TECHOLOGIES FOR SUSTAINABLE BUILT ENVIRONMENTS CENTRE

Investigation and analysis of new-build housing defects during the initial ten years after occupation: a learning perspective

BY

TONY HOPKIN

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Dedication

To my wife Gemma for her continuous support and encouragement.

“Just keep going; you’re nearly there”

Abstract

Rapid growth in the production of new homes in the United Kingdom (UK) is putting build quality under pressure as evidenced by the increase in the number of defects. Housing associations (HAs) contribute 21% to the UK's annual supply of new homes. HAs are experiencing the challenge of government funding cuts and rental revenue reductions. Maximising the benefit of learning from defects is recognised as being a key opportunity for HAs to help address these challenges. Learning from defects is argued as a means of reducing the persistent defect problem within UK house building, yet how HAs learn from defects is under-researched. There is also a lack of research exploring which impacts of defects are perceived as important by the key stakeholders, which has caused confusion over which types of defect HAs should focus their learning on. The aim of this research was to better understand how UK HAs, in practice, learn from past defects to reduce the prevalence of defects in future new homes. The theoretical lens for this research was organisational learning (OL).

An action research approach consisting of diagnosis, action planning, action taking, action evaluation and specifying learning was adopted. Further, the principles of soft systems methodology were incorporated in the action planning phase in order to explore an ill-structured real world problem to identify desirable and feasible changes (action interventions) within a HA. Data collection consisted of questionnaires, semi-structured interviews, a focus group and organisational documents. Data analysis techniques included thematic analysis and simple statistical analysis.

The key findings suggested that OL can potentially reduce defects and revealed that the health and safety implications and home occupant disruption caused by defects are the priorities. OL in HAs appeared to be viewed as a secondary task which consisted of a defects management team capturing and analysing defect data to identify improvement opportunities, with a primary focus on designing out the identified defects. Opportunities for data analysis fluctuated with workload. The use of live data analysis protected against workload spikes. The key findings further enabled the development of a specific OL from defects model for HAs. The findings revealed the importance of a dual approach to learning consisting of a codification

approach of designing out defects combined with a personalisation approach of networking to tackle workmanship and other defects that can’t be designed out. The practical challenges of AR were highlighted when the interventions were abandoned due to changes in key personnel, despite the changes of a live data dashboard being shown to be beneficial after implementation.

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Declaration

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

Tony Hopkin

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List of abbreviations

AI: Action Intervention

APPG: All Party Parliamentary Group

AR: Action Research

ASAP: As Soon as Possible

BI: Building Inspector

BRE: Building Research Establishment

CCTV: Close Circuit Television

CIH: Chartered Institute of Housing

DPC: Damp Proof Course

EngD: Engineering Doctorate

ERs: Employers' Requirements

FOS: Financial Ombudsman Service

H&S: Health and Safety

HA: Housing Association

HB: House Builder

HBF: Home Builders Federation

HO: Home Occupant

ICE: Institute of Civil Engineers

IT: Information Technology

JCT: Joint Contracts Tribunal

KPI: Key Performance Indicator

LABC: Local Authority Building Control

MDIS: MD Insurance Services

MVHR: Mechanical Ventilation and Heat Recovery

NAO: National Audit Office

NEC: National Engineering and Construction

NHBC: National House Building Council

NHF: National Housing Federation

NSH: Night Storage Heaters

OFT: Office of Fair Trading

OL: Organisational Learning

OM: Organisational Memory

POE: Post Occupancy Evaluation

SSM: Soft Systems Methodology

UK: United Kingdom

UPRN: Unique Property Reference Number

WP: Warranty Provider

List of publications

Peer Reviewed Journal Papers

Hopkin, T, Lu, S, Rogers, P, and Sexton, M. (under preparation) *'Learning from defects in a housing association: an action research approach*. Building Research and Information.

Hopkin, T, Lu, S, Rogers, P, and Sexton, M. (2017) *'Key Stakeholders Perspectives towards New Housing Defects'*. International Journal of Building Pathology and Adaptation. **35**(2), 101-123.

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Hopkin, T, Lu, S, Rogers, P and Sexton, M.(2016). *'Reducing Defects through Organizational Learning within a Housing Association Environment'*, World Academy of Science, Engineering and Technology, International Science Index 112, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering, **10**(4), 294-301.

Peer Reviewed Conference Papers

Hopkin, T, Lu, S, Rogers, P and Sexton, M (2016) A Soft Systems Methodology Approach to the Improvement of a Housing Association's Defects Management and Learning Systems. *In: P W Chan and C J Neilson (Eds.) Proceedings of the 32nd Annual ARCOM Conference, 5-7 September 2016, Manchester, UK, Association of Researchers in Construction Management*, 1283-1292.

