# Standardising the route to project handover to improve the delivery of major building projects

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**Abstract:** Project handover is an integral phase in the delivery of major projects and should ideally be considered as a process that kicks off at initiation. Studies have shown that when handover is considered as a date where the keys are handed over to the client or end-user in a rushed and unplanned manner, there is a high probability of heightened stakeholder dissatisfaction and the creation of a performance gap. This reflective study examined three case studies to better understand the challenges experienced during the handover of major projects. The data from the case studies were collected through semi-structured interviews and complemented with project reports, documents and industry reports. The findings highlighted a lack of effective handover procedures that facilitate the collaboration between the delivery and end-users/ facility management teams. Therefore, a project handover framework that leverages best practices to provide a consistent and replicable approach for handing over construction projects is proposed. This research is limited to major building projects. Future research could thus explore the applicability of the proposed framework to other infrastructure projects.

**Keywords:** buildings; building performance; handover; major projects; performance gap; post-occupancy evaluation; project lifecycle; soft landings; standardising.

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## 1 Introduction

The handover phase is the key transition between project completion and commencement of the operations phase. While there is no absolute definition of project handover (Zhu et al., 2021), this milestone is mainly characterised by the exchange of project-related documents between the contractor and the client, confirming the completion of works and acceptance of the deliverable by the client (Lester, 2017). Consequently, the terms practical completion (Royal Institute of British Architects, 2013), project closeout (Thabet et al., 2016), initial handover process (Klein et al., 2012) and the initial occupation stage (Gupta and Kapsali, 2016) are often used interchangeably to refer to project handover. From a construction perspective, handover may refer to the end of the defects and liability period, when there are no longer snags in the snagging list or at the end of the post-occupancy evaluation (Anthony, 2017). Thus, a clear understanding of the project management team's definition of handover is essential. This information ensures that all project stakeholders understand their roles and responsibilities at the project handover stage.

During handover project deliverables undergo commissioning, which involves specified performance testing and trials to guarantee optimal performance in order to prevent complications in the operational phase (Schneider et al., 2016). However, there is consensus that buildings do not operate optimally as there is often a significant gap between the predicted and actual performance (Tan et al., 2018; Jonsson and Gunnelin, 2019). This performance gap has been attributed to:

1 a disconnect between the various stages of the project

2 inexperienced project teams

3 missing project information

4 quality of on-site supervision

5 building design assumptions that do not match with user behaviour (Frei et al., 2017; Qi et al., 2021; Naveed and Khan, 2022).

With the increasing pressure to achieve the Sustainable Development Goals (SDGs) as well as climate ambitions such as net-zero, there is a need to address these performance gap issues to ensure that projects deliver on both their social and environmental goals (Mallah and Jaaron, 2021). This calls for transformation in how projects are planned, delivered and managed to ensure that buildings operate optimally to meet clients' expectations and environmental targets.

The building handover process, in particular, is often overlooked and deficiently implemented (Tan et al., 2018; Zhu et al., 2021). For the most part, attention is given to establishing transferable practices that ensure projects are managed successfully in the delivery phase (Anthony, 2017). Consequently, research on project handover is relatively minimal (Schneider et al., 2016) with very few studies offering a critical overview of the issues experienced during handover and how they hinder optimal building performance (Zhu et al., 2021). To address this knowledge gap, the study seeks to uncover the challenges experienced by the client, designers, builders and end-users during handover. Three case studies were explored and a reflective approach was adopted to develop a standardised route that will facilitate the smooth handover of major building projects; offering a systematic way of dealing with all the issues that may affect the environmental performance of the building, comfort and satisfaction of the end-users.

Since handover is a process that should be planned for from the start of the project and not a date as is often the case (Anthony, 2017), this research effort hopes to shift the focus from handover being viewed as a particular date in the project lifecycle to a process that kicks off at the beginning of the project. This process feeds into the operations phase where the building performance is monitored to guarantee its optimal performance. This study offers the first attempt to provide a step-by-step breakdown of all the activities that need to be completed, including the timelines and provides greater clarity on the duties and responsibilities of all the parties at each step. The proposed holistic and structured approach will ensure sustainable delivery and management of building projects, ensuring that the designers, builders, clients, future occupants and facility managers collaborate in the delivery of the building to achieve optimal performance.

## 2 Literature review

### *2.1 Overview of project handover*

As the project nears its end, the contractor prepares a checklist of all the completed work as well as those requiring completion or correction (Wibowo and Uda, 2018). While contractors follow their internal handover process, they typically are not involved in the project beyond its completion date. This is because projects are transient endeavours with defined endpoints meaning that project teams move on to the next project immediately after handover (Anthony, 2017). For this reason, Whyte and Ibrahim (2012) have identified the handover phase to be particularly challenging because expectations are usually high towards project handover as is the anticipation to move into the new facility and get things back to normal as quickly as possible (Way and Bordass, 2005). The result of this is often a multitude of minor problems that go unresolved undermining the goodwill built up during the delivery phase hence affecting the credibility of the new facility. These challenges increase according to the size and complexity of projects (Schneider et al., 2016).

While traditionally project handover is often seen as a simple tick-box exercise (Healy, 2020), it should be conducted as a smooth transition period from the project delivery to the operations phase and the information incrementally handed over from the project delivery phase through 'mini hand-overs' (Anthony, 2017). This phased handover extends into the operations phase and should involve the facilities management team to ensure that targets are tracked and achieved. This will reduce the discrepancy between the designed and as-built performance (Shan et al., 2017) and increase the possibility of realising the project's benefits post-handover.

## *2.2 Challenges experienced during project handover*

The challenges faced during project handover are a result of two project lifecycle phases coming together at a single point during practical completion (Zhu et al., 2021) coupled with a lack of overarching procedures to ensure the smooth transition from construction to the operation phase. Firing et al. (2016), Schneider et al. (2016) and Shirkavand et al. (2016) have reviewed various challenges affecting handover as discussed in the following subsection.

