligned to analytics would kick-start a project. Emphasis at completion is shifting well beyond the current provision of 'as built' information, requiring a well-established data structure at the outset and a soft landing between completion of a building and its occupation. The insertion of information from the manufacturing and construction stages into the information portal for maintenance and asset information developed alongside (trending towards the notion of a digital twin) is being twinned with use of new ways of accessing this information, such as Augmented Reality (AR), QR codes or embedded chips, the geometry and data being kept live and continually updated until a building is re-used or dismantled. This chapter looks at how these topics are influencing a new project information cycle.

Figure 8.1: Increasing information complexity



Who defines the information requirements?

There is no industry-wide means of setting the information requirements. On larger projects the client traditionally defines them. On smaller projects the architect might set what they will do at each stage and the fee for doing so. The increasing role of specialist subconsultants and subcontractors generates another reason for clarity on the information being delivered as well as the tasks that underpin the information being produced. For example, when does the duty of care bar rise sufficiently to require a consultant specialist? What aspects of the design are best undertaken by specialist subcontractors?

From a client perspective, there is a difference between how an experienced client commissioning projects on a regular and repeat basis, and a client commissioning their first – and perhaps only – project, might set their information requirements. For example, to keep costs down, some experienced clients submit planning applications at stage 2, creating design risks that need to be clear to all. A further complexity is the increasing use of digital tools that are slowly negating the need for 2D information that underpins many PSAs: arguably impeding the design team from shifting towards game-changing digital deliverables. If the client is focused on outcomes and is seeking the most inventive and innovative way of achieving these, it may be best to let the design team determine what information needs to be produced. There are three approaches set out below. There is no 'right' approach and each methodology has its pros and cons.

1) Prescriptive approach: the client team

This is the methodology currently used by the majority of clients on larger projects. The client team sets the information requirements, stating what is delivered by whom and at what stage.

PROS	CONS
This approach: ► enables experienced clients to set exactly what information they require at each stage ► makes it clear who does what when ► makes it easier to individually appoint each designer.	This approach: ► may not set the information required to allow the lead designer to coordinate the design ► results in non-designers defining the design deliverables ► impedes innovation by focusing on traditional information requirements ► requires the client to assess whether the information produced is to the appropriate quality.

2) Industry-wide approach: consensus documents

This approach (not currently taken, although initiatives are under way) addresses the downsides of the first approach. It encourages the development of industry-agreed information requirements developed and agreed by representatives from the client, design and construction teams.

PROS	CONS
This approach: ► enables the optimum information requirements for each stage to be set (contributions and consensus from everyone in the project team) ► gives inexperienced clients the certainty that they are requesting the right information ► allows proposed amendments by a client, design or construction team to be clearly understood.	This approach: ► impedes innovation, as it may focus on traditional information requirements.

3) Outcome-based approach

The client team sets the outcomes for each stage and the design team proposes the optimum information requirements for achieving these.

PROS	CONS
This approach: ► allows the lead designer to determine what information is required in order to meet the client's outcomes and to then set the information required from the rest of the design team accordingly ► encourages innovation from the design team. The lead designer can consider how digital tools will be used and add value to the design process.	This approach: ► makes it difficult for the client to compare what they will get for the proposed fees unless they have the relevant experience ► could result in the poor definition of information in the absence of industry-wide standards ► is difficult to use where the client wishes to independently appoint each designer.

The final twist to these options is that it is not necessary to use one option over another for each stage, and different stages can use different approaches. For example, the client may wish the design team to innovate at stage 2 and set the information requirements; however, they may have prescriptive information requirements at stage 3 for including in the Planning Application, and at stage 4 they may wish the construction team to define what information they require and the extent of involvement of the specialist subcontractors.

The documents used to address the information requirements are considered at the end of this chapter.

The information challenges for the lead designer

Notwithstanding the digital challenge, there are a number of reasons why the lead designer needs to carefully consider the information requirements, regardless of who produces them:

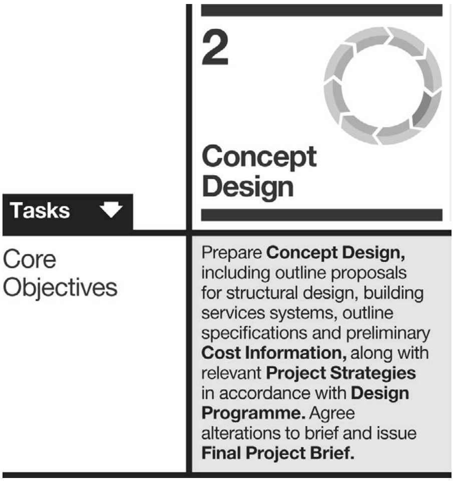
- The design team might change midway through the design process.
- The design baton may be handed over to a specialist subcontractor.
- Planning can occur at stages 2 or 3.
- Different and diverse Procurement Strategys need to be navigated.
- The construction team may take the risk for the quality of information and any incomplete design.
- The client may require information for asset management purposes.

- Modern methods of construction are changing the way buildings are built.
- The design process may require new information deliverables and formats.

The diversity of the design stages

The objectives of each design stage vary immensely and the information and tasks required at each stage need to reflect this diversity.

Figure 8.2: Stage 2 – Concept Design

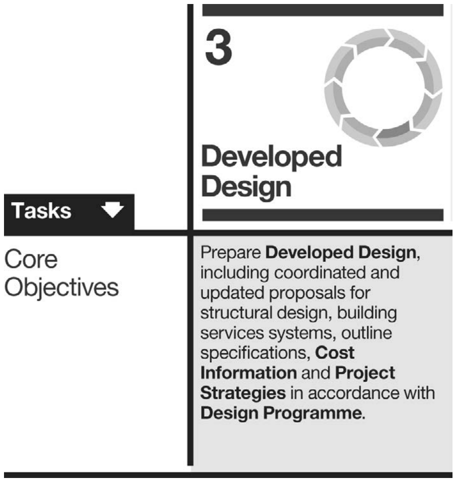


In a digital environment, the stage 2 information requirements are the hardest to set. First, because immersive technologies are transforming the design review process, negating the need for 2D information; and secondly, due to the wide variance in the tasks that can be undertaken. To set the right information requirements it is important to start by considering what the outcomes of the stage will be. To set these, a number of questions need to be considered:

- How close to the Project Budget does the Cost Plan need to be?
- When is the Planning Application to be made?
- Will derogations from the spatial requirements be acceptable?
- What do client gateway or sign-off processes require?
- How much time is there to create a concept that inspires the client and the planners?
- How many strategic engineering and Project Strategies tasks need to be undertaken?

It must be remembered that the stage 2 gateway is intended as a springboard to a more robust development of the design, underpinned by analysis, and that in many instances 'rules of thumb' will be sufficient for many engineering tasks at this stage. Doing too many detailed tasks at stage 2 can dilute efforts to create a design that meets the client's vision.

Figure 8.3: Stage 3 – Developed Design

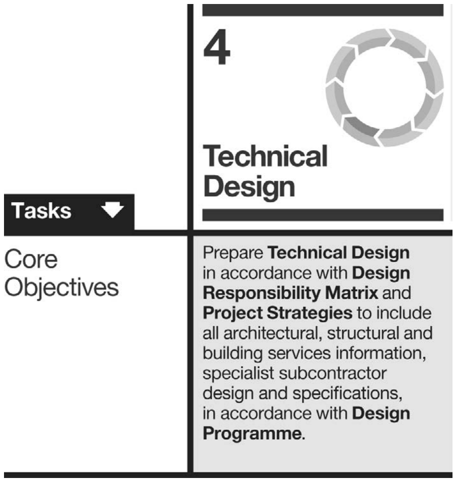


With Concept Design signed-off, the lead designer can focus the information requirements and supporting tasks around the coordination of the design and the development of the engineering analysis. Questions to be considered when setting the stage 3 information requirements include:

- Has any innovative approach been considered in the Construction Strategy?
- What sign-off processes do funders or other stakeholders have?
- What Project Strategies are required to align the model with other stage information?
- Do the layouts need to be checked for compliance with the Building Regulations?
- What detailed analysis is required to underpin the geometric information?
- Does the Procurement Strategy need specific information over and above normal deliverables?

Crucial to stage 3 is the handover of a coordinated design. The lead designer needs to consider what information requirements and tasks are essential in achieving this.

Figure 8.4: Stage 4 – Technical Design



At stage 4 the complexities include:

- the slicing and dicing of the Design Programme depending on the Procurement Strategy and the timing of the design work of the design team and specialist subcontractor design work (see p 238)
- the changing nature of construction and the shift towards modern methods of construction (see Chapter 9)
- the prescriptive v descriptive approaches to design and who is best placed to set these on a specific project.

The appointment of a design team is typically from the commencement of stage 2 to the end of stage 6. However, the diversity of options derived from the above points make this progressively difficult, and increasingly appointment documents include options or break clauses at the end of each stage. The lead designer needs to be aware of the implications deriving from these different approaches.

A changing design process

The changing nature of the design process outlined throughout this publication underlines the need for the client, design and construction teams to carefully consider the most effective information requirements for the design stages. Changes afoot include:

- The demise of 2D: the requirement for 2D information will decrease as clients become comfortable with new ways of undertaking design reviews (see Chapter 10), such as immersive technologies, and as ways of detailing 'full size' eliminate the need for 2D details.

- Design to manufacturing: better and seamless integration from BIM software packages into CAD-CAM (manufacturing) software will reduce the time frame for moving from the design team's descriptive stage 4 information to the specialist subconsultant's information for manufacturing.
- Manufacturer's BIM objects: earlier selection of products and insertion of the manufacturer's information into the relevant design team member's model creates greater geometric certainty and allows the right data to feed into analysis packages (see Chapter 11).
- Integration of analysis and modelling: as more and more engineering analysis software is capable of iterating with the architect's BIM model, real-time analysis will be possible, allowing multiple options to be reviewed on a real-time basis.
- Modern methods of construction: new construction processes will reset information requirements, including robotics and additive manufacturing.
- Design for manufacture and assembly (DfMA): as DfMA methodologies are embraced, it is likely that mass customisation processes will become more commonplace, including the development of larger sub-assemblies that can be configured and bought 'off-the-shelf'.

The importance of tasks

The complexity of the information requirements puzzle means that defining the information requirements is sometimes not enough. In some situations a number of tasks might be required to develop or shape the information being produced. For example, an architect might show toilet layouts in their information for the core of an office building. These layouts might be based on the architect's intuitive knowledge accrued over the design of many similar schemes. However, to accurately define the toilets a number of tasks need to be undertaken:

- The standards to be adhered to need to be agreed – for example, British Standards, British Council of Offices and Regulatory Requirements.
- Spatial requirements need to be determined – for example, cubicle widths and depths which may come from the same standards or suppliers' recommendations and studies.
- Male/female splits or whether unisex provisions are to be made.
- The number of urinals to be used, if any.
- Cleaners' cupboards and disabled toilet requirements.
- Lobby requirements and door arrangements – for example, airports have door-free lobbies.

While the intuitively designed toilet might be 80% accurate and appropriate for stage 2, especially when many other items are being designed using rules of thumb such as risers or lift requirements, some clients may have sensitive financial appraisals and require a greater degree of accuracy. While the above tasks sound like stage 3 tasks, there may be no harm in them being undertaken at stage 2, as long as the Design Programme has sufficient time and fee allowances are set accordingly. It is therefore necessary for the tasks that underpin the information requirements to be clear – arguably these are as important as the information requirements. These can be set within the Responsibility Matrix (see p 207). or as a separate Schedule of Services.

Design process adjustments

Stages 2, 3 and 4 of the RIBA Plan of Work are design stages with diverse information requirements and tasks, as set out above. However, certain topics require adjustments to the design process to take cognisance of a number of topics:

Procurement

The Procurement Strategy does not change the stage 2 information requirements or tasks to be undertaken, although with some forms of procurement the construction team may be appointed and contribute to the development of the Construction Strategy. At stage 3 certain additional information may be required in order to send out information to subcontractors for tender purposes. Options include preparing:

- ► detailed specifications
- ► package information (see p 203) for the packages heavily influencing the Cost Plan
- ► tender information for packages requiring design work by specialist subcontractors (to reduce risks and bring greater clarity to the design proposals)
- ► package information for the early packages on-site, including any design work by specialist subcontractors.

The client team needs to consider what approach it wishes to take and adjust the stage 3 and/or 4 information requirements accordingly, making it clear to the construction team what information it will receive and when.

ERs v CPs

Employer's Requirements: the set of documents on which the construction team will base its tender. These might vary from a simple statement to a comprehensive set of drawings and specifications.

Exchange Information Requirements (EIRs)
The EIRs are a subset of the Employer's Requirements and should be set in the Responsibility Matrix.

Contractor's Proposals: the set of documents that will form the basis of the contract between the client and the construction team. These might range from the design proposals prepared by the design team to a marked-up set of the Employer's Requirements.

Where Design and Build procurement is being used, the Employer's Requirements and Contractor's Proposals need considering. On some projects these documents are similar in content; however, some clients prefer 'light' Employer's Requirements to ensure that the design responsibility clearly rests with the construction team and its designers. The client team needs to consider this crucial interface on Design and Build Procurement Strategys, as well as how products or design aspects that are not completed prior to the setting of the Contractor's Proposals in the Building Contract will be dealt with. How will this information be reviewed and what mechanisms are there in the Building Contract to review and potentially reject it?

Novation (part 2)

The novation of the design team to the construction team for stage 4 neither impacts on the information that is delivered nor the boundaries between the design team and the specialist subcontractors. However, the construction team has greater influence over the materials and/or products that are specified by the design and may influence the workmanship clauses included in tenders issued to subcontractors where these are not included in the Employer's Requirements. The client team should be alert to this point, framing the Employer's Requirements accordingly and/or ensuring that there is a robust process for confirming the products to be used on the project.