Hopkin, T, Lu, S, Rogers, P and Sexton, M (2015) Detecting defects in the UK new-build housing sector: a learning perspective *In: Raiden, A B and Aboagye-Nimo, E (Eds) Procs 31st Annual ARCOM Conference, 7-9 September 2015, Lincoln, UK, Association of Researchers in Construction Management,* 1073-1082.

Hopkin, T, Lu, S, Rogers, P and Sexton, M (2015) Investigating the impact of defects on key stakeholders in the UK new housing sector. *"5th International/11th Construction Speciality Conference" 8-10 June, Vancouver, Canada*, 035:1-10.

Hopkin, T, Lu, S, Rogers, P and Sexton, M (2014) Placing defects at the heart of high quality new homes: the learning perspective *In: Raiden, A B and Aboagye-Nimo, E (Eds) Procs 30th Annual ARCOM Conference, 1-3 September 2014, Portsmouth, UK, Association of Researchers in Construction Management,* 1155-1164.

1 Introduction

This chapter introduces the research background, the core research problem, research aim and objectives, justification for the research, the theoretical position of the research, an overview of the research methodology; and, a synopsis of each chapter.

1.1 Background to the research

In the United Kingdom (UK) there is a housing shortage (e.g. Lang *et al.*, 2016). This housing shortage is due to successive governments failing to meet their housing supply targets (Parliament, 2015). As a consequence, UK house prices have increased, families are living in overcrowded conditions; and, homelessness and rough sleeping have increased (Shelter, 2016). The UK's housing shortage is becoming progressively worse because there is also a considerable shortfall in the number of dwellings being constructed in comparison to demand (Wilcox and Perry, 2013). The UK house building sector is under pressure to deliver upwards of 240,000 new homes per year to meet demand and reduce the housing shortage (Holmans, 2013), a housing output increase of over 40% when compared to 2015 levels (DCLG, 2016). In order to satisfy the increased demand, the UK Government has introduced a number of new-build focussed policies and incentives to increase the housing supply (HM Government, 2011). For example, the Get Britain Building Investment Fund is designed to enable house builders to progress housing development sites that have stalled, have not started or are classified as being on hold (DCLG, 2014).

In addition to the pressure to grow housing supply, under the Climate Change Act (UK Government, 2008) the UK has set a 2050 target to achieve carbon emissions reductions of 80% compared to 1990 levels. The carbon emissions reduction agenda has resulted in the introduction of tougher planning and guidance to the Building Regulations, including changes to part L 'Conservation of Fuel and Power' (DCLG, 2013a).

The house building sector has responded to the dual pressures by significantly up-scaling supply, with a 78% increase in new housing starts for the year 2015-16 compared to the 2008 economic downturn (DCLG, 2016); and, incorporating new technical solutions into new-build houses to meet the tougher regulatory requirements (NHBC Foundation, 2012). Whilst responding to these pressures, the sector is reporting materials, skills and workforce shortages following the 2008 economic downturn. The reported shortages are causing concerns within the industry over future housing quality (e.g. UKCES, 2012; HBS, 2013).

In the UK new-build housing industry, the up-scaling of production with the incorporation of new technical solutions to meet new regulatory requirements has been of research interest. The significant emphasis of research focuses on the new technical solutions (material artefact) itself: how it performs, the demands of the system when integrated, and the micro-economics of the system (e.g. Bevan and Lu, 2012). The potentiality of the new technologies is of particular interest. Hinnells (2008), for example, identifies a number of potential new technologies (including fabric measures and micro-generation) to achieve reductions in energy demand. Sodagar *et al*. (2011), for instance, recommend that straw bale construction is a viable option to reduce carbon emissions.

A review of new-build housing sector literature finds authors concentrating on the 'upstream' implications for house builders of the new ramping up of production whilst delivering against a new set of regulations. The extant literature, though, gives scant consideration to potential 'downstream' implications, namely build quality and defects. The upstream and downstream implications are discussed below.

1.1.1 Upstream implications for business model and standardised design template

A number of commentators have highlighted the upstream implications of new technical solutions for house builders' business models and standardised design templates (e.g. Lees and Sexton, 2014; Pan, 2010). Standardised design templates are defined as *"the design and production plans and practices which, through constant repetition from development to development, permit house builders to meet* *the various market and regulatory requirements as economically as possible"* (Lees and Sexton, 2014: 277). Lees and Sexton (2014) indicate that the rationale for the choices of new technical solutions by house builders is to minimise the disruption to their standard design templates. Sodagar *et al*. (2011) highlight the lack of material availability and pressures on suppliers as part of the minimisation of disruption logic pursued by housing builders.