### *2.2.1 Poor planning*

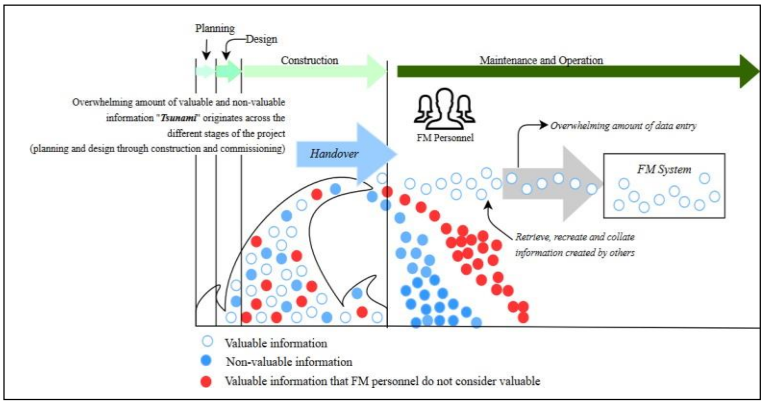
Schneider et al. (2016) argue that the various challenges experienced during the handover process are a result of excessive delays and deficient implementation of the process as a consequence of poor planning. Handover is often considered as a specific date when the keys to the project are handed over to the client or end-user, allowing the contractor to submit the final payment certificate (Lester, 2017). Therefore, the cost and time required to prepare the handover documentation are often underestimated and given less priority as compared to the design and construction phases of the project (Tan et al., 2018), resulting in a rushed handover. This rush often results in defects and client/end-user complaints (Anthony, 2017). For instance, Shirkavand et al. (2016) report that 40% to 55% of the total defect costs are spent during handover. It is therefore paramount to ensure defects are detected early by conducting quality control and undertaking thorough testing before handover, to reduce costs and conflicts with the client and end-user (Forcada et al., 2013).

Poor documentation during the handover process as well as inadequate data exchange because of poor planning result in an information and knowledge gap between the construction and post-occupancy phases of the project (Way and Bordass, 2005). Since the quality of the documents transferred to the facility management team directly correlates with the building's future use and maintenance (Cavka et al., 2015), this impacts the building's performance because the sets of information transferred provide little value to the facilities team (East et al., 2013). For these reasons, the project team needs to plan for project handover as the project commences (Dvir, 2005), incorporating lessons learnt from previous projects (Dvir et al., 2003). Further, the deliverables should be handed over incrementally to the client/end-user and adequate time buffers incorporated into the process to account for problems that may slip off the handover schedule.

### *2.2.2 Tsunami of information*

Current technical guidelines and specifications require that the contractors produce and deliver a set of paper-based documents to the client during handover (Thabet et al., 2016). For major infrastructure projects, the facility managers will not only be required to rekey in all the information found in the binders but also spend time conducting surveys to update and verify the as-built information (East et al., 2013). While having well-documented data and information handed over to the client is a good handover practice (Guo and Chen, 2019), Thabet and Lucas (2017) argue that giving a large amount of 'completed' data to clients towards the end will lead to a 'tsunami of information' phenomenon as illustrated in Figure 1. These large pieces of data might cover all the client requirements, but the high volume of data handed over in one setting will overwhelm the client as they manually sort through to work out the relevant information. It is also highly likely that they may get rid of valuable information that they do not consider valuable at the time.

**Figure 1** Tsunami of information during project handover (see online version for colours)




*Source:* Adopted from Thabet and Lucas (2017)

Further, the in-house operations teams are frequently under pressure to adapt to the change facilitated by the project. Introducing them to the project abruptly during handover may be overwhelming and greatly reduces the chance of realising the project benefits (Anthony, 2017). As such, the project management team should consider involving the client/end-user from the onset of project execution till handover to build their confidence in the team and a sense of ownership in the project output (Dvir et al., 2003; Way and Bordass, 2005). The best practice for data handover includes defining the data requirements at the onset of the project, forming standards for interoperability, and developing the handover process for the inspection of data (Whyte and Ibrahim, 2012).

### *2.2.3 Inadequate consideration of occupants*

Decisions about the building's occupancy and its management are mainly made by the architects during the design phase (Lawrence, 2015). However, in practice, clients and occupants are often abandoned by the delivery team immediately after handover (Way and Bordass, 2005) just when they need most of the help. There is often no clear user guidance, inadequate training of end-users/occupants and insufficient introduction of the building to the occupants (Gupta and Kapsali, 2016; Zhu et al., 2021). Due to this, the occupants' actual behaviour may vary significantly from the predicted behaviour, creating a discrepancy between the as-designed and as-built performance of the buildings, specifically for green or smart buildings (Cavka et al., 2015; Hwang et al., 2017). Because of the discrepancies, most buildings fail to meet their environmental performance targets and user satisfaction.

Conventionally, customer focus is low in the construction industry since the primary objective is on building the end-product and not examining its performance (Way and Bordass, 2005). In the UK, for instance, the culture of evaluating building performance has not yet been successfully embedded in the procurement process since its introduction in the 1960s (Durosaiye et al., 2019). The increasing demand for quality end products by clients follows that poor handover can significantly impact the client's satisfaction. There is, therefore, a need to involve the clients and occupants in determining the requirements (Shan et al., 2017) at all stages of the project lifecycle.