Planning

Planning applications can be submitted using stage 2 or stage 3 information. However, it needs to be clear at the outset when planning will be submitted to allow the design team to consider the implications on the information requirements. Planning applications are usually submitted at stage 3, when the client wishes to keep design costs down before the certainty of progressing is secured. In some instances only the architectural practice will be appointed; however, in some sectors it is recommended that engineers are appointed to provide advice – such as the size and location of plant rooms and risers – to ensure that the contents of the planning application are robust. Furthermore, the elevations, massing and materials will need developing beyond what would normally be produced at stage 2. Submitting a planning application at stage 2 creates risk and the lead designer should be alert to this. Additional tasks may be required in order to bring the elevations up to the appropriate standard for a planning application.

Asset management

Greater emphasis is being placed on providing information at handover for asset management or for maintenance and operational purposes. The maintainability and usability of the building are core functionality requirements and the need to consider these is embodied in the RIBA Plan of Work and the need to consider a Maintenance and Operational Strategy.

Asset information requirements go beyond what would be defined traditionally as 'As-Constructed' Information and need to be set by the client team at stage 1 to allow the design and construction team to consider these requirements accordingly.

Many clients use a CAFM (Computer Aided Facilities Management) system which requires input from the information produced during the design and construction stages. The software continue to evolve, as do the classification systems and the need to integrate with other building systems such as the BMS (Building Management System). The lead designer needs to be alert to innovations and trends for these stage 7 aspects.

Digital Twin

The term digital twin has been used in aerospace and other similar industries for some time. It refers to the model which contains the original simulations for elements such as a wind turbine or an airplane engine. The comparison of this information with the actual in-use information creates the digital twin. The digital twin enables the predicted performance to be compared with actual performance.

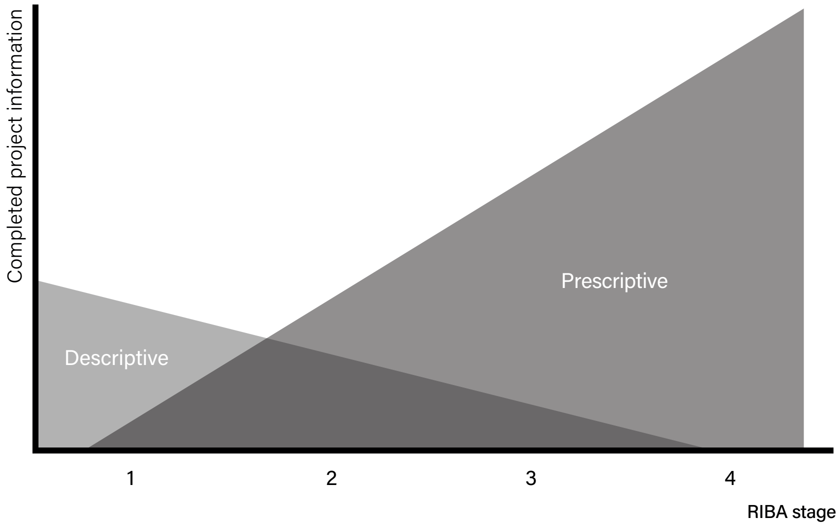
COBie

Construction Operations Building Information Exchange (COBie) is an international standard and non-proprietary data format used to capture and record important project data, including equipment lists, product data sheets, warranties, spare parts lists, and preventive maintenance schedules and other information essential to support operations, maintenance and asset management once a building has been handed over. In the UK, as part of the level 2 BIM suite of documents, a code of practice relating to COBie exists as a British Standard: *BS1192-4:2014 Collaborative production of information Part 4: Fulfilling employer's information exchange requirements using COBie – Code of practice.* The significance of COBie goes beyond providing better data for asset management, including how it might be used to transform the production of O+M manuals. It signals the need to place greater emphasis on the structure of data and how it might be extracted as effectively and efficiently as the geometry from the information models, and it underlines the shift towards whole-life thinking, beyond design thinking geared solely to construction (see p 180 for more details on whole-life thinking). For those working on smaller projects, it may not be essential to learn the detail of how COBie works but it is vital to consider the topics that wrap around it.

Descriptive to prescriptive

At the beginning of a project emphasis is placed on the spaces being designed, although the massing and elevations will be a crucial consideration. There is less emphasis on the building systems and the products that will be used. An early view on products is required as it impacts cost, but it is commonplace for the product selection process to take place at stage 4. Some consider that the construction team should select products to drive down costs. If this is done a robust contractual means of vetting them is required. Some clients may have their own view. This selection process is typically meshed into who takes design responsibility. The two options, descriptive or prescriptive, are set out below. Every design must conclude with a prescriptive set of information (see figure 8.5) with sufficient information in order to manufacture and construct a building. The lead designer needs to make sure that each designer is clear from the outset what aspects they are designing and that the information requirements are clear.

Figure 8.5: Descriptive to prescriptive



The descriptive to prescriptive journey varies for every project. Some clients prescribe products early in the process. Others are happy for the design team to specify and in some instances the contractor can add value by prescribing aspects of the building to suit their supply chain arrangements.

Prescriptive

The designer is responsible for all aspects of the design, including calculations and the specification of products. Prescriptive specifications help the lead designer. The earlier the products are selected, the easier it is to determine any constraints they generate and to close out coordination issues. In some instances, it will be essential to use this approach, as the products may impact on the ability to secure planning consent.

Some clients include prescriptive requirements in their development specification. This can range from a lock that is used across all their premises to a particular kitchen manufacturer. Some clients are interested in the appearance of every aspect of the design and others may be happy with the product that is available at the lowest cost. The biggest argument against specifying prescriptively is that the design team is not able to fully determine the true cost of products. Different construction teams will have different supply chain relationships and will obtain different discounts for different products. Historically, this problem was dealt with by specifying 'or equal and approved.' This allowed the design team to base its design on a particular product, yet allowed the construction team to put forward an alternative. Prescriptive specification allows the geometric aspects to be properly considered. However, it still needs careful consideration:

- Where has the product been used before?
- How many years has the product been in use?
- What are delivery timescales?
- Does the product have any certification to prove it meets the relevant standards?
- Are there finishes options?
- Is the cost all in? (i.e. are there any supports or brackets excluded?)

A rigorous methodology for selecting products avoids these possible pitfalls and provides an audit trail for the future. As traditional construction product manufacturers innovate and new products and materials come to the market, the lead designer needs to be alert to what the design team is specifying and ensure that the client team is aware of each product's provenance.

Shop drawings

Prescriptive designs can sometimes require shop drawings to be produced by suppliers for fabrication purposes. For example, a toilet cubicle or roof access ladder manufacturer needs to produce information beyond that issued by the design team to facilitate their fabrication processes. This information is called 'shop drawings.' Sometimes this information is issued for approval (in order to ascertain that the subcontractor has interpreted the design team's requirements correctly) and sometimes it is not.

Prescriptive – generic

An alternative to prescriptive is specifying in a generic way. The design team retains design responsibility for the design, yet the construction team is able to select the specific product and manufacturers to be used. This approach has pros and cons:

Pros	Cons
The construction team has greater flexibility to leverage its supply chain partners.	The project specification has to be completed twice: once agnostically and then with the selected products.
This approach allows best value components to be selected for 'non-visible' items for which the design team may not have a stated preference.	Many products have subtle differences. The geometry of the final product may impact on the coordinated design. For example, the most cost-effective glass specification might have a higher solar absorption percentage, requiring adjustments to the mechanical services design.
	It is difficult to complete the detailing for the building without having a specific manufacturer in mind. For example, one dry-lining manufacturer's details are different to another's.
	The approach is not suitable for many 'visible' items. For example, a specific brick or cladding panel may be referenced in a Planning Application.

This publication counsels caution with this approach. It is suitable for a single-stage Design and Build scenario, allowing the Employer's Requirements to be based on prescriptive (generic) products. It is, however, strongly recommended that the construction team identifies its supply chain within the Contractor's Proposals with every product identified and agreed for inclusion in the Building Contract. This allows the design team to progress any stage 4 detailing based on the products to be used on the project.

From the lead designer's perspective this approach is particularly risky. Different products may have different geometric characteristics. While it is relatively simple to specify agnostic of a specific manufacturer, caution needs to be used with regard to an object's geometry. For example, different light fittings might have different dimensions or one cladding may have a bigger build-up than another, with both scenarios generating different fixing details and interfaces. The lead designer should keep a handle on products that might have varying geometric characteristics and consider the timing of their selection and the possible impact on interfaces and any interdependencies. Crucial product selections might be included in the Design Programme to reinforce this point.

Descriptive

Descriptive approaches allow aspects of the building to be specified by their performance requirements. For example, a descriptively specified partition would state the fire and acoustic ratings and other performance criteria rather than the rather than the specific product specification. Where the design team produces descriptive information, a specialist subcontractor completes the design, producing information for comment and taking responsibility for the information produced.

A descriptive approach might be great for the architect who can design a bespoke cladding system or the client who gets the most cost-efficient air-handling units, but it is bad news for the lead designer. It requires the design team to prepare design intent information, possibly based on conversations with specialist subcontractors, including a performance specification. Pushing more and more design activity towards the end of stage 4 and/or overlapping with stage 5 generates significant design management challenges. It restricts the time available to identify and resolve interface issues.

The lead designer must be alert to these interfaces and the associated interdependencies, and should consider areas of concern and ways of managing them – for example, using the Design Status Schedule (p 114) to track such design work. The greater the extent of descriptive elements, the greater the design risk. In the absence of prescriptive information, assumptions must be made in order to coordinate the design. This is particularly the case at stage 3 where items still to be designed may generate coordination issues.

Where assumptions are incorrect or are not included as constraints in the performance specifications, there is a risk that changes to the coordinated design will be required, particularly where a number of descriptive items come together, such as a descriptively designed balcony meeting a descriptively designed cladding system. This challenge should not be underestimated.

The lead designer has two approaches to mitigate this risk: first, to ensure that the extent of design work by specialist subcontractors is limited, minimising this work, ensuring that the design team takes responsibility for as many aspects as possible. This can be dealt with at stage 1 when the Responsibility Matrix is being agreed.

Secondly, the lead designer can set out all of the items where issues typically occur, such as those noted above, and place constraints on the subcontractor design. This strategy is, however, not foolproof and an experienced lead designer can still find that changes are required as specialist subcontractors undertake their design.

Descriptive v prescriptive design information

With designers unable to *finalise* the design of descriptive design elements prior to a specialist subcontractor being appointed, a means of developing the design – for coordination and tender purposes – is required. Design intent information for descriptive aspects enables the principles of these elements to be developed in parallel with other aspects of the design. This approach also:

- communicates the design concept to the tendering specialists, allowing them to be developed as part of their tender proposals
- clarifies the scope of the anticipated works in sufficient detail for accurate tender costs to be submitted
- enables zones to be established, to allow the structure and other aspects to be developed in parallel
- allows adjacent interfaces to be considered and set out – for example, brickwork can proceed on-site and curtain walling can be tendered at the same time.

There is little guidance available on what descriptive design information should contain. When preparing descriptive information designers should meet with the potential specialists for carrying out the work, to enable as many design aspects as possible to be considered. As the design will be developed in detail by the specialist subcontractor, the designer should be careful not to draw too much detail, as that may limit the ability of the specialist to contribute to the design or make the designer responsible for areas of design where they do not have the appropriate expertise. Conversely, if too little is drawn, particularly at interfaces, coordination of other aspects of the work may not be adequately completed. Typical details for an element for which the architect is responsible (Figure 8.6) and one where a specialist subcontractor will develop the design intent proposals (Figure 8.7) are illustrated overleaf.

Figure 8.6: Prescriptive detail

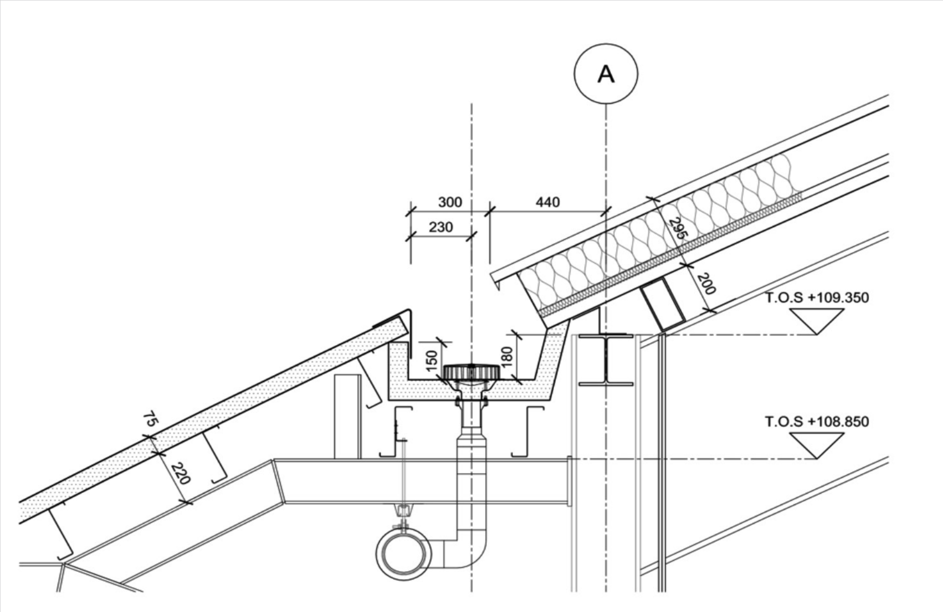
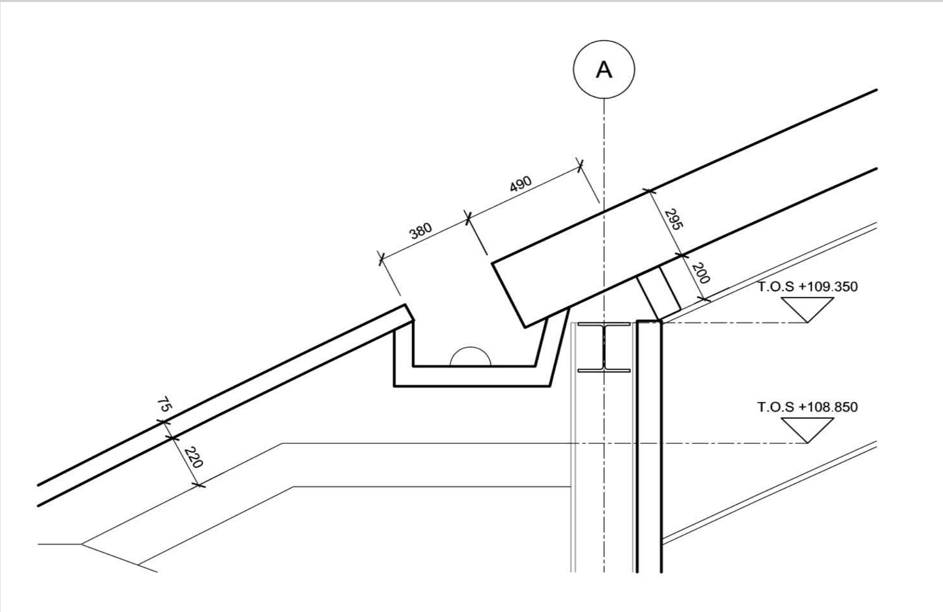


Figure 8.7: Descriptive detail



Building systems v package design

Every building contains a number of systems that need to be developed as part of the design process. A core role of the lead designer is considering the relationship and interactions between these different systems and the information required at each stage in order to efficiently progress these. Stage 4 information for these systems is typically issued to the construction team as a whole; however, it is common for the construction team to then split these into packages which are tendered by subcontractors. These 'packages' are similar in nature to the systems on the building. For example, the mechanical, electrical and plumbing (MEP) systems might be combined into a single services package. This creates risk, as the construction team allocates aspects of the work and interprets interface requirements. For example, the specification clauses for sealants will be issued as a whole rather than as individual clauses for curtain walling and toilet areas, and would not typically define who undertakes the sealant: is it the brickwork or curtain walling contractor? The design team can add value to this process, subject to the relevant fees being paid, by:

- issuing drawings defining the specific scope of work for each specialist subcontractor (shading of elevations, for example)
- issuing package specifications that assist in clarifying the scope and setting out the detailed constraints for each package
- showing package reference numbers for each element on detail drawings, paying particular attention at interfaces. For example, is it the brickwork or curtain walling trade contractor who installs the mastic between brickwork and curtain walling?