1.1.2 Downstream implication for build quality and defects

The importance of potential 'downstream' implications of the ramping up of supply and the introduction of new technologies for build quality and defects is less prominent in the literature, but strands are to be found and are growing in volume and influence. There is increasing evidence that the inclusion of new technologies can and does adversely impact new-home quality; both in the material sense of the home itself and in the well-being of occupants. Yao and Yu (2012), for example, raise concerns of the risk of overheating in low-energy homes with high thermal performance and airtightness characteristics. While Osmani and O'Rielly (2009) report builders' concerns about micro-renewables bolted on to properties, following several instances where damage has occurred after installation. Gill *et al*. (2010) drill further down on the types of defects in the low-energy homes they surveyed. These defects include numerous leaks to rainwater harvesting systems and the failure of a biomass district heating system.

There has been even less focus on the potential effects that ramping up housing supply will have on the new-build housing sector in general. The house building industry is said to be particularly prone to the cyclical cycle of boom and bust (Eurostat, 2010). It is often argued that in periods of housing market boom, build quality is reduced as delivery dates tighten and materials/workforce capacity becomes stretched (e.g. Sommerville *et al*., 2004). The build quality question is especially salient and raises a potential pressure for site management. In addition to quality being neglected, other pressures exist at the site management level and beyond, evidenced by the house building sector currently reporting materials, skills and workforce shortages (e.g. HBS, 2013; UKES, 2012).

When the issues of skills, materials and workforce shortages caused by the rapid increase in production are coupled with the additional requirement to introduce new technical solutions into new homes to conform to tougher regulations, a number of potential downstream implications for suppliers, site management, trades, and general build quality may arise causing an increase in defects. Indicative evidence of build quality reduction and an increase in the number of new housing defects can be found in the Home Builders Federation (HBF) survey, for example, which shows that in 2017 98% of home owners reported defects within their new-build house, the highest this figure has been since 2010; and, 69% of home owners reported over five defects in their new-build house, an increase of 10% compared to 2015 (HBF, 2017). Further, new house quality is becoming an area of increasing interest. For example, the All Party Parliamentary Group (APPG, 2016) undertook an investigation into the levels of quality and workmanship in new homes and concluded that the levels of workmanship in new homes are unacceptable and reducing defects should be a priority for the UK house building industry.

The argument to this point is that new housing defects are an important area of research focus. What has become clear from the review of literature surrounding the challenges facing the UK new-build housing sector (i.e. increase of supply and regulatory change) is a primary focus on the potential upstream implications this has for the house builder. The literature regarding the new-build sector's challenges has not focused on the potential downstream implications of the ramping up of supply and the introduction of new technologies for build quality and defects. Defects are a current problem in new homes. However, as the UK house building industry increases volumes to contribute to reducing the housing shortage and achieving government production targets, there is potential for quality to suffer further (evident in the increase in defects over the previous few years of recovery and production increase since 2008). The current problem of defects in new homes and the potential for that problem to become worse makes research into defects and reducing them an important area.

Housing associations (HAs) contributed circa 21% of the UK’s supply of new housing in 2015 (DCLG, 2016) and supply the majority of the UK’s affordable housing. Affordable housing is crucial to the UK Government’s housing targets. For example, the UK Government has a long-term target of commencing construction on 400,000 affordable homes between 2015 and 2020 (HM Treasury, 2015). This housing output would be an increase of nearly 300% compared to the preceding five years (DCLG, 2015). In addition to the pressures of tougher regulation and the need to increase housing supply HAs are under additional funding pressures. In recent years HAs have experienced a decline in funding from the UK Government (KPMG and Shelter, 2014). To exacerbate the situation of declining funding, from April 2016 HAs are also required to reduce social housing rents by one per cent each year for the subsequent four years (HM Treasury, 2015). HAs are not-for-profit organisations that can use any profit they make from rental income and the sale of homes to maintain existing homes and help finance new ones; and are typically financially regulated and funded by the Government (NAO, 2005). The reduction in central government funding has in some cases made HAs cautious in planning new developments (KPMG and Shelter, 2014). The HAs themselves further fear that the rental income reductions will greatly constrain their ability to help the UK Government to drive housing growth through the development of new homes (NHF, 2015). The HAs, however, are committed to helping ease the UK's housing shortage by developing new homes to rent, as well as for sale via shared and private ownership schemes. Due to their desire to reduce the UK's housing shortage a number of HAs are reviewing their processes to maximise profit as they prepare to build with limited or no grant (Chevin, 2013).