### *2.2.4 Insufficient consideration of the building performance*

When the building's actual performance lags behind its predicted optimal performance, a performance gap is created (Tan et al., 2018). For instance, there is consensus that there is little to no correlation between the predicted and the actual energy use in the operations phase of the building (Lawrence, 2015). Axon et al. (2012) assert that this performance gap is most prevalent in non-residential buildings since the activities of the end-users may vary daily. This is attributed to the early design decisions made for the project, design complexities, building specification errors and usage scenarios that do not match the actual usage, together with poor commissioning and unfavourable interactions between the occupants and building technologies (Frei et al., 2017). The majority of the designers and contractors have shown little interest in learning from the building's actual performance and clients do not want to pay them to do so (Way and Bordass, 2005; Durosaiye et al., 2019). This lack of incentive for the design professionals is the main reason for their indifference to learning from the occupants. Consequently, this sparks conflict between the project parties with clients blaming the designers for the performance gap while the designers blame the occupants for not understanding how the building was modelled (Sharpe, 2019).

To narrow this performance gap and ensure smooth delivery of the buildings to its clients, the Building Services Research Information Association (BSRIA, 2021) developed the soft landings framework for the UK, which was later modified for Australia and New Zealand. The soft landings framework aims to deliver buildings that achieve a close match between the predictions of the design team and the expectations of the clients and end-users (Way and Bordass, 2005). The learning loop, which is defined as passing on knowledge to future projects to innovate better designs, is the most important element of the soft landings framework (Ahmed et al., 2021) in improving building performance through efficient handover. While the soft landings framework offers guidance for a smooth transition into the operations phase, it does not itemise the activities that should be completed nor does it provide a breakdown of the exact timelines within the project lifecycle in which these activities should be completed before the completion date. Further, previous publications on soft landings have mainly focused on the value of post-occupancy evaluations and aftercare and do not sufficiently emphasise the interactions between the various project stakeholders (Gana et al., 2018). This research, therefore, aims to build on the soft landings framework to address these gaps.

In summary, the handover phase has been known to present challenges worldwide (Schneider et al., 2016; Shirkavand et al., 2016) and impact negatively on project success (Dvir, 2005) and building performance (Way and Bordass, 2005; Lawrence, 2015). Despite the potential benefits of a smooth handover and post-handover, the majority of research in building construction focus on achieving greater efficiency in producing materials, constructing at low costs and more predictable delivery (Way and Bordass, 2005). With the increasing emphasis on the end-user requirements and a growing interest in improving the quality of the projects based on the customer's perspective, there is a requirement to transform the handover process (Kärnä et al., 2009). However, there is still a lack of an effective handover process that facilitates the collaboration between the delivery and asset management teams (Le et al., 2018). Providing a standardised route to handover will therefore facilitate project success through increased user value, reduced conflicts and improved overall building performance (Schneider et al., 2016).

## 3 Research methodology

### *3.1 Research design and sampling logic*

This study applied a qualitative approach that employed three case studies as the research strategy. Qualitative research explores the experience, as well as perceptions of respondents to the subject matter based on their real-life situations (Amaratunga et al., 2001) and the case study approach, in particular, was best suited for this study as it shed light on different issues (Flyvbjerg, 2006). Since projects have different characteristics, selecting a single case study to investigate the key issues experienced during the handover process would have raised concerns over generalisation, replicability and relevance (Yin, 2014; Martinsuo and Huemann, 2021). The evidence from the multiple cases is often considered more compelling as the findings are robust; allowing for generalisability (Yin, 2014). Three distinct case studies (refer to Table 1) were therefore purposively selected based on varying descriptions (for instance, construction/delivery period, usage of the building, client requirements and cost). Their selection was done in order to investigate diverse project handover issues and draw out similarities between different projects.

The three case studies were chosen because of three major reasons. First, they were delivered under the design-build procurement process. This was important as it allowed the research team to explore the challenges experienced by the different stakeholders (e.g., client, contractor and end-users). Second, they were major building projects with budgets ranging from £1million to £400 million. Major building projects were the focus of this study because they traditionally present challenges due to their scale and complexities. Lastly, they had contrasting characteristics in terms of cost, client requirements, usage and delivery period. This was particularly important to ensure that the outcomes and findings of this research can be replicated in different building projects.

**Table 1** Case studies description

| *Case study* | *Description* |
|---|---|
| Case study 1 | • This was a primary school construction project facilitated by a major City Council in England.<br>• £2 million project delivered within 5 months.<br>• The project was contracted to a multi-national company as the main contractor under the design-build delivery process.<br>• The supply and installation of certain equipment, e.g., lifts were subcontracted to other local companies.<br>• The client was the city council and the end-users were the school (i.e., teachers, students and parents). |
| Case study 2 | • A major renovation of a sports (cycling) facility facilitated by a major City Council in England.<br>• £1 million project delivered within 3 months.<br>• The project had special requirements (for instance, specialist contractors, specific construction materials) which resulted in a complex procurement process. The client was the city council and the end-users were the national cycling team and other cyclers who use the facility for recreation.<br>• The project needed to be completed within the time allocated in preparation for the elite team training. |
| Case study 3 | • This project is a £400+ million higher education investment project and one of the largest building construction projects in the UK.<br>• The project was delivered over 10 years.<br>• The client was the university's capital programs and the end-users are the occupants of the building. |

### *3.2 Data collection*

A reflective approach was adopted to examine how the handover procedures were implemented in each of the projects and to understand the challenges experienced by different delivery teams and end-users. The required qualitative data from the case studies were collected through semi-structured interviews conducted using open-ended questions to allow each participant to narrate their own unique experiences with the different projects. The interviews were supplemented with project reports, documents and industry reports [e.g., building the case for net-zero (UKGBC, 2020)]. Yin (2014) argues that such documents are useful in corroborating and augmenting evidence from other sources. The interviews were carried out with 16 participants from the three case studies who were selected using purposive sampling based on their profiles (Table 2). Purposive sampling was deemed appropriate as it helped to select a sample of participants that had the necessary knowledge and skill in the research area (Cattell et al., 2016; Samarakkody and Perera, 2021). The participant selection was based on:

1 their level of experience collected throughout their years working on different projects locally and internationally

2 their thorough understanding of the selected case study projects to provide the research team with relevant insights

3 their interest and knowledge on building performance

4 willingness to participate in two rounds of interviews.