While some argue that some of these tasks are the responsibility of the contractor, there is no doubt that a coordinated set of the designer's drawings and specifications aligned with the contractor's scope documents will lead to fewer claims and disputes from subcontractors.

Design responsibility

On some forms of procurement design responsibility rests entirely with the design team, although increasingly the construction team has to take responsibility for discrete elements of the design undertaken by specialist subcontractors. On Design and Build projects the construction team accepts responsibility for all aspects of the design, including the work of the design team. A common misconception is that Design and Build procurement changes the design responsibility of the design team and the specialist subcontractors. It does not. It simply sets who ultimately takes responsibility for the design: the same parties will have undertaken the same design work no matter what form of procurement was used. On traditional Building Contracts 'contractor design' is framed as Contractor Design Portion (CDP). On Design and Build projects the design team will be employed by the construction team (possibly via novation – see p 57).

Information formats

One of the challenges in a digital environment is how to define the information requirements at each design stage. New workflow focuses on native or interoperable file formats and on how these can be better connected to assist more effective analysis. From a client perspective, new design review experiences (see Chapter 10) provide better ways for the client team to engage with the design process, yet contracts are still predicated on 2D information, common data environments framed in ways that inhibit rather than foster collaborative working.

While planning applications still require 2D information, the rest of the design process does not. The lead designer needs to consider how to nudge the client team towards digital deliverables, including helping it use the digital tools that allow 3D design reviews. One challenge for the lead designer is the means of defining digital deliverables. The LOD (Level of Detail) conundrum (see p 205) has been approached differently in the UK and the US: while the US methodology is commonly used in the Middle East, it is not necessarily appropriate to the forms of construction used there. Nor has the UK system been widely adopted. Chapter 11 points to the future where the LOD conversation may disappear as fabrication quality objects are used in the design from the outset. The lead designer needs to keep abreast of these developments if they are to facilitate a shift away from traditional information requirements.

Although 2D information can now be 'sliced' from the 3D model post-production (see p 143), work in the 3D to 2D workflow creates inefficiencies. The lead designer can:

- maintain the status quo and produce the 2D information requirements requested by the client team – this does not face the future nor encourage innovation
- focus on digital deliverables, delivering 2D deliverables at the end of a stage only – this encourages 3D workflow during the stage but provides the comfort of more traditional deliverables
- look at ways of defining digital information (see p 186); however, these are not currently robust for a digital future and are still predicated on geometry not data
- define the outcomes required at each stage and let the design team confirm the deliverables – this reduces waste by encouraging design teams to prepare the optimum information.

The level of detail conundrum

UK – BIM Toolkit
The BIM Toolkit developed by NBS meets the requirements of Level 2 BIM and can be used by a client to define the information required (called data drops or information exchanges) at each project stage. The BIM Toolkit includes a Digital Plan of Work used to set the Level of Definition required at each project stage. The Level of Definition in the building information model is defined by the graphical (LOD) and non-graphical (Level of Information or LOI) information as defined in PAS 1192-2. Different elements in the model may develop at different rates, with requirements and responsibility for model development set in a Model Production and Delivery Table. See toolkit.thenbs.com for more information.

USA – BIM Forum
The BIM Forum is the US Chapter of buildingSMART International. It has developed an LOD framework that is aligned to a number of protocol documents by the American Institute of Architects (AIA), including the G202-2013 Building Information Modelling Protocol Form. Here, LOD refers to the Level of Development required for model elements rather than Level of Detail. This recognises that an element in the model which appears visually very detailed might in fact be generic and at a low level of design development. This framework acknowledges that different elements of the project develop at different rates, enabling the design team to efficiently communicate to one another the extent to which a Model Element has been developed and to which elements may be used and relied on. See bimforum.org/lod/ and AIA, Guide, Instructions and Commentary to the 2013 AIA Digital Practice Documents for more information.

2D model views v 2D drawings

In many contracts 2D information outputted from the model is requested in the same format as CAD information. This approach has two major drawbacks. First, it requires post-production work in order to add graphic information to the 2D files driven from the 3D model before drawings can be issued. This can be extremely inefficient if regular issues of 2D information are required, due to the need to re-do the 2D information each time a 3D model is 'pushed' into the 2D environment. Secondly, such information does not add value to the design process, once the information is 'flattened' it is not possible to leverage the 'real-time' information created as the model is updated. While it would be sensible to eliminate the need for 2D information, recent software developments would suggest that it will be simpler to create 2D views from the model from inside the 3D environment. Once this becomes feasible in client friendly software it will be possible to seamlessly shift between 2D and 3D environments. Contracts will need adjustment to reflect this way of working. The short-term solution might be to define the 2D 'model views' (model view definition) that are required rather than prescribing traditionally scaled drawn information.

How are the information requirements captured?

There are four documents crucial to defining the information landscape. These are set out below.

The Exchange Information Requirements (EIRs)

The EIRs set out the core information requirements from a client's perspective.
The EIRs document:

- needs to consider what information is required at handover and for In Use activities
- might consider the information required from the design team to satisfy internal gateways
- can lay out the deliverables required, including 2D deliverables, and whether the native models or interoperable versions (IFC) are required
- the data deliverables required at handover.

The EIR document does not need to consider the internal workings of the design or construction teams. The purpose of the document is to consider how to facilitate the information required by the client post-handover. However, more experienced clients may set the information requirements at each project stage to be clear about what is expected without assigning these to a specific party.

Information deliverables: the contractual conundrum

The contractual landscape has for many years been predicated around the issue of 2D drawings and other documentation, such as letters, emails or specifications. At the time of publication, adherence to these contractual norms is holding back innovation and efficiency improvements. For example, positioning VR as a sideshow rather than business as usual that can be used as a more informative design review tool or limiting the delivery of models (in native or IFC format) as the contractual deliverable. Furthermore, IP – including copyright – considerations are based on single project innovation. Much needs to be done to look at how to overcome the resistance to data-rich, intelligent 3D models as contractual deliverables and how IP might work in multiple project environments.

The Responsibility Matrix

Precisely defining responsibility, including information requirements, in a Responsibility Matrix:

- ensures that the client receives the information required to deliver the outcomes required at each project stage
- enables the information required by the lead designer to be more accurately defined
- allows fees to be set more accurately
- avoids design responsibility ambiguities in the design team
- determines the design boundary between the design team and the construction team
- avoids discussions around who is designing what during the design process
- facilitates collaborative working
- enables new conversations and possibilities around digital deliverables
- assists the coordination process

- assigns responsibility in the event of a dispute
- unlocks innovation by guaranteeing consistency of who designs what.

Figure 8.8: Responsibility Matrix – stage 2 principles

<table>
<tr><th colspan="2">Stage 2 Responsibility Matrix</th></tr>
<tr><td colspan="2">The lead designer should produce a comprehensive schedule that sets out what each member of the design team will do at stage 2. From a client perspective it is crucial that the design team demonstrates that the Concept Design meets the brief. This will certainly need a set of 2D views showing that each of the requirements has been achieved and, if not, that any derogations have been agreed and the Final Project Brief adjusted accordingly.
The information delivered at stage 2 needs to be considered, along with the tasks that underpin this information, as noted below.</td></tr>
<tr><td>Information Deliverables</td><td>Schedules of Services</td></tr>
<tr><td>The Information Deliverables at stage 2 have traditionally focused on a list of 2D information, including plans, sections and elevations. This is changing as more immersive technologies provide better ways of clients engaging with the design process. Furthermore, not everything can be contained in the model and the information that sits outside the model is of equal importance. This includes important Project Strategies that the client may need to sign-off and the lead designer coordinate. There is no fixed list of information deliverables at stage 2. The client and the lead designer need to agree what is required by the client to demonstrate that the client's objectives and goals have been achieved. This will be a mixture of documents and models that have been coordinated and will increasingly include less 2D information (except for model views) and more 3D information that is data rich.</td><td>There is no clear approach to when many of the tasks that need to be undertaken during stages 2 and 3 should be done. Some clients want to keep fees low because they have no certainty of gaining planning consent. Others may have the reverse view and wish detailed exercises to be undertaken to determine that their building has been robustly designed. This is a crucial consideration for the lead designer. For the former, stairs, toilets and risers might be based on rules of thumb and for the latter on robust calculations. The appropriate response needs to be discussed with the client and the lead designer needs to make this clear in the Responsibility Matrix included with any fee proposal, so that the degree of certainty driven by the tasks that underpin the design are clear to all. In addition, the lead designer might have an optimum position of the tasks to be undertaken at stage 2 and those that can be left to stage 3 driven by the most effective Design Programme.</td></tr>
</table>

Exchange Information Requirements

Within UK level 2 PAS standards the information requirements for a project were defined as the Employers Information Requirements. These have recently been updated to an ISO standard with this term now adjusted to Exchange Information Requirements.

Figure 8.9: Responsibility Matrix – stage 3 principles

Stage 3 Responsibility Matrix	
With the Concept Design signed-off at stage 2, stage 3 is fundamentally about developing the engineering analysis and completing any geometric information so that the architectural and engineering teams can work independently of each other at stage 4. It is inevitable that in developing the engineering aspects, interfaces with the architecture will need to be iterated. For example, energy or daylighting calculations requiring tweaks to the glazing percentages or specification. Although the goal of stage 2 is to conclude as much of the architectural design as possible, it is inevitable that adjustments to the design will need to be discussed with the client. This is part of design development (see p 175). The Responsibility Matrix for stage 3 needs to include the tasks necessary to achieve this goal and the deliverables to demonstrate this.	
Information Deliverables	**Schedules of Services**
The Information Deliverables at stage 3 might be similar to stage 2. For example, the same Project Strategies might be included, having been taken to the next level of detail. Although there is less emphasis on the visual aspects of the scheme, adjustments that have been made or developments to the façade will require careful consideration and the points set out in stage 2 will still be relevant. With a lot of technical work undertaken, it needs to be clear what information the client requires. Lay clients may not need to see any information and experienced clients may wish to understand aspects of the technical approach in greater detail.	The crucial goal of the tasks undertaken at stage 3 is ensuring that the geometric federated model is coordinated at the end of stage 3. Any changes to this at stage 4 are disruptive, impacting the work of many designers. The lead designer needs to make sure that the Responsibility Matrix is clear regarding the tasks required by the design team to do so and that this matrix is agreed with the client.

Figure 8.10: Responsibility Matrix – core considerations

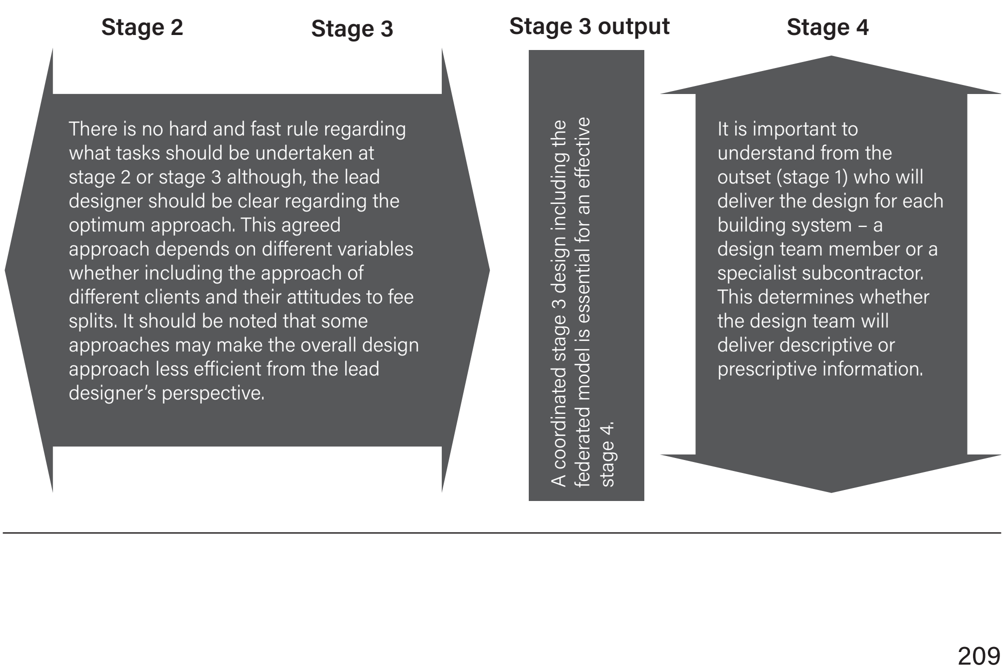


Figure 8.11: Responsibility Matrix – stage 4 principles

Stage 4 Responsibility Matrix	
The purpose of the stage 4 Responsibility Matrix is simple. It needs to be clear regarding who is delivering the final information for manufacturing and construction. One complexity is that where this design is being undertaken by a specialist subcontractor, a member of the design team will need to issue a descriptive set of information first that clearly states the requirements, including the scope of work. This might be used to appoint a specialist subcontractor under a Pre-Contract Services Agreement (PCSA) or to tender the works. Where the work is prescriptive, a design team member will deliver the information required for construction.	
Information Deliverables	**Schedules of Services**
The Information Deliverables need to be clear regarding the boundary of the design team and the specialist subcontractors. Regardless, there is no set list of information deliverables for each building system and the lead designer needs to make sure that these have been properly considered. One point that the lead designer needs to be alert to is the changing nature of stage 4 deliverables. This might include data for asset management purposes and other tasks relevant to stage 5 or beyond.	There is less need to list tasks at stage 4, although for some building systems this may bring clarity to the expectations from each designer. The tasks necessary to facilitate the new future-stage 4 information landscape associated with modern methods of construction may also be necessary to make the requirements crystal clear to all.