It is argued that many HAs need to cut costs through reducing repair and maintenance expenditure (Inside Housing, 2017). Responsive repairs (unplanned repairs resulting from defects) are the largest area of expenditure for most HAs (HouseMark, 2012). Due to the large expenditure on responsive repairs, HouseMark (2013) advocate that maximising surplus from service charges is a key issue for HAs in ensuring their business is viable in the long-term. Service charge is defined as *"payment directly or indirectly for services, repairs, maintenance, improvements, insurance, and the landlord's costs of management"* (HouseMark, 2013: 13). Love (2002) argues that auditing defect repair costs and implementing appropriate process improvement strategies has potential to eliminate the costs associated with repairing defects.

With the number of defects on the rise in new homes in the UK, learning from defects by continuously reviewing and improving is seen by the HAs as a key opportunity to maximise surplus revenue as they prepare to build with reduced funding and rental incomes. For example, continuously studying past performance and improving future practice based upon the knowledge gained has been seen by HAs as a means of reducing responsive repairs (repairing defects) (Coastline, 2015). Similarly, continuously monitoring previous expenditure (including repair expenditure resulting from defects) and improving performance based upon the understanding gained from that monitoring is viewed by HAs as a means of reducing costs (e.g. Arcon, 2015).

This section has identified defects in new homes as an important area of focus and has outlined that learning from defects has been recognised as being a key opportunity for HAs to address their current challenges. The next section discusses the research problem.

1.2 Research problem

Learning from defects to reduce the occurrence of recurring defect problems in the new-build housing sector is commonly advocated as a normative prescription, both nationally and internationally. In the international context, Macarulla *et al*. (2013), for example, argue that if house builders in Spain analyse their defect performance they can gain an understanding of the nature of defects occurring and develop strategies to reduce them. In the UK context, Auchterlounie (2009) states that the UK house building industry should implement a feedback system to enable the builders to assess their current systems and their outputs. Roy *et al*. (2005) emphasise that house builder's re-examining and modifying their working practices has the potential to reduce quality failures. Baiche *et al*. (2006) synthesise a number of learning prescriptions in their argument that continuous review, research and feedback is a means of reducing housing defects in the UK. Davey *et al*. (2006) further advise that the development and sharing of good practice has the potential to reduce defects.

A similar learning prescription can be found in a number of government and industrial reports which have been published to guide how house builders can improve their new-build housing performance. The 'Home building' report, published by the National Audit Office (NAO) (2007), for instance, suggests that by tracking and measuring the performance of different construction techniques and processes year-on-year, house builders can compare one technique against another in order to make improvements in performance. The NAO (2007) further recommend that houses' quality performance assessment should include analysing the number of warranty claims and number of defects within properties. Industry bodies offer similar guidance. The 'Management of post-completion repairs' report, for example, published by the National House Building Council (NHBC) Foundation (2011), advocates an approach of recording and analysing defect data, and feeding the outcomes of the analysis into the improvement of the design and construction of future homes. Government, industry, and academic guidance share a common position that the 'learning perspective' is an important approach to the reduction of defects in new homes.

In summary, the extant defect scholarship argues that house builders should learn from defects by continuously recording and analysing their defect performance to gain an understanding of what is going wrong in their properties/organisation (Baiche *et al*., 2006; NAO, 2007; NHBC Foundation, 2011; Macarulla *et al.*, 2013). Based upon their understanding the house builders should feed this knowledge back (Baiche *et al*., 2006) to develop strategies to reduce defects (Macarulla *et al.*, 2013) and improve the design and construction of future homes (NHBC Foundation, 2011). These strategies and improvements can be made by undertaking research (Baiche *et al*., 2006), developing and sharing good practice (Davey *et al*., 2006); and, re-examining and modifying working practices (Roy *et al*., 2005). The extant literature is, however, silent on how HAs *actually* learn and make improvements based upon past defect data. Therefore, there is a need to better understand how UK HAs, in practice, learn from past defects in an effort to reduce the prevalence of defects in future new homes.

1.3 Justification for the research

The justification for this research is threefold. First, defects have been researched for a number of years, yet the volume of defects in new homes are excessive and appear to be increasing rather than decreasing. The high and increasing volume of defects in new homes suggests two potential problems: a) that either the existing body of knowledge on defects is insufficient to address the problem of defects in new homes in the UK; or b) the research has not had sufficient impact to influence the house building industry to change its ways and drive defect reduction.