Further, the interviewees were selected from the client, contractor and end-user to ensure greater diversity in thinking, provide a balance in the findings and certify that all the responsible parties for a smooth handover process were represented.

**Table 2** Participants' profiles

| *Case study #* | *Party* | *Designation* | *Years of experience* |
|---|---|---|---|
| Case study 1 | Client | Head of major projects | 22 |
| | Client | Construction project manager | 13 |
| | Client | Quantity surveyor | 15 |
| | Contractor | Senior project manager | 9 |
| | Contractor | Designer | 10 |
| | Contractor | Building main contractor | 11 |
| | Sub-contractor | Building sub-contractor | 9 |
| | End-user | Head teacher | 15 |
| Case study 2 | Client | Program manager | 12 |
| | Client | Senior project manager | 15 |
| | Client | Quantity surveyor | 20 |
| | Contractor | Project manager | 9 |
| | End-user | Facility manager | 10 |
| Case study 3 | Client | Sustainability manager | 9 |
| | Contractor | Project director | >20 |
| | Contractor | Building services engineer | 15 |

All the interviews lasted between one and two hours and were conducted using a common interview guide to ensure that the different interviews were guided by the same questions. This study conducted two rounds of expert interviews. In round one, the different experts provided their experiences delivering the case project they were involved in, focusing on the handover phase. The interviewees identified the challenges they had faced during project handover based on their experiences and provided a breakdown of the different elements and technical activities that were required to ensure a smooth handover process. At the end of the interviews, the experts were requested to provide realistic timelines in which these activities would be completed over the project lifecycle.

### *3.3 Data analysis*

The audio-recorded interviews from round one were first transcribed and analysed using Nvivo software. The interview data from each of the case study projects were then classified under three headings as follows:

1. gaps in the handover processes
2. opportunities to improve the handover process
3. the technical activities that need to be completed to ensure a smooth handover.

This exercise was conducted by moving back and forth between the interview data, project documents, industry reports and existing literature to make sense of the emerging findings and identify patterns in handover procedures (e.g., Nowell et al., 2017). The emerging technical activities were each linked to a project lifecycle phase (that is, initiation, planning, delivery, closure, initial aftercare and extended aftercare). For instance, the quote "the handover plan is first drafted jointly by all the relevant stakeholders based on lessons learnt from previous projects" [Construction Project Manager, Case study 1] was linked to the project initiation phase. This process was done iteratively, moving back and forth through each of the technical activities and linking them to the project lifecycle phases. Saturation was achieved when no further handover activity emerged from the analysis. Specific criteria adapted from Yin (2014) were applied to ensure the reliability and validity of our findings (refer to Table 3).

**Table 3** Criteria for judging research credibility

| *Test* | *Tactic* | *Implementation* |
|---|---|---|
| Construct validity | • Use multiple sources of evidence<br>• Establish chain of evidence<br>• Key informants review draft case study report | • Evidence was collected from three different case studies and 16 different participants.<br>• Additional evidence was obtained from multiple project and industry reports.<br>• The case study descriptions have been provided based on all the sources of information.<br>• Original materials derived from the interview transcripts and industry reports have been referenced in the paper.<br>• A second round of interviews was conducted with the participants to review the findings. |
| Internal validity | • Pattern matching<br>• Explanation building | • The findings from interview transcripts and reports were analysed to identify patterns between the various projects.<br>• The findings from existing literature were used to explain emerging findings. |

**Table 3** Criteria for judging research credibility (continued)

| *Test* | *Tactic* | *Implementation* |
|---|---|---|
| External validity | • Replication logic | • Three different case studies were selected for analysis to ensure that the findings would be generalizable to other major building projects. |
| Reliability | • Use case study protocol<br>• Develop case study database | • A case study protocol that contained the data collection procedures and interview questions was developed.<br>• A database was created for each of the case study projects to store data from primary and secondary sources. |

All the technical activities identified from the empirical data and secondary sources were mapped onto the project lifecycle, creating the route to handover framework. A second round of interviews was then conducted and the participants were requested to analyse the proposed framework and provide recommendations for improvement based on their expertise. These interviews focused on the timelines of each identified activity and the roles and responsibilities of each party. The findings from these interviews were then used to modify the framework to reflect the findings from the client, contractor and end-users.

## 4 Findings

The findings presented in this section are based on the views of the project managers from both the client and contractor side, designers, builders and end-users of the three case studies. Both cases 1 and 2 were facilitated by a major city council in England but run under different programs of work and project teams. Therefore, the experiences of the project participants in delivering these two projects were collected and presented separately while providing relevant examples where necessary.

### *4.1 Gaps in the handover process*

#### *4.1.1 Case study 1*

The findings revealed that, though the contractor typically had their internal handover processes, it was up to the project managers to thoroughly plan for handover, which was often carried out in a rushed and disorganised manner. During the handover of the school project to the end-users, "nothing was dictated or structured. To be honest, it was rushed." [Construction Project Manager, Client]. Further, the end-users were involved only a few days before the handover. It is at this point that they were given all the necessary handover documents, from schematic drawings, mechanical, electrical, and plumbing data and warranties as well as training. The headteacher (end-user), who also doubled as the facility manager, noted that: "on the day of handover, I received a bunch of documents stored in a box." They were however unable to identify the documents that they received. It is therefore highly likely that they experienced challenges filtering out the relevant documentation that they required for the operational phase; illustrating the 'tsunami of information' explained in the literature review.

The headteacher pointed out that a few weeks after handover, "we had issues with the lift and had the fire brigade come over a couple of times because staff and students were stuck in there and could not locate where the isolation switch was. Trying to find the information of who the contractor was for the lift, and who could get us out, was a nightmare." Based on these findings, it was evident that the gradual training of end-users/ occupants on the operation and maintenance (O&M) procedures was overlooked. Giving data and information to the end-users/occupants at the completion date does not necessarily translate to knowledge transfer. Therefore, knowledge transfer to end-users should be staggered, and gradually introduced to them for a smooth transition into the operations phase.