To avoid a multitude of documents, the Responsibility Matrix needs to be multi-party. This avoids ambiguity and the possibility of documents that include contradictory requirements. This document can be bound into Professional Services Agreements and where the specialist contractors have design responsibility, the Building Contract.

The built environment industry is at a crossroads where the traditional design responsibility matrices – used to determine the design team member responsible for the aspect of the design and whether that design is to be descriptive or prescriptive – are not sufficient to cover the granular detail required on a BIM project. Similarly, the LOD conversation (see p 205) has not reached sufficient clarity for recommended use nor is there clear guidance for the balance between modelled information and any 2D information or schedules that might be derived from it. Rather than produce a template, this publication counsels that until there is greater clarity on these crucial topics the lead designer should ensure that whatever combination of documents is produced by the client and/or design team the following topics should be considered and covered in any Responsibility Matrix or other supporting and contractual documents, so that:

- it is clear which member of the design team is responsible for each aspect of the design
- the method of defining each aspect of the design is clear; increasingly, Uniclass 2015 is being used as the classification tool for these purposes
- at stage 4, it is clear whether a descriptive or prescriptive design is required

- the tasks required to underpin the design process at stage 2 and 3 are clear – for example, are rules of thumb to be used or calculations prepared for stair, toilets and other aspects of the design
- the client information requirements for each stage are clear, including who will deliver the information and any support required from other design team members, See RACI below
- the BIM Execution Plan is clear regarding who will model what when and the purpose for which the BIM model will be used, as well as clarity regarding the workflow between the modelling process and any 2D outputs
- the implications of a planning application at stage 2, requiring additional tasks to bring the plans or elevations up to a suitable level of detail, or the need to create an Employer's Requirements document at stage 3 requiring enhanced deliverables are thought through.

In addition to the above, it is important to ensure that other documents, such as those noted below, are properly integrated and coordinated, and any ambiguities are resolved before design commences.

The BIM Execution Plan

The BIM Execution Plan is a means of the lead designer demonstrating to the client team how the client information requirements will be delivered. It will contain:

- information on the design process, including workflow diagrams
- classification, file naming and folder structures
- the software and hardware to be used on the project, including the means of facilitating client design reviews
- the types of information deliverables and any information associated with achieving these.

RACI

RACI Responsible, Accountable, Consulted, Informed are commonly used project management tools to help define design responsibility. Crucially they also consider the parties supporting the design lead for a topic, and which parties need to be informed about the development of a specific topic. This useful tool can bring clarity to the high level of who does what but such schedules do not typically cover prescriptive or descriptive design allocations, nor do they look at BIM modelling deliverables or the required 2D outputs. These need to be covered in a separate Responsibility Matrix.

Schedules of Services

Schedules of Services can capture the tasks required to add clarity to the information requirements. They:

- make clear the specific tasks required during the design stages
- bring clarity to aspects that might be ambiguous or capable of being undertaken by a number of parties
- help to define the interface between designers when the design baton is being handed to another designer at some point during the design process
- help the lead designer to make sure that the right tasks are done at the right time.

This chapter:

- Explained why information is more complex than it used to be
- Explained why there is a need to define who does what when
- Proposed a number of options for who might prepare the Responsibility Matrix in order to add value to the design process
- Looked at how the EIRs must iterate with the Responsibility Matrix and Schedules of Services to effectively define who does what when

CHAPTER 9

CONNECTING DESIGN AND CONSTRUCTION

Introduction

The way buildings are made has changed little over the years. The majority are still constructed using traditional technologies and techniques, such as the cavity wall. As a result, the construction industry has not seen productivity improvements for years. This scenario is changing – the way buildings are made is evolving. A revolution is on its way.

Modern methods of construction, including DfMA, the use of modular (volumetric) design principles, the increasing use of robotics on-site and off-site, and new materials and manufacturing processes are increasing. Some can be easily adopted, other will take years to be commonplace. Either way, the lead designer needs to understand these different approaches and how they might impact on the design process. Transformational construction techniques are inevitable as construction teams race to differentiate themselves from their competitors. Those who embrace modern methods of construction will not only build faster and cheaper but also safer and with reduced environmental footprints. There are no downsides to a more effective construction industry.

New construction techniques do not just benefit the construction team. They offer new design possibilities and new paradigms, which is why many designers are excited by the possibilities, ranging from new manufacturing technologies such as additive manufacturing or the opportunities presented by modular construction. However, the built environment industry is fragmented, making the biases underpinning traditional construction techniques difficult to challenge and those driving innovation have some convincing to do.

A significant challenge for the lead designer in the future will be determining the most appropriate construction technologies for a project and setting these in the Construction Strategy. These need to be considered by the design team early in the process to avoid traditional methods being embedded into the Concept Design and, of course, new technologies require different and better information at stage 4 (see p 215) when the trend is for the design team to produce less. They also impact on interfaces and interdependencies. Simply, modern methods of construction need a recalibration of the design process and the information that it delivers. This chapter considers the technologies that are driving the change and the topics the lead designer needs to consider.

The changing nature of construction

Before considering the impact of modern methods of construction on the Construction Strategy, this section looks at the changes that are under way, how these impact on the design process and how they transform the way buildings are made.

What is designing for manufacturing and assembly?

Design for manufacture and assembly (DfMA) embraces a number of topics but is primarily arranged around four topics:

1. Building spaces using modular (volumetric) techniques
2. Building larger sub-assemblies
3. Detailing for assembly
4. Eliminating wet and hot trades (see p 220)

These topics are considered in detail below; however, more information is available in the DfMA overlay to the RIBA Plan of Work available at www.supplychainschool.co.uk/uk/offsite/construction/clients-and-designers/architects_designers/dfma.aspx This website also contains a plethora of information on many DfMA processes being used by the construction team and its supply chain.

Figure 9.1: When to consider modern methods of construction

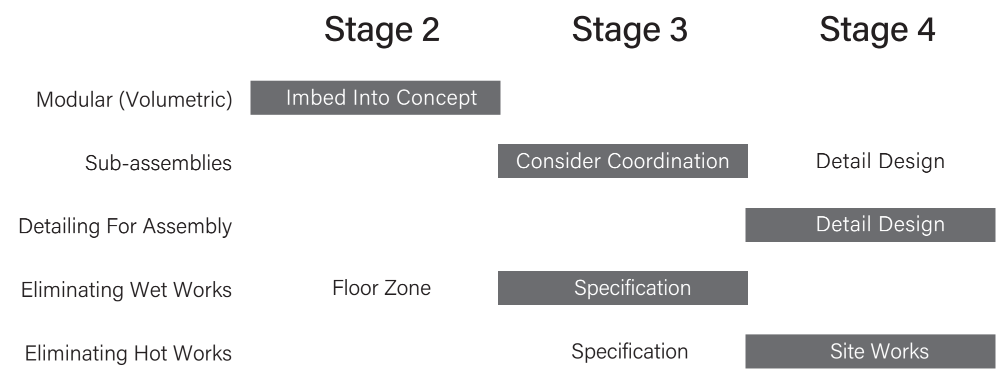


Figure 9.1 underlines that many DfMA initiatives cannot be left until stage 4. Some need to be embraced early in order to be successfully integrated into the design. Specifically:

- modular (volumetric) techniques need to be considered at stage 2 (and possibly by the client team at stage 1), as they place a number of constraints on the design process
- larger sub-assemblies might need to be imbedded into the Concept Design but many of them can wait until stage 3 when the coordination work is being undertaken
- detailing for assembly and eliminating wet and hot trades benefit from early consideration but can still be integrated into the design at stage 4.

The Supply Chain Sustainability School

The off-site management school (www.supplychainschool.co.uk) aims to educate and inform the construction industry of the benefits of carrying out a greater proportion of 'construction' off-site. Although the school focuses primarily on providing advice for specialist subcontractors, it also contains advice for designers.

Building using modular techniques

The use of modular – sometimes called volumetric – construction techniques is not new. Prefabricated modular is commonplace in the hotel industry, with rooms arriving complete with carpets, fittings and, in some instances, curtains and beds. The residential industry is waking up to the realisation that modular techniques have many advantages. One residential developer has reduced the timescale, from their client (the owner of the new home) configuring the interior of their home to the handover of the keys, down to eight weeks and is looking to reduce this further. Modular construction comes with a number of benefits:

- Units can be manufactured in a factory where more stringent quality control measures can be put in place and more repetitive tasks undertaken (a misconception is that better environmental conditions drive quality).
- Less skilled labour is required, diversifying the labour pool required by the construction industry, which has a shortage of traditional construction workers.
- Site-works are minimised, removing many of the risks associated with traditional construction from inclement weather to working at height.

The downsides of modular are:

- It reduces the possibilities of using local labour during construction, which can be required for local political reasons (this can be overcome by using 'flying factories' – see p 217).
- Unit sizes are restricted by transportation limitations, placing a major constraint on the design process.
- The supply chain (manufacturers providing the technologies) is limited and undercapitalised, requiring investment to generate growth and capacity.
- Manufacturers have limitations on how their modular units can be adjusted from project to project, limiting creativity or generating planning issues.
- Off-site processes used are still predicated on traditional construction techniques and have not matured to the same level as other manufacturing industries that are already using 24/7 factories geared to lights-out manufacturing.

On-site 'flying' factories

Flying or 'pop-up' factories are factories set up on-site or close to site. The benefit of pop-up factories is that the raw materials can be transported to the site, minimising materials handling and removing constraints around unit sizes. A significant number of units are required to justify this approach. Local labour can be utilised, which is seen as a major benefit from a planning perspective.

Lights-out manufacturing

Lights-out manufacturing (or dark factories) are commonplace in manufacturing. Factories using robotics do not need canteens, toilets, parking or other amenities, nor do they need lighting or heating. Some product manufacturers are beginning to use such factories but cases are limited. Lights-out factories can run 24/7 and on the basis of the reduced areas and operational costs are more effective, although a core reason for the 'lights out' are the sensor technologies used by robotics.

When considering a modular approach, the lead designer needs to consider whether the proposed modular units are:

- Repeatable: having 100 standard units with (say) four different one-off corner units requires the design and tooling for five modules to be developed. Simply, if the units are not repeatable at scale, the solution is unlikely to be cost-effective.
- Transportable: they must be designed to comply with legislation, with larger modules requiring escorts, incurring additional costs. Flying factories are not suitable for every project and should not be taken as a given.
- Connectable: where modular units are being connected to form a building, the modules must be shown on the layouts with 'fat' walls shown where units connect and consider services connectors for power, water and drainage.

Where there is repetition, and sizes are within transportable rules, modular is an excellent approach and can be used for smaller, complex elements such as prefabricated toilets. If the industry obtains more capital and scales, costs will nudge down and become a differentiator. When this happens the demise of traditional construction will accelerate. The car industry has been embracing mass customisation design to manufacturing processes for some time, and some residential companies already allow the future owner to configure their house.

Buildings as products

An increasing number of companies are designing and manufacturing buildings as products. This approach is popular because the design quality, costs and delivery timescales are known at the outset. The companies taking this approach need to make upfront investments in the design of the products and need to produce marketing material. It is likely that this approach will become more commonplace. Those considering this approach need to consider the implications of generating products, such as the risk of defects being repeated or the need for different insurances (product insurance).

Not every building can be manufactured using the modular approach. For example, large-span open-plan offices, factories, warehouses and high-rise residential projects require traditional structural approaches. Other building types, such as hospitals, are suitable for a modular approach, but the need for many one-off units does not currently make this approach viable from a cost perspective in these sectors.

Building larger sub-assemblies

Where modular units cannot be adopted, there are still significant benefits in considering the use of repeatable sub-assemblies that can be manufactured off-site or in near or on-site factories before installation. Examples include:

- unitised cladding systems or flat-pack external wall panels
- prefabricated utility cupboards and bathrooms in residential projects
- pre-assembled mechanical risers or major horizontal distribution routes.

Sub-assemblies

A sub-assembly is an element of the building where a number of components are assembled together off-site before being craned into position on-site. Sub-assemblies speed up construction by minimising work on-site. Sub-assemblies have greatest benefits on larger buildings where modular approaches are not suitable.

Sub-assemblies have all the benefits of modular construction and the considerations are the same. The biggest barrier to the use of sub-assemblies is changing the attitude of suppliers and manufacturers, shifting them towards providing sub-assemblies as products rather than as a reactive solution developed through a specialist subcontractor in response to the design team's design intent information or as a contractor innovation as part of a Value Engineering proposal. For example, if items – such as bathroom pods – were available from catalogues, it would speed up the design process and create more cost certainty. By shifting to a product approach, greater research and development can be brought to bear, and through repetition of approach comes new ways of making sub-assemblies faster and cheaper. When considering larger sub-assemblies, the lead designer needs to consider:

- Can the sub-assembly be made by an existing product supplier?
- Do the specialist subcontractors have the skills to develop the design and manufacture the proposed sub-assembly?
- Is the approach going to be cost-effective (this might include verifying that higher manufacturing costs are offset by reduced site installation times)?
- What is the weight of the unit and how are the units handled and transported on-site?