Second, learning from defects to reduce the occurrence of recurring defect problems in the new-build housing sector is commonly advocated as a normative prescription, both nationally and internationally in the government, industrial and academic literatures. The extant literature suggests that house builders should seek feedback from previous projects to improve future ones, and prescribes generic guidance to house builders on how to achieve this. The prevailing literature, however, provides very little empirical insight into how house builders *actually* learn and make improvements based upon past defect data. Therefore, there is a need to better understand the phenomenon of learning from defects.

Finally, in response to the challenges of the funding squeeze and the increase in the number of defects in new homes, HAs are seeking to modify their existing processes of how they learn from defects to identify improvement opportunities which will help them to reduce long-term repair costs and maximise their surplus revenues in order to develop more new homes to help ease the UK's housing shortage. This research has the opportunity to contribute to both scientific knowledge and have a positive impact in industry by reducing defects within new homes.

1.4 Research aim and objectives

The aim of this research is to better understand how UK housing associations (HAs), in practice, learn from past defects in an effort to reduce the prevalence of defects in future new homes.

In order to achieve the stated aim a number of objectives will need to be satisfied:

1. Gain insight into which impacts of defects are actually important to the key stakeholders involved in their detection and remediation from construction on site until the end of the warranty period.

2. Understand HAs' localised defects analysis procedures, and their current knowledge feedback loops to inform future practice.
3. Design and test action research interventions to develop new defects assessment tools and learning systems to reduce targeted defects.

1.5 Theoretical position

The theoretical lens for this research is organisational learning (OL). More specifically, Berkhout *et al.*'s (2006) OL model has been adapted to guide this research (see Figure 1.1). Berkhout *et al.*'s (2006) OL model both resonates with the housebuilding industry's process-oriented characteristics and has previously been used to offer explanatory power to learning processes of house builders and housing associations. The OL model is a cycle that consists of the following four main constructs: 'signal recognition and interpretation', 'experimentation and search', 'knowledge articulation and codification'; and, 'feedback' (see section 2.9 Organisational Learning for further details).

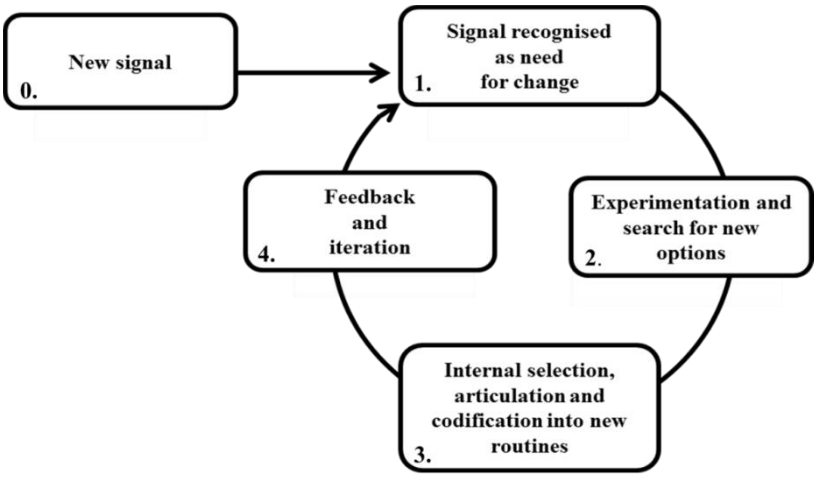

Figure 1.1: Organisation learning (adopted from Berkhout et al., 2006)

1.6 Research methodology

An action research (AR) approach was adopted (see Figure 1.2). 12 HAs and 292 key stakeholders involved in the detection and rectification of defects in new homes were used in the diagnosis phase of the AR cycle. A single case study (in this case, one HA) was used for the action planning, action taking and action evaluation phases. The case study lasted 22 months. The data collection techniques comprised of literature review, interview, questionnaire, organisational documentation and focus group. Data analysis techniques included thematic analysis and simple statistical analysis.