### *4.1.2 Case study 2*

The senior project manager (client) noted that "we have a 15-day route to contract process but do not have a structured plan for handover. We just follow a schedule of requirements, which is quite deficient." This lack of a structured process for handing over projects led to delays in the delivery and handover of the project to the end-users as stated by the project manager viz: "we had a lot of pressure trying to make some considerations for both the cycling and cheerleading teams who had to use the space for a competition" [project manager, contractor]. It is therefore critical to start planning for handover from the project initiation phase and the clients/ end-users engaged throughout the delivery phase of the project while being updated on the progress and shortcomings. Furthermore, client and end-user engagement should be prioritised during this phase making sure that they are always updated on shortcomings and defects to prevent severe delays during the handover period. This close collaboration will ensure risks are better accepted, avoided, and mitigated, preventing minor risks from escalating into major risks, and increasing the likelihood of realising the project benefits.

Sharing lessons learnt and obtaining feedback from the experience is a crucial part of the handover process. The program manager (client) noted lessons were identified at the end of the project. However, "just because lessons were identified, it does not mean that they were learnt. Lessons are only learnt if they are directly applied in future projects." Communication, collaboration and sharing of lessons identified between the relevant stakeholders from the initiation stage till project handover will therefore ensure that mistakes are avoided and the successes during project delivery and handover phases are implemented in current and future projects.

### *4.1.3 Case study 3*

The entire project lifecycle from initiation to handover spanned over ten years. Therefore, a lot of retrospective thinking on the environmental targets of the project went into the final stages of the delivery and handover. Since technology changes rapidly, the sustainability manager (client) acknowledged that "some of the net-zero targets set out for the project in 2012 might not seem as ambitious now. Technologies and knowledge have changed a lot since then and there is a different kind of policy landscape." Therefore, to achieve the environmental targets, "it is no longer sufficient to rely on business-as-usual approaches and siloed thinking among different delivery teams" [project director, contractor]. Sharing knowledge will create opportunities for the different stakeholders to collaborate in creating opportunities for achieving the net-zero targets during handover and into the operations phase.

For a successful handover, post-occupancy should be considered since "it is not just about measuring your carbon impacts during delivery, but also how do you maintain and operate? We have to set up post-occupancy evaluations so we can continue to monitor if we hit our targets during the operational phase." However, one of the key challenges identified is that clients and contractors commit to the post-occupancy evaluation only for compliance purposes (i.e., BREEAM to achieve credits at the design and construction phases). However, it is not implemented and is often cut out to save money. Post-occupancy evaluation and aftercare requirements should therefore be embedded into the contracts during the procurement process to ensure a smooth transition from construction to operation and measure the performance of the building to guarantee the achievement of targets and end-user satisfaction.

### *4.2 Opportunities to improve the handover process*

The participants from each of the three case study projects identified various improvement opportunities that could facilitate a smooth transition from the construction to the operations phase. These opportunities are based on best practices and lessons learnt from delivering each of the projects. The findings from each of the case studies have been mapped and linked to the different project lifecycle phases in Table 4. While the three cases had different characteristics, it is worth noting that there were similarities in the findings. In effect, these opportunities apply to various building projects and should be tailored to meet the individual project requirements.

### *4.3 The proposed route to handover process*

The proposed route to handover is a framework that leverages best practices to provide a consistent and replicable approach for handing over projects. It emphasises the progressive staging of the technical activities through 'mini-handovers' while providing a holistic view of the diverse needs and requirements of the project manager, designers, builders/contractors/sub-contractors and end-user/client. The technical activities that need to be completed to ensure a smooth handover process are detailed and broken down into the lifecycle stages in line with the project lifecycle stages provided by Ward and Chapman (1995) and Fernandes et al. (2021) viz:

1 project initiation (A1–A5)

2 planning (A6–A8)

3 delivery (A9–A30)

4 closure (A31–A34).

Based on the emerging findings to include post-occupancy evaluation in the handover process, initial aftercare (A35–A40) and extended aftercare (A41–A47) were further incorporated as per the soft landings framework presented by BSRIA (2021). All the phases are sequential with mini handover activities and information flows, following the traditional design-build project delivery method and timelines given with respect to the completion date (i.e., T-12 weeks meaning 12 weeks to the completion date).

**Table 4** Opportunities to improve the handover process

| *Project lifecycle phase* | *Case study 1* | *Case study 2* | *Case study 3* |
|---|---|---|---|
| Initiation | • The activities to be completed during handover should begin at day zero of the project.<br>• The lessons learnt in this phase of the project should be shared during the stage review. | • Planning for handover should begin at the initiation phase of the project.<br>• The project team should agree on the roles and responsibilities to be implemented throughout the handover process. | • The project targets (e.g., net-zero targets) should be defined at the beginning of the project.<br>• The key criteria against which the project will be evaluated should be defined. |
| Planning | • A stage review should be conducted at the end of this phase to ensure that the project is on track to meet its targets. | • The potential users of the building should be involved in the design process to address any issues. This will help in addressing performance gap issues. | • Monitor the building design against the identified targets. |
| Delivery | • The existing project team members should share knowledge with any new team members.<br>• The building contractor/sub-contractor should start drafting the end-users/client training plan and demonstration materials at least 3 months before the completion date.<br>• Gradual training of the end-users/clients should be conducted and the trainer should verify that the trainee (s) have fully understood how to use the equipment, e.g., lifts, fire escape.<br>• The trainer should obtain feedback from the trainee (s) after the first training session and use the feedback to improve the delivery of the refresher training.<br>• The O&M procedures and handover documents should be gradually handed over to the facilities team. | • The roles and responsibilities assigned in the initiation phase should be reviewed periodically as the project team grows.<br>• The client should regularly inspect the deliverables in order to determine any defects and agree on the rectification fixes.<br>• A refresher training of the end-users/ client should be conducted at least one month before handover. | • The facilities management team should be involved in reviewing the installed systems so as to bridge the knowledge gap between the delivery and operations teams.<br>• Track the project's targets against the project teams' responsibilities. |
| Closure | • The project team should hand over the acceptance documents at the project's handover date. | • The delivery team should organise a completion meeting where all remaining project documents are handed over to the client. | • A customer satisfaction survey should be completed to obtain information on the handover process in order to improve future delivery.<br>• Re-evaluate the project targets set out in the initiation phase. |
| Initial aftercare | • A member of the delivery team should be on-site to deal with any complaints and queries from the end-users.<br>• A user satisfaction survey should be completed at the end of the first year after the handover date. | • The contractor/sub-contractor should complete any repair works within the first year after the handover date. | • Review the building's performance against the re-evaluated targets. |
| Extended aftercare | • Another user satisfaction survey should be conducted within the first three years after practical completion to determine the level of user satisfaction.<br>• The contractor/sub-contractor should complete any latent defects and conduct a closeout review with the client. | • The project team should handover the final testing certificates 12 months after the handover date.<br>• Lessons learnt should be shared within the project team to improve delivery of future projects. | • Post-occupancy evaluation and aftercare to ensure smooth transition into the operations phase<br>• Periodic review of the building's performance. |