Detailing for assembly

If it is not feasible to use modular or sub-assembly approaches, it may be possible to look at how elements can be constructed more effectively and efficiently on-site. Examples include:

- designing a precast stair with inserts for the balustrading brackets, avoiding drilling on-site
- specifying electrical components with plug-in connectors, avoiding the need to make connections manually on-site
- designing components that 'snap-on', avoiding the need for nails or screws.

This aspect of designing for manufacturing and assembly requires a great deal of consideration by the design team. As noted above, it is difficult changing the mindset of those who have designed and detailed buildings in a particular way for a long time. The lead designer might facilitate workshops and presentations from industry leaders on the topic to nudge the design team towards an appropriate response, wholeheartedly embracing the topic in the Construction Strategy. The construction team, suppliers and specialist subcontractors are also instrumental in making these changes, as they are fundamentally about the supply chain helping to drive the specifying behaviours of the design team. Detailing for assembly can also be construed as a way of optimising traditional construction (see p 222) before more radical approaches are adopted.

Eliminating wet and hot trades

As well as detailing for assembly, the design team should consider avoiding wet and hot works on-site. Wet works, such as screeds, slow down construction requiring drying-out time before the next construction activity can take place. Hot works, such as welding handrails on a staircase, create the risk of fire and sometimes need to be undertaken in congested areas of the site. Eliminating both speeds up construction and creates safer construction-sites.

This initiative is straightforward for the lead designer. When considering the Construction Strategy the lead designer needs to meet with the design team to discuss where hot or wet trades might be traditionally adopted, and consider and agree alternative approaches or ways of eliminating these – for example, encouraging the architect to specify a dry screed in lieu of a wet one or avoiding welded joints in handrails. These approaches can be recorded in the Design Status Schedule, allowing the cost consultant or others to flag any concerns.

Solutions might be added to a checklist or guidance so that where the lead designer is working with a different design team, knowledge can be disseminated quickly, nudging DfMA forward.

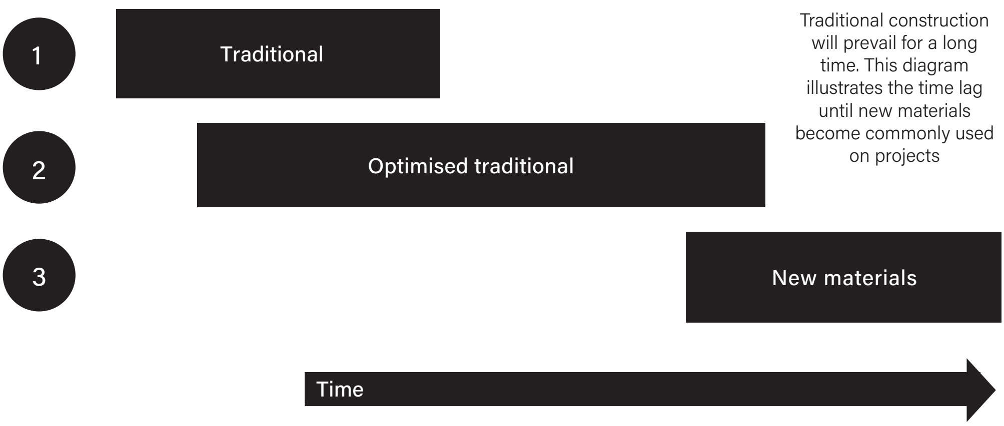
What will drive the increase in robotics?

Robotics are good for undertaking repetitive tasks and can also be used to reduce health and safety risks. Robotics are not currently good at moving around sites, and for precision work they need good guaranteed stability. Current examples of robotics currently being used on-site include for:

- demolition, significantly reducing health and safety risks
- 1st fix drilling of holes in concrete soffits, avoiding the need for scaffold towers and manual overhead drilling
- surveys, including capturing real-time progress
- spraying insulation in confined spaces, such as the floor voids in existing buildings
- concrete finishing
- exosuits that help reduce the possibilities of injuries to construction workers carrying loads
- tying and bending of rebar for in situ concrete.

Robotics are currently used primarily for demolition and assembly purposes, i.e. their use on projects is temporary in nature. This helps uptake because while the use of robotics needs consideration of how robots and humans can work together, some of the more stringent health and safety requirements arising from new materials or additive manufacturing embedded into the permanent works do not apply.

Figure 9.2: Timeline of new construction technology



The capital cost of robotics, limited use cases and the lack of clarity on the next generation tasks they will perform on-site or off-site is preventing greater uptake. Once new-use cases have been trailed and proven, and the gap between the cost of human capital and robotics narrows further, greater uptake will occur. When new-use cases are established, the plant hire industry may also respond to the challenge, allowing more SMEs (small- and medium-sized enterprises) to embrace the technology. The rental of robotic machinery will increase when the return on investment (ROI) is clear to both those using and renting them.

On-site, current trends lean towards automating traditional construction processes, such as the use of bricklaying robots. The automation of traditional construction processes by robots rather than craftsmen is an interesting one, although it does underline the challenges in moving away from traditional techniques. On balance, it seems illogical to be automating traditional construction rather than reinventing the cavity wall and the materials that sit within it.

As the use of modular construction increases and sub-assemblies grow in size, the use of robots on-site to assemble larger components will occur more often. It is likely that the programming for these robots will be undertaken by specialist consultants working for specialist subcontractors. The lead designer needs to be aware that the use of robotics on-site will change current buildability assumptions. Kinematic considerations (see Figure, p 222) require re-evaluation of buildability and other assembly considerations. For example, bricklaying robotics needs entirely different access requirements than the scaffolding and 'hop-up' requirements of the bricklayer, and may require different detailing to suit the limitations of the robot's 'way of working.'

Kinematics

Many robotic devices work from a static position. Kinematics examines how robotic arms will undertake the tasks required of them by looking at the motion of the robotic arms. For example, can the arm reach to install a fitting at the end of an assembly?

What new manufacturing technologies are being developed?

New materials and manufacturing technologies will create the next wave of innovation that will follow on from robotics. This era will include new materials such as graphene or additive manufacturing (3D printing) and will be more disruptive, creating different challenges for the uptake of robotics, materials, products or sub-assemblies being made for incorporation into completed buildings. This will start with the need for new standards and codes to meet regulatory requirements. The likely scenario is that new elements will be used initially in low-risk environments. For example, 3D printing is more likely to be used for a one-off house or an internal glazed partition, generating a lower-risk profile than 3D-printing a façade. Simply, the uptake of these technologies will take longer where the risks are higher.

While the lead designer and the design team should embrace new materials and manufacturing methodologies, they should also exercise caution. Where such technologies are proposed they need to ensure that:

- the client team supports their use
- the design team is aware of any engineering implications
- adequate testing and standards are in place
- case studies are reviewed
- any regulatory hurdles are determined and closed out early in the process.

The complexity of traditional construction innovation

Although this exciting wave of modern methods of construction and the next wave of construction innovation, including robotics and new manufacturing technologies, is upon us the lead designer needs to be mindful that traditional suppliers and manufacturers will continue to innovate in order to maintain their share of the marketplace. Examples of recent innovation by those supplying traditional construction technologies include:

- plaster systems designed to improve acoustics
- floor constructions enabling fast installation and the incorporation of underfloor heating
- doors and windows achieving better environmental criteria, yet allowing in more light.

Where traditional materials are used, there are a number of initiatives that the design team might use in order to optimise their use, including reducing waste. For example, designing around available sheet sizes for plasterboard, timber or aluminium or pushing out information from models to produce bills of materials (see p 182).

The lead designer might consider adding a section to the Construction Strategy that considers innovative use of traditional products or means of reducing waste either in the factory or on-site. The core message from the Construction Strategy section, is that once a design is set it is difficult to take on board many of the points covered above.

Other changes driving construction innovation

It is important to recognise that the construction team is not just innovating around modern methods of construction but also the logistics involved in the construction of a building:

- Using 4D BIM (see p 163) in order to rehearse and optimise the construction sequencing.
- Partnering with logistics companies in order to guarantee the flow of materials, including sub-assemblies to site.
- Leveraging consolidation centres where materials can be held before being sent into congested city centres.
- Using point cloud surveys to undertake real-time as-built and progress information.
- Setting up the use of hand-held devices to improve the flow of information on-site.

The design team needs to acknowledge these step changes and consider how it can contribute towards these transformations, including delivering the information required for this new construction future.

4D BIM

4D BIM, or time, allows the construction team to rehearse a number of different construction scenarios, allowing them to optimise the Construction Programme and to consider logistics issues on-site. Construction equipment, including cranes or cement mixers, can be added into the visualisations produced to consider more detailed logistic aspects. It is not common for 4D visualisations to be produced during the design process; however, as modern methods of construction are embraced it may be essential to produce such visualisations as part of the Construction Strategy to give the client the confidence that the right approaches are being taken.

How the Construction Strategy adds value to the design process

Experienced architects and engineers use a great deal of intuition as they develop their proposals. As such, traditional construction methodologies unwittingly become embedded into a design. What is clear from the above section is that many construction technologies cannot simply be addressed solely at stage 4. To overcome this the design team must consciously consider modern methods of construction at the outset of a project. Understanding the constraints of modern methods of construction becomes core to its uptake until the knowledge of such systems is embedded into the intuitive knowledge of the design team. The preparation of a Construction Strategy at stage 2 is a core requirement of the RIBA Plan of Work. This strategy:

- ensures that the correct modern methods of construction are given sufficient airing at stage 2 and are imbedded into the Concept Design proposals as appropriate
- puts buildability and any construction constraints at the heart of the design process
- allows buildability concerns and other construction aspects to be coordinated with other Project Strategies
- ensures that buildability is still considered, either by the design team or by a specialist construction adviser when there is no construction team at stage 2
- establishes that the right information requirements for stage 4 have been considered.

Where the design team is considering new or unique aspects in the design, it might also engage with the specialist subcontractors likely to tender for the works, holding workshops with them to assist in the development of the design. This achieves a number of objectives:

1. It allows buildability and health and safety aspects to be considered at the design stage.
2. It makes the design intent details more realistic.
3. It ensures that the proposals are affordable.
4. It harnesses the specialist design skills and different innovation strands with which only the specialist contractors can assist.

The Construction Strategy might be prepared by the design team with the assistance of a construction adviser (see p 41). The increasing diversity of approaches (including current and improved traditional construction materials and products), modern methods of construction (including modular and robotics) and new manufacturing technologies and the likely timescales for their uptake means that traditional and new approaches will sit alongside each other for a long time. As such, for the foreseeable future the lead designer will need to consider with the client team, construction adviser and/or the construction team which approach is appropriate for a project and for the majority of Procurement Strategys. The conundrum is that significant decisions around the construction methodologies might need to be made before the construction team is on board. Different construction teams may be comfortable, or not, with different approaches, further complicating this challenge.

This chapter:

- Showed how the lead designer and design team need to keep abreast of changes in the way buildings are made to avoid traditional design construction being embedded into the Concept Design
- Described how multiple construction innovations will take place concurrently, placing greater importance on setting the right approach in the Construction Strategy in the early stages of the design
- Indicated how optimised traditional technologies, the use of robotics and new technologies such as 3D printing will transform the way we make buildings but will create challenges to the regulatory environment

CHAPTER 10
REVIEWING DESIGN

Introduction

Reviews of a design are core to the design process. The lead designer needs to understand the value and importance of different types of reviews, acknowledging the most important ones in the Design Programme. Some reviews of the design are informal, others formal. Some proactive, others reactive. Some consider aesthetics, others functionality, and many both. Simply, design reviews are central to the design process and the lead designer must facilitate the right reviews at the right time as part of proactively coordinating the design.

Design reviews by the client team or external stakeholders might not take place regularly; however, they are the ones most likely to influence the direction of the design. Immersive technologies are facilitating new client review processes and no longer must clients attempt to interpret 2D information. They can 'walk inside' their building, gaining a sense of the experience the completed building will offer.

Different reviews are required to recognise the diversity of design tasks undertaken at each stage. As well as facilitating design reviews, the lead designer needs to record any actions and drive them to conclusion: issues that fester can quickly develop into hot topics (see p 116), impeding the effective progress of the design.

Digital tools are changing the review process. Some focus on geometry, allowing coordination to be proactively undertaken, while others leverage the data in the model, automatically validating that it contains the necessary information. The design team needs to be aware of these technological changes, incorporating new review processes into its workflow. With 2D information increasingly redundant, it is feasible to keep the majority of information in a 3D workflow where the imbedded intelligence can be used more effectively.

This chapter concludes by looking at the challenges of reviewing the work of specialist subcontractors and how reviews can be effectively used internally to assess design quality or for quality control purposes.

In summary, this chapter considers the different types of design reviews, when these should take place and how technology will enhance the review experience for everyone in the project team in new and previously unimagined ways.

What type of design reviews are required and how do they add value to the design process?

The lead designer needs to understand the subtle nuances of different design reviews and how to best leverage each type of review. Design reviews include:

- the client team reviewing the initial ideas prepared during the Concept Design stage by the architect
- the lead designer reviewing proposals for typical grids and riser locations prepared by the structural and building services engineers respectively as part of strategic coordination exercises during the Concept Design
- an architect or engineer's office reviewing the design of current projects to make sure that they align to the values and brand of the practice and/or QA processes
- the project manager reviewing the Project Strategies for compliance with the Project Brief
- the information manager validating that the design team information has been delivered as set out in the Employer's Information Requirement
- a town planner reviewing proposals and determining if they meet the requirements of local plans or other planning topics prior to making a recommendation to the planning committee
- a community group reviewing the design proposals as part of the planning process
- the health and safety adviser reviewing the Developed Design to consider any health and safety issues
- the client's FM team reviewing the design to ascertain if the Maintenance and Operational Strategy meets corporate requirements
- the construction team reviewing the Concept Design to provide comments on buildability and sequencing
- the architect, structural engineer or building services engineer reviewing the design work of a specialist subcontractor
- a client monitoring team reviewing the Contractor's Proposals to ensure compliance with the EIRs.