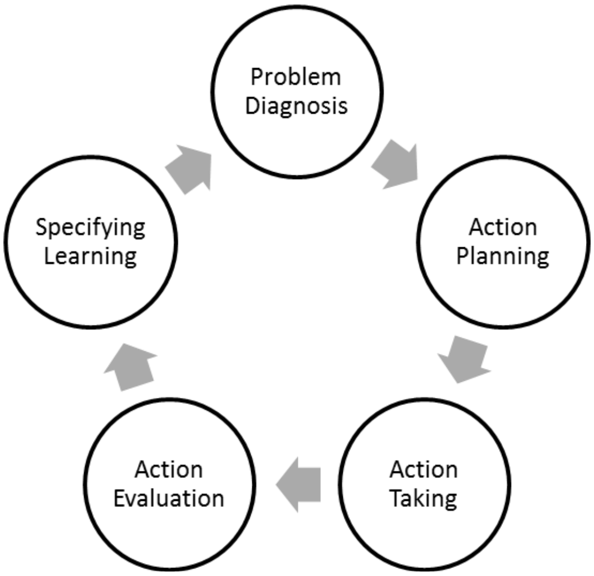

Figure 1.2: The process of AR (adopted from Lu and Sexton, 2009)

1.7 Synopsis of the thesis

This thesis is structured into five chapters. Each of the chapters are summarised below.

- **Chapter 1: Introduction**

Chapter 1 introduces the background to the research, the central research problem to be addressed, research aim and objectives, justification for the research, the theoretical position, an overview of the research methodology; and, a synopsis of each chapter.

- **Chapter 2: Literature review**

Chapter 2 presents and synthesises the relevant literature which develops the research problem and resultant aims and objectives of the research. First, the key characteristics of the UK house building industry are outlined. Second, the key features of UK housing associations (HAs) that may affect how they learn from defects are discussed. Third, the measures for ensuring construction quality in UK house building are presented. Fourth, a definitional debate on defects is presented, which is followed by the adoption and justification of an appropriate defect definition to be used for the purposes of this research. Fifth, the way defects are detected and rectified within new-build houses in the UK is explored from the start of construction on site to the end of the warranty period. The exploration outlines the process and also identifies the key stakeholders involved. Sixth, the potential areas of impact that defects can have on the key stakeholders involved in their detection and remediation are presented. Seventh, the research relating to defects in new homes is reviewed leading to the identification of learning from defects as an under-researched area, as well as a lack of guidance on which types of defects the house building industry should focus on when reducing defects. Eighth, organisational learning (OL) is studied and a suitable learning model that resonates with the UK house building industry's characteristics is adopted to guide the research design. Finally, the chapter is summarised and the key points clarified.

- **Chapter 3: Research methodology**

Chapter 3 discusses and justifies the choice of methodology used in this research. First, the researcher's philosophical position is outlined. Second, a number of potential research approaches are introduced. Following this, the adopted action research is discussed and justified. Third, the overall action research process used in this research is outlined. Fourth, the unit of analysis for the research is presented. Fifth, a discussion of the differing research methods and techniques used is provided. Finally, a discussion of how the research has been validated is presented.

- **Chapter 4: Key findings**

Chapter 4 presents the key research findings positioned around the five stages of the AR approach set out in Chapter 3, to satisfy the aim and three objectives expressed in Chapter 1. All of the AR phases start with a discussion of the practice followed by a reflection on the findings. The chapter begins by discussing the findings from the diagnosis phase, first looking at the impact of defects, followed by learning from defects. The action planning phase is discussed second, starting with securing access to HAs culminating in the action planned with one HA from the diagnosis phase (in this case, HA02). Third, the action taken by HA02 is outlined, including problems identified and interim solutions. Fourth, the action taken is evaluated, both in terms of how the planned actions were implemented, and how effective those actions were in relation to improving the HA's learning. Finally, the general knowledge gained during the AR is discussed in the specifying learning section.

- **Chapter 5: Discussion and conclusion**

Chapter 5 discusses the key findings in relation to the research aim and objectives as well as presenting the conclusions drawn from the research. First, reflection on the research aim and three objectives is presented. Second, the contribution of this research to organisational learning theory is discussed. Third, the contribution this research has made to methodology is presented. Fourth, the contributions to practice as a result of this research are outlined. Fifth, the implications for policy arising from this research are discussed. Finally, the limitations of the research and areas for further research are articulated.

1.8 Chapter summary and link to next chapter

This chapter has set out the background to the research and the key focus for this research. The next section will position the outlined research issues within the relevant literatures.

2 Literature Review

2.1 Introduction

This chapter reviews the relevant literature which will identify and underpin the pivotal aspects being investigated in this research. The chapter is structured as follows:

(1) The key issues in the UK house building industry are outlined (Section 2.2).

(2) The key features of UK housing associations (HAs) are discussed (Section 2.3).

(3) The measures for ensuring construction quality in UK house building are presented (Section 2.4).

(4) A definitional debate on defects is presented, which is followed by the adoption and justification of an appropriate defect definition to be used for the purposes of this research (Section 2.5).

(5) Defects detection and remediation during construction, the builder's liability period and warranty period within new-build houses in the UK, along with the key stakeholders involved are outlined (Section 2.6).