### *4.3.1 Project initiation [A1-A5]*

Since handover is a process and not a date, the activities that need to be completed for this phase begin at day zero of the project. Therefore, the project team should commence the handover process immediately after the project kicks off. "The handover plan is first drafted jointly by all the relevant stakeholders based on lessons learnt from previous projects [A1]." [construction project manager, case study 1]. This handover plan brings the client/end-users, designers, construction and operations teams together early on to agree on the key deliverables that will meet the client's requirements, "agree on the roles and responsibilities [A2], the timing of the transfer from the construction to operation team" [A3] [senior project manager, case study 2] and jointly define the key performance indicators (KPIs) that will be monitored throughout the project.

Since all new building projects need to have a net-zero target by 2030 as required by the World Green Building Council (Laski and Burrows, 2017), "this stage is also critical for defining the net-zero targets [A4] of the building. This can be done by reviewing similar building projects to understand how to improve infrastructure delivery, building fabric performance and drive energy efficiency" [project director, case study 3]. In particular, the project should target reducing both operational and embodied energy by exploring low-energy options. Doing this at initiation provides an opportunity for the clients and project delivery team to bring to the fore the key criteria that should be considered to ensure that the net-zero targets are prioritised and aligned to the project deliverables.

At the end of this, a stage review [A5], which also involves collating the lessons learnt, is conducted to ensure that the project will be on track to deliver an end-product that is fit for purpose and meets performance criteria.

### *4.3.2 Planning [A6–A8]*

At this stage, the client, together with the design team monitor the design against the stipulated targets [A6] while tracking all the design assumptions and estimates made. It is also critical that the design is reviewed by the potential occupiers [A7] of the building as this may provide opportunities to renew and address any issues that may emerge regarding the occupiers' expectations and comfort. In terms of the net-zero targets, "the design of the project should be focused on the net-zero carbon outcome, reviewing various sustainability options and taking care not to 'value engineer' and compromise the vision" [UKGBC, (2020), p.57]. A second stage review [A8] is therefore conducted to ensure that the likely performance of the designed end product will meet the expectations of the occupiers and the stipulated environmental targets.

### *4.3.3 Delivery [A9–A30]*

As the project commences into the construction phase, there may be new members joining the team. Therefore, "knowledge sharing between the existing and new project team members should be encouraged while also reviewing the roles and responsibilities for the new joiners" [A9] [construction project manager, case study 1]. For instance, the facilities management team should be brought on board to review the heating, ventilation and air conditioning (HVAC) systems to bridge the knowledge gap between the delivery and operations teams. This will also facilitate a sustainable approach to maintenance and operations. In addition, the agreed net-zero metrics are continuously "tracked against each individual's responsibilities [A10] ensuring that they are in line with the net-zero commitments and obligations" [sustainability manager, case study 3].

At this point, the technical activities that need to be completed in preparation for the actual completion date need to be actualised. The findings from empirical data show that these activities should be staged from three months to the actual completion date (i.e. 12 weeks to the project completion date), starting from the drafting of the end-user/ client training plan by the building contractor/ sub-contractor [A11] and preparation of training materials such as videos and demonstrations [A12]. At 7 weeks to the completion date, there needs to be greater involvement by all the key stakeholders to support the operational readiness of the project. "The client should be on-site to inspect deliverables [A13], determine defects [A14] and agree on rectification fixes and tweaks" [A15] [program manager, case study 2]. These regular reviews during the construction phase ensure collaboration between the relevant stakeholders and discussion on real-time issues, enabling the right solutions to be identified that will achieve both net-zero commitments and client requirements. The building contractor/sub-contractor also drafts copies of the operations manuals including health and safety files and manufacturers' maintenance recommendations [A16].

Training is a crucial element during handover as it ensures the end-users can maximise the benefits of the project and narrow the gap between the predicted and actual building performance as discussed in the literature review. The findings of this research highlight that training should include three basic steps:

1 the trainer demonstrates knowledge and procedures to the trainee

2 the trainee is given time and space to familiarise themselves with the materials

3 the trainee is tested by the trainer to validate their understanding and knowledge.

This, therefore, implies that "training is only complete and efficient if the trainee (end users/ clients) can validate their knowledge and understanding of the O&M procedures to the trainer" (builder/contractor) [head of major projects, case study 1]. Consequently, proper training ensures that the end-user/ client involvement in the handover process is phased in and not rushed or crammed up at the end of the project delivery phase as is currently the practice. Therefore, 6 weeks to the completion date, "the contractor conducts the first training session [A17] and obtains feedback from the trainees [A18] on the quality of the materials" [senior project manager, case study 1]. Thereafter at 5 weeks to the completion date, the contractor/ sub-contractor goes through the training demonstrated in A17 with the end-user/ client to 'test' their level of understanding [A19]. Based on the client's feedback, the contractor makes the necessary changes to the training materials [A20] in preparation for the refresher training session.