While this list is comprehensive, it is far from exhaustive, underlining the importance of the review process and for the client team and the lead designer to determine and programme-in the types of design reviews required (for example, pre-application discussions with the planners).

Everyone in the project team needs to be alert to the review process. Design reviews undertaken too early can be counterproductive, yet if undertaken too late they can disrupt the design process, requiring further iterations of the design. Design reviews add value to the design process by:

- ensuring that any interested parties concerns have been properly dealt with
- identifying risks or problems earlier in the design process, allowing them to be addressed
- helping ensure that the work of the designers is coordinated
- allowing trends across a number of projects to be identified and managed
- complying with the requirements of management systems
- demonstrating compliance with ISO standards.

The amount of information produced by the design team increases as a design develops. The earlier design reviews are undertaken and the design signed-off, or amendments identified and made, the more efficient the next design stage will be.

Proactive

Design reviews where design information is presented for immediate comment by others – including the client and stakeholders, such as planners, local community groups or joint venture partners – are the cornerstone of the design process. Visual information is core to such reviews and might consist of drawings on a wall, a presentation projected on to a screen or, increasingly, videos and immersive technologies.

For design reviews to be successful, careful planning and preparation is required, along with meticulous recording of discussions to ensure that actions and decisions are made available for future reference. Reviews to consider aesthetics are normally facilitated by the architect providing the design leadership for the project (as described on p 22). In some instances, reviews might be used to consider functional requirements and the lead designer might chair the meeting. In the majority of situations the core design team members would be in attendance to hear opinions and views first hand and to provide appropriate responses on their aspects of the design.

A core benefit of this type of review is hearing the reviewer's views first hand and having the ability to respond. However, a fine balance is required. Designers should be cautious about making knee-jerk reactions to comments that are made, avoiding 'designing on the hoof' in response to comments made (see p 233).

Reactive
Design reviews using design information for formal comments by others, including the client team or planners. Reactive design reviews are a crucial part of the design process, including peer or QA reviews and client gateways or signing-off requirements. They need to be considered as carefully as proactive design reviews.

When issuing information for reactive reviews, it is important to make sure that the information is complete. There is no point asking someone to review an aspect of the design if it is incomplete or ill-considered. Conversely, it is easy for some reports to get bogged down in too much detail. An executive summary can succinctly record progress to date and tease out any strategic considerations or decisions that are required.

Reactive reviews are more common at the end of a stage. It is crucial to set out the expectations or decisions required from a report, possibly outlining the next steps or the work that will be undertaken at the next stage. It is important that sign-off processes are carried out as quickly as possible to avoid comments impacting on the next design stage.

Balancing proactive and reactive design reviews

Proactive reviews solicit immediate comments, requiring reviewers to 'shoot from the hip', whereas reactive design reviews allow more considered responses. The lead designer needs to bear this in mind. A crucial proactive review might give some essential comments and direction but it may need backing up by a reactive review to give reviewers time to reflect on their comments and their implications. Some reviewers may not wish to be put on the spot at a proactive review, requiring time to craft and consider comments. Different types of proactive and reactive design reviews are considered in detail below. The lead designer needs to recognise that both are crucial and core to the design process.

Facilitating a proactive client design review

The rules for facilitating a successful proactive workshop are the same for the most important of client meetings as they are for the smallest of design team discussions. Make sure the objectives are clear, the right information is available and the correct people are present.

What needs to be considered when reactively reviewing design team information?

Reactive design reviews at the end of a stage should ratify a successful coordination process by the lead designer. They should not be used to carry out coordination *per se*, although it is inevitable that minor design issues will be identified during the process.

- The information should be reviewed against design decisions that have been agreed at design workshops and information contained in the completed and signed-off stage reports.
- Information should be reviewed against other relevant Project Strategies as well as Building Regulations, British, or European, Standards or Sector specific guidance such as HTMs (Health Technical Memorandum) used in the healthcare sector.
- Comments need to be clear and objective: too many subjective comments make it difficult for those being reviewed to understand what is required. Such comments include: ' Can this be moved over here?' or 'Can this beam be smaller?'
- Timescales should be included in the Design Programme for design reviews and for the time required by each design team member to amend their information in line with any comments that have been made.

Why do immersive technologies radically transform client design reviews?

2D information is not the best means of illustrating a design to a client, underlining why watercolours, artists' impressions, visualisations and animations have always been core to client reviews. Historically, it was only viable to provide 3D snapshots of the design, but the shift towards 3D immersive environments, where the client can navigate inside a design, has created a step change. Clients can understand the spaces better and how it feels to be in them, awakening their imagination and allowing them to review every aspect of the developing design. Increasingly, client user groups are demanding immersive experiences. They know it makes their role easier. Unfortunately, new review experiences are seen as a 'bolt-on' by many to traditional 2D processes rather than a new way of working. The lead designer needs to changes the status quo by nudging client teams towards 3D workflow, promoting and improving the use of these game-changing digital tools.

For an immersive environment to be successful, the architect needs to model everything that the client can see. This is a crucial point for the lead designer: producing this information may require some additional exercises to be carried out earlier by the design team. For example:

- The stair structure will need discussion with the structural engineer and will need balustrading details to be considered.

- The ceiling layout may need discussion to allow the appropriate components to be added.
- Catalogues will need to be reviewed and costs checked to allow light fittings to be added to the model.

Immersive Technologies

Immersive technologies provide game-changing ways of undertaking design reviews. For example, rather than sitting round the table to discuss a design, the client and the designers can use headsets to place themselves and their digital avatars inside the model. The client can then comment on the design proposals in profoundly different and more granular ways. Virtual reality and 'Augmented Reality' are similar. Both use headsets to project the proposed design in a manner that the client believes are 'inside' the building. The difference between them is that virtual reality projects an image of solely the proposed design while AR projects images on to a real background allowing, for example, a maintenance team to 'see' where wiring is behind a wall or planners to see the image of proposed building in its proposed setting.

When is the client designing?

There are many parties who influence the design of a building, including planners, historic bodies and regulatory bodies, and comments from these stakeholders cannot be construed as design: the design team adjust and adapt the design in response to comments. Clients' comments can be different. The client may have strong views on the design and occasionally they may insist on a specific change with which the design team disagrees. The client has now shifted from commenting mode to instructing mode.

Where such instructions are not aesthetic in their nature – for example, comments relating to items where the performance of the building might be impacted – the lead designer needs to be particularly careful. In these situations where the client wishes to deviate from the design team's professional advice, all conversation and communication must be carefully recorded, especially if the advice is that their changes are not suitable. In extreme circumstances, where the change goes beyond what a practice is willing to promote as part of their brand or to ethically accept, this might result in the design team walking away from a project.

New review possibilities created by immersive technologies compound this challenge: with the detail that was previously 'hidden' in the head of the designers now revealed, the client can 'see' and understand everything to do with their project, allowing greater granularity of comment. While this greatly enhances the design review experience, it also creates more possibilities for the client to comment:

- Can we change this staircase? I saw a great timber stair in Fred's house.
- Do we need to use a plasterboard ceiling? I would prefer a timber ceiling like the one in my gym.
- Are there different light fittings available? I like the one in the local museum.

With more to discuss, it is inevitable that more comments will be made. The lead designer will need to consider how to deal with a new generation of client comments that might impact on the design itself. What response is given when the client instructs an approach that the architect does not believe will create a good outcome?

Avoid the temptation to design on the hoof

The benefit of iterative design reviews is that immediate comments from reviewers can be solicited. While quick and instant feedback is invaluable, it may not be robust and it can sometimes be worth following up some client decisions to make sure that once the reviewer has slept on them they are still confident of their decision.

Similarly, the design team needs to be careful in how it responds to comments made in a review. Months of iterative work can easily be unwound with a knee-jerk response from a designer. Sometimes it is appropriate to debate; other times it is best to reflect what has been said and to go away and consider the comment in detail and to respond at a later date.

Reviewing the work of the design team

Proactive reviews of the ongoing work of the design team forms the backbone of the coordination process and are central to the lead designer's role and managing iterations of the design. Design work will be reviewed in a number of ways including at:

- regular progress meetings
- regular design team workshops
- impromptu workshops to discuss specific topics.

Proactive design reviews are essential for developing the detail of a project, allowing granular discussions on specific areas of a building or on a particular topic (for example, how the façade will be maintained). Proactively reviewing design information is core to the iterative design process. Indeed, to leave such exercises too late in the design process could result in substantial issues being revealed during the reactive review process requiring additional time for the necessary iterations to the design to be made to avoid further issues downstream including contractors pricing the additional risks or information requiring adjusted when work on-site is due to commence.

At the end of each stage reactive design reviews are instrumental to the coordination process, allowing the lead designer to:

- confirm that the client team's proactive comments have been addressed
- ratify that items that have been discussed have been incorporated into the design
- carefully check that design team's information has been coordinated (primarily geometric information)
- review the Project Strategies and be clear that they are coordinated with other information
- check that the design information is aligned to the Cost Plan.

Impromptu design review workshops: layering-in the detail

As the design progresses, the lead designer might identify a particular aspect of the design that needs additional focus and development. A workshop can then be facilitated where this aspect can be reviewed, discussed and developed to maintain design progress. Perhaps a collaborative task team is formed. By having fewer individuals and the right designers in the room it is more likely that the correct conclusions and outcomes will be reached.

Although digital tools are increasingly being used, in many instances sketches and conversations can help to iterate and resolve design challenges quicker. The lead designer needs to use a mixture of traditional design skills and new technologies and tools to facilitate the right conversations with the right people. A further consideration is that the earlier design stages might benefit from more traditional tools, such as sketching, whereas the later stages, when the flesh has already been put into the model, might harness digital tools more effectively. Managing the dynamics of proactive reviews and determining the right technique to deliver the right results is a core skill of a successful lead designer.

Refining clash detection: a proactive rather than reactive tool

Design teams are using 3D tools to assist the coordination and design review process. The core tool used for this is called clash detection. Clash detection allows information in the federated model to be automatically reviewed for geometric 'clashes', with reports highlighting the number of clashes generated. Those undertaking the lead designer's role should have a number of concerns regarding the increasing use of this tool. It:

- is increasingly used reactively; it would be better if such tools could be used to avoid clashes in the first place
- can only identify clashes if information has been included in the model: incomplete modelling generates deceptive results
- can result in 'lazy' design, with designers not giving full consideration to the position of elements in the model, knowing that someone else will identify and resolve any errors
- can only identify one party to resolve a 'clash'. Coordination requires a more nuanced approach and a number of people may be required to resolve a coordination issue
- cannot record the complex conversations that might be required to resolve a specific area of the building: what is the right object to move?
- can record clashes that might not be of concern. For example, a 1,000 floor boxes 'clashing' with a raised floor
- cannot pick up subjective design aspects: other methods are required
- skews the lead designer's role. Those leading clash workshops may not have the skills to determine who is best placed to resolve a clash.

Conversely, properly conceived this tool enhances the coordination process. Those undertaking the lead designer role need to help reposition this tool towards being a reactive rather than proactive tool that:

- can be used to proactively coordinate and review aspects of work as design progresses, possibly using task teams to develop areas of the project
- can be used to record decisions that are made in design reviews, including who will do what prior to the next design review by linking comments around part of the model into a Design Status Schedule.

By resetting the use of this invaluable tool proactively, the coordination process is enhanced. More importantly, when clash reviews are undertaken reactively, as intended, they would be more QA-orientated, identifying one or two items that have 'slipped through the net', allowing them to be addressed before the coordinated model is issued.

Do digital requirements change design reviews?

Verifying and validating that the design and/or construction team's information meets the client's information requirements will increasingly become part of the design review. Verification checks will progressively become automated. Validation will continue to leverage the design review process until subjective aspects of the design can be reviewed by other means.

Verification and Validation

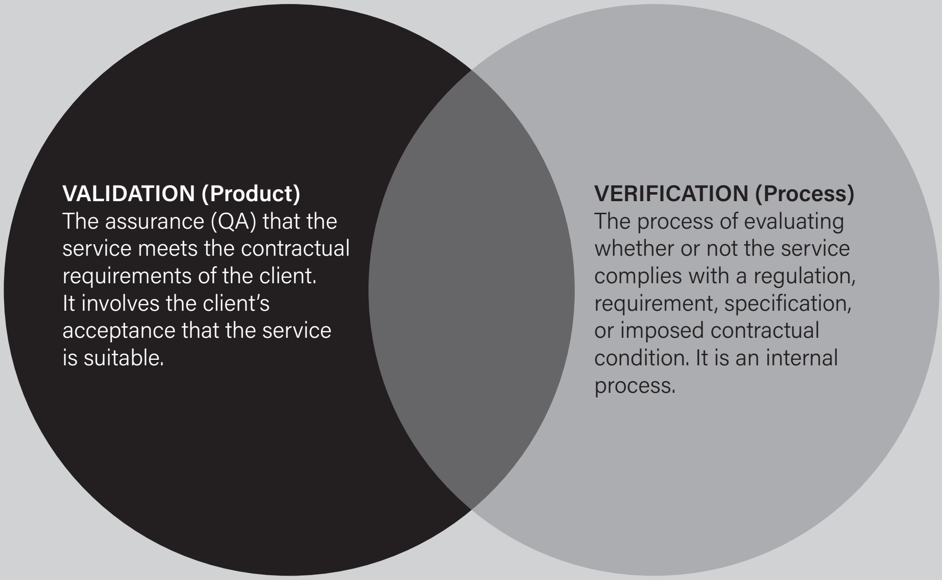
Verification and Validation are terms derived from the software industry. They are separate procedures used to check that a design meets the requirements of the client's brief and that it fulfils its intended purpose. Translated into the design of a building they are:

- Verification: Have we built the models right? Verification is concerned with whether the information complies with the client's information requirements, has been well produced, is error-free, contains the expected data and so on (i.e. is it high-quality information?).
- Validation: Have we designed the right building? Validation checks that the building will meet the client's needs (i.e. will this building achieve the desired project outcomes?).