(6) The potential impact that defects have on the key stakeholders involved in their detection and remediation are presented (Section 2.7).

(7) The research relating to defects in new homes is reviewed leading to the identification of learning from defects as an under-researched area, as well as a lack of guidance on which types of defects the house building industry should focus on when reducing defects (Section 2.8).

(8) Organisational learning (OL) is studied and a suitable learning model that resonates with the UK house building industry's characteristics is adopted to guide the research (Section 2.9).

(9) The chapter is summarised and the key points clarified (Section 2.10).

2.2 Key issues in the UK house building industry

This section discusses the key issues in the UK house building industry. First, the UK housing shortage is discussed. Second, a review of the reliance on private house builders and housing associations (HAs) for the majority of the UK's supply of new homes is undertaken. Finally, the dependence on traditional construction techniques and subcontractors are presented.

2.2.1 Housing shortage

In the UK there is a considerable shortfall in the number of dwellings available (a housing shortage) (Lang *et al.*, 2016). This housing shortage has been a longstanding problem. In 2016 the UK's current housing stock is circa 23 million (Shelter, 2016) and the UK's population is circa 64 million with 81% being over 16 years of age and able to purchase a home (ONS, 2016). Since 2003, the UK's housing stock has only risen 9% (Shelter 2016). Over the same period the UK's population has risen 19% and the net migration has increased circa 70% (ONS, 2016). The reason for the housing shortage is the failure of successive governments to build enough homes to accommodate the increase in population over the last few decades (KPMG and Shelter, 2014). Due to the housing shortage UK house prices have increased 140% since 1999 and almost 450,000 families live in overcrowded conditions in England. In addition to overcrowding, more than 81,000 households were made homeless during 2013/14 and rough sleeping has increased by 37% since 2010 (Shelter, 2017). It is claimed that an additional 240,000 plus new homes a year are required to meet demand and needs to reduce the housing shortage (Holmans, 2013).

2.2.2 Reliance on private house builders and housing associations for the UK's housing supply

In addition to the shortage of homes there is a prolonged shortage of new homes being constructed (Wilcox and Perry, 2013). Over the past decade, on average, approximately 160,000 new homes have been completed per year (DCLG, 2016). Figure 2.1 below shows the volumes of new homes completed by local authority, HAs and private house builders. There are two key reasons for the UK's housing supply shortage: a) the reduction of houses being built by local authorities since the 1980s; and b) the reliance placed on private house builders to supply the majority of the UK's new homes (for sale) and HAs to supply the UK's affordable homes. Affordable housing is defined *"as social rented, affordable rented and intermediate housing, provided to eligible households whose needs are not met by the wider market. It must remain at an affordable price for existing and future eligible households"* (UK Government, 2015). Private house builders and HAs contributed 70% and 20% respectively of the UK's housing supply over the last decade (DCLG, 2016). Whilst private house builders construct the majority of homes in the UK, it is worth noting that 23 of the largest house builders are responsible for constructing circa 65% of that volume (NHBC, 2016a). In addition to the private house builders, HAs and local authorities, self-built houses by owners account for only 8% of the UK's supply of new homes each year (Wilson, 2015). Of the UK's housing supply the Home Builders Federation (HBF) (2015) estimate that approximately 38% of all housing completions in the UK are affordable homes.