At 4 weeks to the completion date, the contractor hands over the copies of the operations manuals [A21] that were drafted in A16 and the client evaluates all the handover documents to guarantee completeness and accuracy [A22]. Additionally, they conduct "a refresher training [A23] based on the feedback obtained" [program manager, case study 2] while finalising the demonstration of the building operations and maintenance (O&M). Thereafter, the final training materials and documentation are handed over to the end-user/client [A24]. The contractor, together with the client examine the progress made on rectification fixes and tweaks agreed on at A15 and update the handover plan if needed [A25]. At 2 weeks to the completion date, these rectification fixes and tweaks should be completed by the contractor [A26] before the final tour of inspection [A27] by all the relevant stakeholders, and handing over all the required documents [A28]. Further, the delivery team should "review the HVAC systems with the facility management team [A29] and also embed the net-zero targets into the maintenance contracts [A30] if outsourcing the facility management team" [project director, case study 3]. This will ensure that the targets agreed upon in the planning phase are fed into the operations and maintenance phases of the project.

### *4.3.4 Closure [A31–A34]*

A "completion meeting [A31] is organised for all the relevant stakeholders" [senior project manager, case study 2] at the actual completion date. At this stage, the handover acceptance documents including the certificate of completion are signed [A32] and the customer satisfaction survey completed [A33]. For major building projects, the entire project lifecycle from planning, design to construction involves various stakeholders and could span over several years. For instance, Case study 3 spanned over 10 years and because of the technological changes that were experienced in more than a decade, the project team needed to re-evaluate the strategies for achieving the set out net-zero requirements [A34] in the as-built design.

### *4.3.5 Initial aftercare [A35–A40]*

While conventional handover practices stop at the 'handover date' (practical completion), there is a need to extend this into the use phase to deal with any defects and review the building performance to ensure that the building performs optimally and its net-zero targets are achieved. Immediately after the completion date, the building contractor/sub-contractor should plan the repair works that need to be completed during the defects liability period [A35]. Further, within the first six to 12 months after the completion date, a representative from the delivery team should be on-site to pass knowledge to the occupants [A36] and deal with any problems, complaints or queries [A37]. This reduces the frustrations and tensions that are often experienced during initial occupancy. Additionally, "the building's energy performance and emissions are reviewed to ensure that the building is on track to achieve its net-zero targets [A38]" [Sustainability manager, Case study 3], the facility management team evaluates whether the occupants understand the operation of the building [A39] and a user satisfaction survey is completed [A40].

### *4.3.6 Extended aftercare [A41–A47]*

At the end of the first year (12 months after practical completion), the final testing certificates for the building should be issued [A41] and a post-occupancy evaluation conducted within the first three years after the completion date. This is a retrospective process in the handover process to understand the areas where the building falls short in terms of expectations by periodically monitoring and evaluating its performance [A42]. The data is captured continuously using surveys, questionnaires and technical monitoring to adjust the services and systems for the building [A43] and work towards closing the performance gap. "Learning from how the building is performing in its operational phase and using the evaluation data to fine-tune the systems to perform better allows for the continuous improvement of the end-product and the realisation of benefits from the project" [head of major projects, case study 1]. Further, all latent defects are also completed [A44], a final closeout review is conducted [A45], feedback is obtained from the users on the building's performance and their level of satisfaction [A46] and the project team convenes to discuss the lessons learnt from delivering the project [A47].

## 5 Discussion

This research effort sought to examine the challenges experienced during project handover to detail the project handover procedures that will ensure client satisfaction and guide towards the delivery of project benefits. Three case studies examined revealed the inefficiencies in the current handover practice which consider handover as a specific date where ownership of the project is transferred to the client (Lester, 2017). This results in a rushed process with little to no training of end-users/occupants resulting in frustration and complaints during the operation phase. Additionally, the client/ end-users/facility management team are often provided with all the relevant documentation at the close of the project, which overwhelms them and makes it difficult to sort through valuable and invaluable information. Handover should therefore be planned for from the initiation phase and viewed as a process and not a particular date in the project lifecycle (Anthony, 2017).

The findings further revealed that the initial occupancy period after the completion date is critical as the designers' and builders' input can be fed forward for the benefit of the occupants and the client; ensuring that the intended benefits are realised. Moreover, a lot can be learnt about the building's performance, user satisfaction and comfort during this period and fed back into future projects to improve performance. However, this post-handover stage is frequently neglected and considered a distraction and a nuisance (Way and Bordass, 2005). Building designers and builders normally leave the project after completion, missing the opportunity to observe the building's performance and creating the building performance gap (Fadeyi, 2017) discussed. To address this, the handover process needs to extend beyond the practical completion date. Following the official project completion date, the measurement of impacts will be continued by the facility team with the assistance of the project management team. This is in line with Mochal and Krasnoff (2013) idea of having a project management office to continue the process of gathering performance data and assessing occupants' behaviour in the initial phases of occupation. Post-occupancy evaluation should therefore be included in the contractual agreements as part of the handover process as a system of measuring the performance of the building based on data gathered from social, environmental and energy monitoring (Kansara and Ridley, 2012).

### *5.1 Theoretical implications*

While the handover phase is a critical stage between the construction and operation phases, literature does not provide a critical examination of all the technical activities that need to be accomplished to deliver benefits to the users and achieve the targeted environmental performance of the building. A standardised project handover process for major building construction projects is therefore proposed based on the findings of semi-structured interviews with the key project stakeholders involved in delivering three different case study projects. The process details 47 technical activities that need to be completed for a smooth handover process and provides a breakdown of the timelines that each activity should be completed before and after the completion date.