Verification should be carried out by the design team before information is issued to the client and possibly included as part of a quality management (QA) system such as ISO9000. Many clients will undertake their own verification (possibly using a third party) to confirm that project information has been delivered as intended. Verification is an objective process and as such will be increasingly automated. With the shift towards information for greater use, cases post-handover in stage 7 verification becomes an important task, making sure that the client has the right information for the future. Building Regulations are predominately rules-based and could be covered under verification processes.

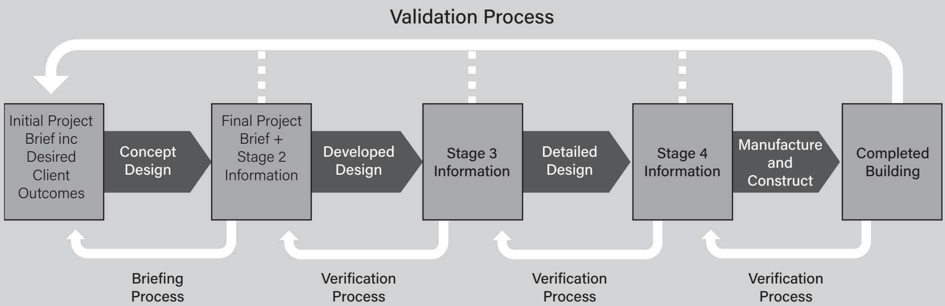
In contrast, validation is a subjective process. Validation checks that the design meets the requirements of the client's brief, including the requirements of stakeholders. For a building, some validation aspects can be automated. For example, have the spatial requirements been met? Other aspects to do with building's appearance, or if the design will meet the client's outcomes, must be reviewed by the client team. In the future AI tools linked to big data might be able to make the subjective objective, including the automated granting of Planning Permissions; however, for now, these notions are a long way off.

Figure 10.1: The different roles of verification and validation



Verification starts with the agreed outputs from the previous stage whereas validation requires each stage to be reviewed against the Project Brief.

Figure 10.2: Using a verification and validation fit on a project



Considerations when reviewing specialist subcontractor design information

Information produced by specialist subcontractors must be formally and reactively signed-off to allow more detailed shop drawings and CAD-CAM information to be produced, enabling manufacturing to commence. It is crucial that those reviewing the design information of specialist subcontractors consider several significant factors:

- Specialist subcontractors can only base their information on what they have been provided. If this information is incorrect, their drawings will also be incorrect (although any anomalies may be identified and rectified during the subcontractor's design process). Therefore, when checking drawings consider how diligently your own package of information has been prepared. Was it rushed for a deadline? Did you rigorously check your information? Was it checked thoroughly by someone else? If, after considering these points, you have any doubts, then a careful check of the specialist subcontractor's drawings, particularly in relation to setting out, is recommended: better spending an extra few minutes checking drawings than the hours, and significant cost, of adjusting a prefabricated component that arrives on-site and does not fit at a crucial interface.
- Information issued to site can be queried by the tradesmen on-site when, for example, a brickwork or dry-lining setting-out dimension is missing or does not seem to tally. The implications of incorrect information impact on-site productivity but can be rectified without significant implications. Conversely, incorrect information used by specialist subcontractors can result in sub-assemblies that do not fit into the building arriving on-site. The consequences are therefore more serious.
- The checking process should *never* be used to change what was included on the design intent information. For example, making a flashing 100 mm deeper because it 'looks better' is a change of scope and will incur additional costs. The change control process should be used and the designer's information amended and reissued as necessary if the change is accepted by the client.
- Likewise, design intent information should *never* be amended to reflect the detailed information on the specialist subcontractor's design information. The design intent information is, effectively, superseded by the specialist subcontractor's information. The only exception is where the design work of one designer impacts on another, requiring the interface to be amended. For example, if the development of the curtain walling impacts on the brickwork design, the brickwork aspect of the drawing should be amended. However, if the curtain walling designer requires adjustments to elements that only impact on his own works, the design intent information would remain 'as is.'

Returning specialist subcontractor information

It is now an established procedure to return specialist subcontractor design information with a category. These categories are usually defined in the tender preliminaries and they ensure that there are no ambiguities regarding the status of a drawing. The categories are:

- Category A: Fabrication and/or construction can commence
- Category B: Fabrication and/or construction can commence once information has been amended in line with minor comments
- Category C: Fabrication and/or construction cannot commence.

Each specialist subcontractor should produce its own Design Programme, which should show design workshops and the periods when information will be issued. More importantly, this programme must allow for a number of iterations of information (Category A is not always achieved on the first issue) and for the subsequent amendments and reissue of information. In some instances a number of design team members may need to comment on a particular aspect of the specialist subcontractor's information. These comments will need to be coordinated before they are returned.

How do internal (peer) design reviews by the design team aid the design process?

Peer reviews allow a second look at the proposals. Such reviews might question the decision-making processes around a topic, flag an area of the design that has not been considered or identify emerging trends or best practice that should be considered. In many instances they are a quality assurance requirement.

Why do design reviews by the architect improve the design process?

A fresh pair of eyes can identify aspects of the design that may not comply with the brief or are not in line with best practice for a particular sector. Internal design reviews can also ensure that the design objectives of a practice are being achieved, and by identifying design issues early in the design process they can be dealt with more effectively and efficiently. Design reviews can also benefit a project by:

- flagging up any significant flaws in a concept
- ensuring that any sector-specific considerations have been taken cognisance of
- ensuring that the design is progressing in line with best practice

- ensuring that the design is achieving the quality expected by the practice
- identifying technical issues inherent in the design
- harnessing the collective knowledge of a practice
- allowing buildability or maintainability aspects to be considered
- determining that the design can be achieved within the client's budget
- ensuring that any assumptions that have been made are realistic and achievable.

Internal design reviews also have other practice-wide benefits, such as:

- serving as audits to demonstrate compliance with an Integrated Management System
- allowing senior staff an overview of the many projects that may be in development
- enabling significant issues to be dealt with before the design progresses too far.

How do internal (peer) design reviews by the engineering teams aid the design process?

Architectural peer reviews deal mainly with subjective topics. Engineering reviews are more focused on the basis of the design and the analysis that has been undertaken. Reviews might reveal that certain assumptions are not robust. Simply, they ensure that the work carried out is correct. With tighter fees and faster timescales it can be easy to forget about such reviews. However, an error is best identified as early as possible, so that it can be rectified without significant effort or cost.

Do not forget about QA

Some digital technologies speed up or automate aspects of the design; however, new workflow can also result in information not being outputted as required. For example, clients talk about instances of receiving blank drawings or other errors that should have been obvious. Simply, in the context of new workflows and ways of working, QA reviews remain crucial. They ensure that the information being issued is to the quality intended. Many QA processes are, however, predicated on traditional workflow and new gateways or measures might be required to make QA processes more robust into the future as more and more digital tools are leveraged in the design process and a greater proportion of design reviews are undertaken in 3D.

This chapter:

- ► Defined the need for designs to be reviewed by different parties during the design process and the need for different reviews at different stages to accommodate diverse stakeholders
- ► Considered the differences between proactive and reactive design reviews and how both should be leveraged by the lead designer to progress certainty as to the design's direction
- ► Explained how immersive technologies will transform the client review experience
- ► Set out how new digital tools are transforming the way the lead designer reviews the work of the design team including greater use of 3D design reviews and ongoing management of model issues in 3D
- ► Considered how to review the design work of specialist subcontractors and how to use reviews for internal purposes, including design quality and quality assurance purposes

PART C

Mindful of the future

CHAPTER 11
MINDFUL OF THE FUTURE

Introduction

Those undertaking the lead designer role may believe that their current knowledge and experience will allow them to practise well into the future. However, many of the design processes presently used will not be relevant. As such, it is important to conclude this publication with a chapter that looks at the topics that will drive change in the future, further redefining the designer role.

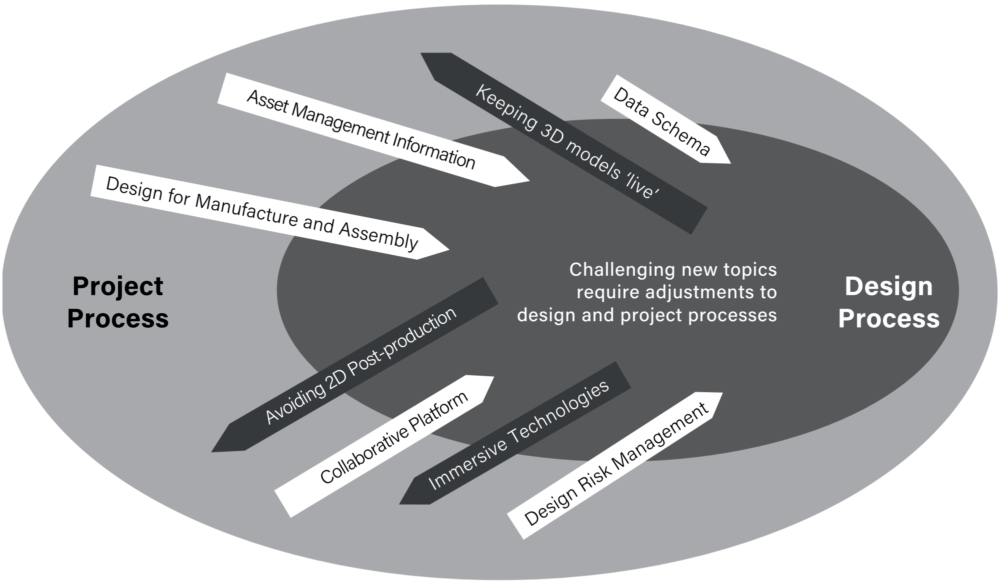
While BIM nudges the design team towards better defined deliverables and good data stewardship, improving asset management outcomes, and is arguably changing the tools we use to design, it is not transforming the design process. Indeed, some would argue that it has made aspects of what is done more complex and less productive. What is clear at this point in time is that innovation is focused on parts of the process rather than the whole, creating confusion and complexity as we plug new initiatives into existing design processes. The opportunities to innovate are immense. However, fragmented project team structures make change difficult and until these topics are set into a new design process they will have minimal impact towards the goal of transforming the designing and making of buildings and delivering improved outcomes. When the next wave of digital innovation arrives, delivering whole project innovation, it is inevitable that significant disruption will take place and many current business models will be unsustainable. With this in mind, it is the topics that will drive radical and transformational change of the design process that are of interest to the lead designer, and this chapter looks at ten such themes.

The goal of this chapter is to open the eyes of those undertaking the lead designer role to the art of the possible, so that once the rest of the publication has been digested, those looking to the future can consider how to reshape the design process. Although getting up to speed on many new tasks and topics may seem a daunting prospect, it is important to alert those undertaking the lead designer role that rapid and regular paradigm shifts in the 'way we do things' will happen in the years to come and that the benefits of embracing these new tools will be significant. It is difficult to predict when these technologies will mature. However, the direction of travel is set and if the lead designer role is to remain relevant, new skills will be required and new services adopted, leading to the next major iteration of the RIBA Plan of Work, in which the design stages are given a radical overhaul.

Looking to the future

There are many topics being explored and introduced into the project process, making it difficult to keep abreast with the ideas that may make a difference to project outcomes. This is a crucial consideration for the lead designer. In transforming the design process, and how it transitions to the making process, it can be easy to forget that emphasis always needs to be placed on how ideas and innovation benefit the client and improve the outcomes of the project. Figure 11.1 illustrates this, acting as a reminder that the reverse is also true: changes to the design process require adjustments to the project process. Below are ten innovations that are likely to transform the design process and improve project outcomes.

Figure 11.1: The project and design processes



In addition to the topics below, there is a plethora of subjects – including blockchain, the internet of things and talk around new materials such as graphene – that may, or may not, impinge on our ways of designing and making buildings. So a challenge for the lead designer is filtering out the noise and determining what topics really will transform the design process, with emphasis on new ways of designing and making buildings. The future is exciting but it is increasing in complexity and becoming difficult to navigate. Those who fail to innovate will continue to create great products but they will find it progressively difficult to coexist with designers who are using faster and smarter ways of designing.

1 Redefining products

With many conversations centring on procurement, it can be easy to downplay the importance of products in the design and making of a building, yet many products need to be selected and specified during the design process. Selection criteria – including aesthetics, cost or performance criteria – vary. Products come in different shapes and sizes, although they are generally restricted by weight and the ability of humans to safely handle and move them around sites. Manufacturers provide product technical advice to specifiers and advertise their products in industry magazines to encourage uptake. The market is competitive and who specifies products is a moot point that was considered in detail on p 196.

Kit houses have been around for years, although uptake has been limited to one-off houses. A number of new residential products are emerging on the market as modular moves at scale into this sector. However, while these prefabricated homes may minimise site time, they are still predicated on traditional design processes. The hotel industry has leveraged modular rooms for many years and while some rooms are dictated by a particular hotel's design standards, these need to be interpreted and redrawn for every project. Similarly, hundreds of toilets for commercial office buildings must be designed every year, yet they are designed from scratch every time.

Toilets, kitchen pods or even bigger components, such as operating theatres, should be available from catalogues where fittings and finishes can be selected around pre-configured layouts. Designers would be able to focus on other aspects of a project rather than crafting every element of a building. Costs would be more predictable. The question is: will product suppliers rise to the challenge and produce larger products requiring assembly or will new companies be formed in response to this opportunity? At present it is impossible to say. And once Pandora 's box has been opened, could more and more be selected from catalogues, or designed using configurators as part of mass customisation processes facing additive manufacturing processes? Ultimately, will stages 3 and 4 disappear? In such a scenario is there any reason that buildings could not be designed, manufactured and assembled within weeks? If a housing company was to agree acceptable design parameters and variations with different planning departments, and each variable was signed-off by Building Control, this approach could be made even faster.