This study contributes to the project management body of knowledge as well as building performance measurement by providing new insights for a smooth transition from the construction phase to operations so as to achieve the building performance targets. The standardised approach to project handover adds value by encouraging a review of the net-zero targets at the point of design, construction, handover and post-handover as a catalyst for achieving the environmental performance of the building sector. It also provides 'forward-looking' handover procedures that embrace early collaboration between the designers, users and the client in order to co-create the end product; prioritising the client requirements and end-user needs throughout the project lifecycle.

### *5.2 Practical implications*

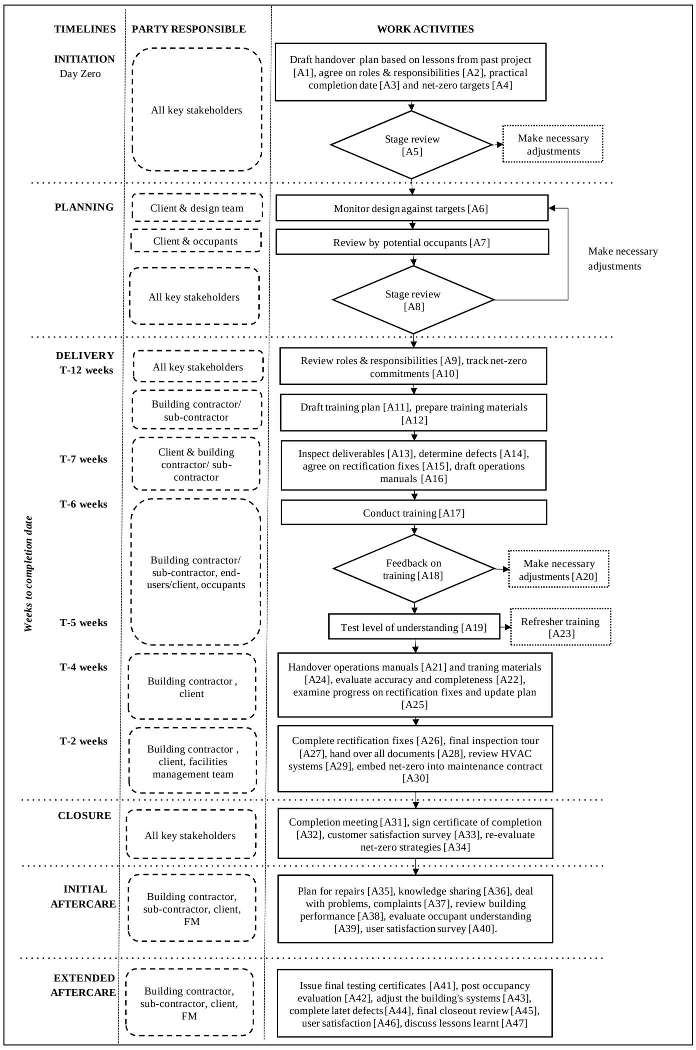
The proposed route to handover process stresses the measurement of performance during the project handover and post-handover; a practice that is currently overlooked within project handover. While contractors may perceive the cost of post-occupancy evaluation to be high, it can be balanced against the gains from less rework and snagging revisits, client satisfaction, references to other clients and lessons learnt to improve future projects (Way and Bordass, 2005). The findings of this research effort will therefore guide both practitioners and researchers to facilitate the effective handover procedures that will eliminate project handover challenges. Further, the output of this study could provide evidence to policymakers to initiate policies that will ensure buildings deliver on their net-zero targets.

Although this study highlights the gaps in the current handover procedures and provides a solution for the inefficiencies during handover based on stakeholder input, it is impractical to conclude that the proposed process is a one-size-fits-all handover process. Projects are unique in nature, scale and complexity, thus, different projects and schemes have different checklists, which in turn may require a different range of stakeholder engagement. Further, the technical activities will vary according to the type of project and the contractual agreements in place. Project management teams should, therefore, use this process as the basis for handover planning and tailor the steps to suit their project needs.

## 6 Conclusions

This research effort has examined the various challenges experienced by clients, contractors and end-users during project handover. An extensive study across three different case study projects was carried out, building on rich datasets collected from interviewing key stakeholders and examining project reports, documents and industry reports. This study found that the handover process is often rushed, leaving the end-users/client overwhelmed as they sort through a pile of information post-handover. The knowledge transfer from the delivery team to the operations team should therefore be staggered through 'mini-handovers' to avoid the 'tsunami of information' phenomenon. Further, there is a need to extend this phased handover process into the operations phase to include the initial and extended aftercare. This will ensure that the project's targets are tracked and achieved, the user's complaints and queries are sufficiently addressed and the project delivers on its benefits.

**Figure 2** Standardised route to project handover




*Source:* Authors

This research extends prior studies on building performance measurement by presenting a replicable handover process that focuses on proper planning, gradual handover of project-related information, client engagement throughout the project lifecycle, effective training of end-users and, measurement of performance during handover and post-handover to increase the likelihood of benefits realisation from the project deliverables. Based on empirical data, this study presents 47 technical activities (Figure 2) that need to be completed before and after the practical completion date to ensure a smooth transition from the construction to the operations phase of the project. Additionally, incorporating the structured approach to project handover will contribute towards achieving the building net-zero targets by helping to close the performance gap and reduce the carbon emissions associated with the extra energy use and consumption in the operations phase.

### *6.1 Limitations and future research*

While this study sheds light on the key technical activities for a smooth handover, it has the following limitations that may provide direction for future research. First, although we identify the process for the effective handover of building projects, future studies should examine the practical implication of this standardised process on on-going projects and quantify the impact on performance and user satisfaction. Second, this route to handover process is tailor-made for major building projects. Future research could therefore explore the applicability of the process in other infrastructure projects such as road and rail construction.

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