2 Object-based modelling

CAD digitised the drawing board, replicating the deliverables, and today the QA and review processes used for decades remain in place. BIM efforts are in danger of following this same perilous and diluted path with intelligent 3D, data-rich information being flattened into 2D formats aligned to traditional review processes. 2D bias is impeding the creation of new digital design workflow. Thinking beyond current design processes, digital libraries of spaces containing all of the necessary objects for that space can be created – for example, the furniture, light fittings and finishes in a living room, a meeting room or an operating theatre. These objects would contain datasets usable in the design process and would be VR ready, allowing them to be immediately viewed in a virtual environment, enabling the client to select finishes and specifications as part of the review process. Objects can also be worked up with suppliers to be fabrication-ready, allowing immediate manufacturing once the client has signed-off the design and statutory approvals have been concluded. In an object-based environment, the design process needs to consider different tasks – for example, spaces themselves might have some intelligence and rules built in. By way of illustration, a dining room not located next to a living space might flag as an anomaly. An object-based approach reduces the design challenge to less project-specific tasks. For instance, if the room is flexed, how does the ceiling or floor layout adapt? How are the walls between the spaces determined? Or how does the extract from the operating room find its way back to a mechanical riser? Ultimately, room intelligence will automatically select the walls in between each room – for example, selecting a fire-rated wall between a kitchen and a storeroom, using Building Regulation-based rules to set compartment walls or selecting the size and route of the duct from the grille in the operating theatre to the riser.

3 Designing for new ways of making

Historically, the design team has produced the information required to construct a building; however, increasingly descriptive information is produced for certain aspects of a building, allowing specialist subcontractors to use their skills to complete the design. For both, current BIM workflow is geared to the production of 1:100 general arrangement drawings and the 1:5 details used for traditional construction processes on-site. As the shift towards more off-site manufacturing grows, new forms of information will be required. This information will be 3D, data rich and 100 per cent accurate, enabling next-day manufacturing after the lead designer hits the metaphoric 'make' button at the end of the design process. The object-based modelling suggested in the last topic is ripe for such an approach, as is the product-orientated approach mentioned before that.

The challenge for the design team will be tracking and determining how large-scale projects are made. Will this become a mix of modular components and traditional construction assembled by robots – for example, modular toilets, stairs and lifts used in an office building and then wrapped in a steel frame forming the open-plan areas? Will site labour disappear or will robotics become commonplace on-site, triggering an era of 24 hour-on-site assembly? In a scenario where the future can only be imagined, the lead designer needs to scan the horizon, looking at emerging technologies, considering who would provide the information for these, and in what form, and how these new ways of making fold back into the early design stages.

What is clear is that traditional 1:100 and 1:5 deliverables add no value to the design process and will soon be consigned to the bin. The industry needs to be ready for this.

4 Connecting analysis

Disconnect between the engineer's analysis packages and the designer's BIM models is a core and current inefficiency in the design process. In some instances, a number of models or steps may be required to connect the most up-to-date model to analysis software. When a number of options are being iterated this is not only inefficient and time-consuming but may be worthless: by the time the analysis has been undertaken, the design has moved on. There are a number of solutions to this conundrum. The first is that 'quick and dirty' software packages emerge to provide not the final analysis but the equivalent – or better than – rules of thumb information that the engineer has historically provided in the early project stages. This approach would allow options to be evaluated with good-quality engineering input, with the more complex analysis processes plugged in once a particular option becomes clear.

The second solution is workflow, where engineering analysis links directly into the architect's model, giving granular and accurate information as options are prepared. In this environment dashboards displaying the data from different options would allow real-time comparisons and the ability to discard less viable options. For example, on a residential scheme, information on aspects including daylighting, heat loss or heat gains could be made available as the design was being undertaken, allowing unworkable solutions to be discarded earlier, resulting in more robust stage 2 designs and faster stage 3 coordination.

5 Design automation

It is dangerous for any built environment professional to believe that a unique building can be delivered with anything but the current slow, craft-based design process that, despite the length of time involved, delivers incomplete and inconsistent information and may not result in the best outcomes. Key to unlocking innovation is considering how the information for making and using the majority of buildings might be delivered faster and better, yet developments towards connected 3D, data-rich information are far from inspirational: they continue to harness analogue multidisciplinary thinking and face 2D workflow. Those who can keep the geometry and data live throughout the project lifecycle will prevail.

As noted earlier, innovation is occurring in pockets of the process. For example, architects have been using scripting skills for some time to optimise the geometry of their projects, sharing scripts with the structural engineer for optimising the geometry and calculating member sizes by connecting into analysis software. Others have been focusing on data stewardship that allows datasets to be standardised and information structured in a manner that seamlessly flows from manufacturing into FM, where AR can be used to reveal the serial number of a light fitting revealing the bulb type, was it was last replaced and, in a more sophisticated system, how many are in stock and where they are located. The cost consultant is connecting the designer's models to 5D tools that speed up the preparation of the Cost Plan. Real-time cost updates are not far away nor are bills of material. The contractor is able to use 4D tools to rehearse the construction process many times before determining the optimum and safest way forward, identifying and eliminating risks along the way. The circular economy requires us to consider the end of a building's life in greater detail. Can it be re-used? How would it be dismantled rather than demolished?

The list of these incremental innovations is endless. However, while passionate conversations and innovations around these many topics are exciting and future-facing, they are meaningless unless they are framed around, and distilled into, the overall project process that must apply equal weight to many topics from cost, design, sustainability, safety or other considerations. The key challenge is lack of ownership of the overall process. At present, clients appoint and control the project team and are therefore best placed to drive innovation. However, how do they recognise what good look likes and how to evaluate why one tool or approach is better than another?

In the complexity of this context the lead designer must provide the crucial contributions to the design process of the future. Those who are first to transition to digital workflows based around inter-disciplinary task-driven environments will reap enormous benefits. Many stage 4 decisions are rules-based or repeatable from previous projects, and as such are ripe for automation. We will soon have tools that automate the working drawings for windows and ductwork, allowing fabrication-ready information to be coordinated into the design quicker and more accurately, with machine-learning tools derived from thousands of projects looking for anomalies until progress reaches the point where faster design processes are feasible. Project managers will have access to dashboards that advise on progress and other matters.

6 Closed loop design (and manufacturing)

A number of manufacturers are already harnessing closed loop design processes to make their manufacturing processes more efficient and sustainable. This methodology allows changes and adjustments to the design while maintaining the automatic production of information for manufacturing. So, for example, if a closed loop system was used for the design of modular housing it would be possible to change items in the design, such as the size or location of a window, yet still be able to push manufacturing drawings out the next day. Closed loop design processes need design and manufacturing workflow to be connected. This can be facilitated by leveraging workflow diagrams considered as a core tool for the lead designer in Chapter 5.

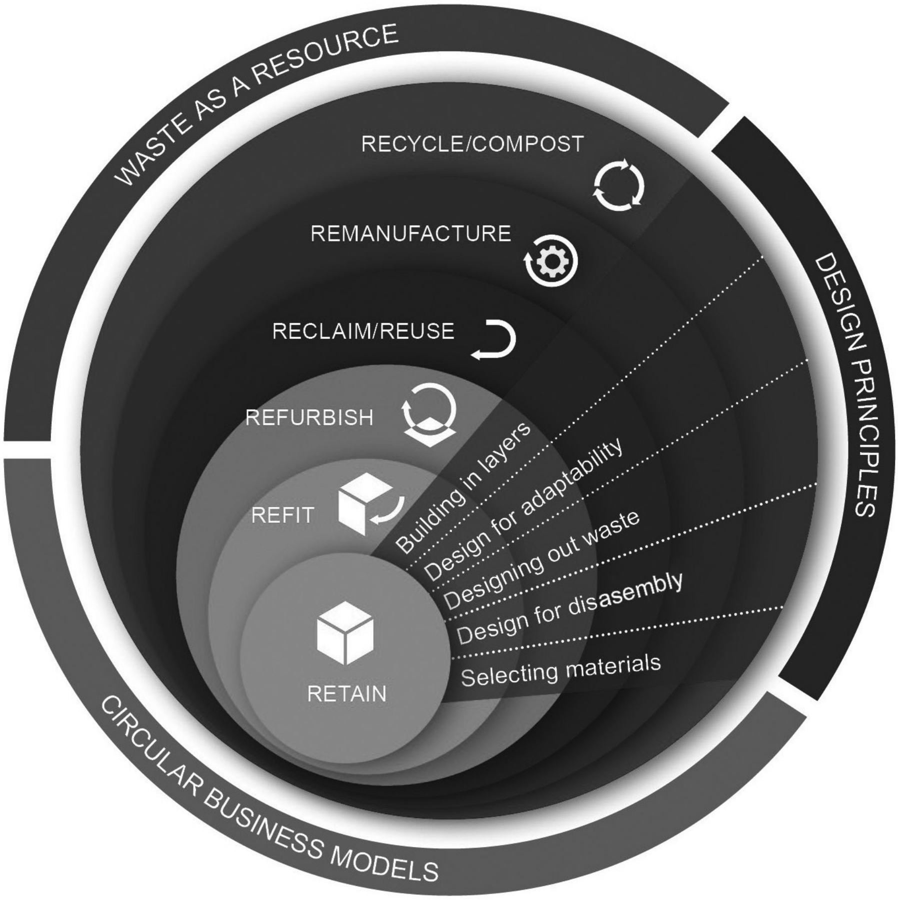
7 Circular economy

Whole-life thinking was considered in Chapter 7 and in Chapter 5 the importance of the Operational and Maintenance Strategy was outlined. However, in the longer-term circular economy thinking is more likely to transform the design process when it comes to whole-life thinking, with notions such as new product thinking and object-based modelling chiming with this way of thinking.

In traditional economies materials are extracted from their source to make things and at the end of their life these things are disposed of. Increased recycling reduces the environmental impact of this process and many demolition contractors already collect and recycle plenty of parts of a building at the end of its life. A new approach had been born: the circular economy. This looks beyond such approaches, leveraging innovation to refine and redefine products, aligning them to a design process that eliminates waste. When materials are recycled they are downgraded. In a circular economy, virgin materials become interchangeable with recycled ones, reducing costs, waste, demand for natural resources and the environmental impact of making things. For buildings, circular economy thinking goes beyond whole-life ideas. Products are designed to allow removal for repairs or replacement during the building's lifespan before they are recovered, reused, recycled or regenerated at the end of their service life. Buildings are designed to be adaptive, allowing different uses during their lifespan with maintenance, repair, re-use, remanufacturing, refurbishing and recycling considered beyond current norms. For example, renting rather than purchasing light fittings and disposing of them at the end of a building's life encourages the supplier to reduce energy costs. Demolition is a crude and dangerous activity. In a circular economy, buildings would be dismantled, not demolished, and the components re-used. More information on the circular economy can be obtained from:

- www.ellenmacarthurfoundation.org/circular-economy
- www.wrap.org.uk/about-us/about/wrap-and-circular-economy
- *Building Revolutions: Applying the Circular Economy to the Built Environment* by David Cheshire

Figure 11.2: The circular economy



8 Data

A common error made by those trying to understand BIM is to see it as just '3D CAD'; however, it is the data in the model that allows better connection of analysis software and the creation of new ways of working, such as object-based modelling. The datasets or attributes in a digital environment allow many new possibilities, although the challenge remains of establishing consistent ways of classifying data and determining, for example, the right attributes. However, the bigger value of data might lie outside the design process. For example:

- How smart sensors aligned to data analytic tools can improve the performance of buildings.
- How data can be leveraged to create smart cities.

- The idea of digital twins providing feedback for improving the performance of buildings and also providing feedback for the design of future buildings.
- How data can help promote evidence-based design processes with a view to creating better Project Outcomes.
- How the integration of GIS and BIM will assist projects in the longer term.

Geometry will always be important from the lead designer's perspective, as it determines the physical form of all aspects of a building. However, connecting data streams will be core to innovating the design process and, more importantly, how the design process integrates into project processes, portfolio approaches, In Use possibilities and the broader integration of buildings into a smart city environment.

9 Artificial Intelligence (AI)

Word documents are easily scanned by AI tools and books can be easily converted into machine-readable files, which is why professions such as law have seen an uptake of AI. In the design industry the uptake of AI tools, such as machine learning, are hampered by a lack of machine-readable content. Detailing partitions is dictated by rules around fire, acoustics, durability, structural deflections, moisture resistance, finishes, height and buildability, and as such they can be automated. However, the complexity of building determines that simple rules are not enough to cover the diversity of junctions encountered. When automated systems become aligned to AI, game-changing possibilities are feasible. One-off conditions that are encountered will be capable of quick referencing against thousands of designs, and such a system would become better and better as new details are added to the system. The AI engine would continue learning until no human intervention was required.

Once the knowledge of thousands of professionals has been harvested by a machine-learning system, new design processes will be feasible, facilitating faster and more accurate decisions. The notion of making the right decision at the right time will be revolutionised. These systems will also analyse who makes and influences decisions. They will realise, for example, that some architects want to specify, or influence, the specification of MEP components, while others do not. They will learn that certain practices have firm product preferences and that others are happy to consider alternatives. They will also learn what decisions a client wants to influence or place rules around. They will focus on early decision-making processes in order to reduce design iterations around the many systems in a building, helping the design team to design to cost and in the process redefine and automate risk management.

The question is who builds the information in quantities sufficient to train an AI tool? Will it be the software vendors who can use huge quantities of cloud-based files to train tools? Will it be the designers who have the intuitive knowledge to train the tools? Or will it be the product manufacturers? Only time will tell. What is clear is that the creative aspects of the design process will prevail. How these engage with AI will be crucial in determining the design process of the future.

10 Open source

Open source software is increasingly used in the design process. Scripts for many design routines are openly shared on the web with different individuals improving and de-bugging them along the way. Open source approaches allow smaller entities to punch above their weight by connecting with many other similar entities. Research and development costs can be shared across multiple practices. Other industries have already demonstrated this. The biggest barrier to open source is traditional IP thinking that aims to protect invention and innovation using traditional routes such as patents, registered trademarks or other ways of protecting copyright. Those redefining the design process would benefit from understanding the pros and cons of these different approaches.

This chapter:

- Indicated that perpetual change is here to stay: the lead designer must be adept at adapting to and embracing new tools or techniques as they become available
- Observed that a number of drivers have impacted project processes with many of these topics requiring refinement to the design process
- Showed how a great deal of innovation is happening outside the design process; however, many topics require tweaks to the design process
- Observed that there are many incremental digital innovations but their impact is diluted as they are plugged into traditional design processes
- Observed that the opportunities to innovate are many; the lead designer of the future should consider how to use the many topics and tools to redefine the design process

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