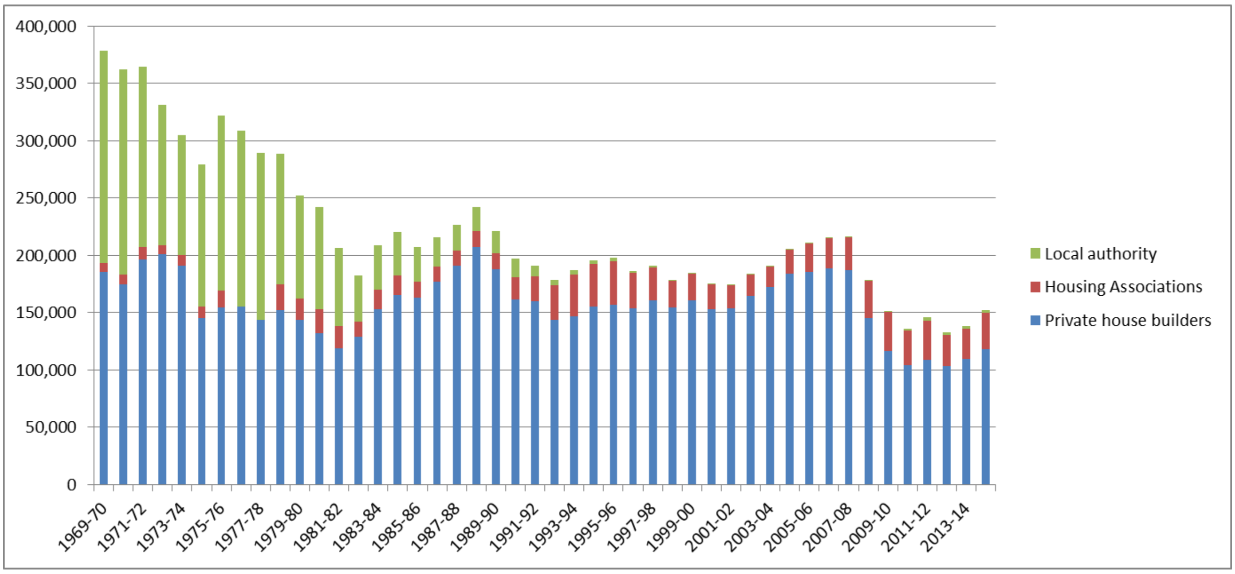

Figure 2.1: Volumes of new homes completed by local authority, HAs and private house builders between 1969 and 2014 (DCLG, 2016)

2.2.3 Private house builders and housing associations dependence on ‘traditional’ construction methods and subcontractors

The majority of homes in the UK are constructed using “traditional construction” consisting of a cavity wall constructed of brick and block or block and render, which accounts for 70% of the UK’s new homes by construction type, followed by the use of “timber frame” (15%) (NHBC, 2017a). It has regularly been claimed that offsite construction can help the UK to increase the supply of new homes (The Housing Forum, 2015; NAO, 2005). Further, the UK Government are calling for house builders to consider new models of construction such as offsite manufacturing (DCLG, 2017). Whilst there are many different construction types used internationally, such as offsite construction in Sweden (e.g. Johnsson and Meiling, 2009; Bergstrom and Stehn, 2005), or concrete walls in Norway (e.g. Liso *et al.*, 2006), the UK remains reliant on “traditional” methods of construction. One reason for the continued reliance on traditional methods of construction is argued to be a lack of skills due to the reliance on subcontractors (e.g. Homes for Scotland, 2015; UKCES, 2012). Private house builders tend to subcontract between 90% and 100% of their work to contractors, and procure materials from a range of individual suppliers (Farmer, 2016; HBF, 2015). It is argued that house builders’ use of subcontractors enables them to respond quickly to opportunities and free up capital as subcontractors are often not paid for their work until after it is done (Calcutt, 2007; DBIS, 2013). Private house builders’ use of subcontractors is a historic issue which is argued to have delivered good profits for the house builders over a number of years and offers them a means of surviving the volatility of the construction business cycle (Calcutt, 2007; Dainty *et al.*, 2001). Private house builders’ use of subcontractors is seen as an issue (despite the positives) because it gives house builders very little incentive to train trades, and leaves the industry highly dependent on their subcontractors to provide the skills they need (Calcutt, 2007). The issues of skills shortages, housing shortage and under-supply of new homes, and a reliance on private house builders and HAs are key concerns in respect of defects in new homes (see Sections 1.1, 1.2, 2.8).

2.3 Key features of UK housing associations

The previous section has identified that approximately 38% of all housing completions in the UK are affordable homes, and housing associations (HAs) supply the majority of them. This section will highlight key features of HAs in the UK.

2.3.1 Housing associations tend to be non-commercial organisations

HAs tend to be non-commercial organisations (HBF, 2015), whereby the HA is an independent not-for-profit (non-profit-distributing) organisation (Shelter, 2017). HAs can use any surplus revenue they make from private sale (Farmer, 2016), sale of shared-ownership homes, rental income (KPMG and Shelter, 2014), and surplus from service charges (HouseMark, 2013) to maintain existing homes and help finance new ones (NAO, 2005). The maintenance of existing homes and the volume of HAs who build homes for private sale are discussed in more detail in Section 2.3.4.

2.3.2 Housing associations can be financially regulated and funded by the government

In addition to being non-commercial organisations, HAs can be financially regulated and funded by the government through the Homes and Communities Agency (NAO, 2005). HAs can develop “grant funded social and affordable housing” (homes built through money received via government grants) or develop homes for private sale using their surplus revenue (see Section 2.3.1 above) (Farmer, 2016).

In order to receive government funding for shared ownership homes and affordable housing, HAs are required to bid for funding for specific schemes (HCA, 2016). When bidding for funding, the HA’s proposed scheme will typically be in relation to supplying new housing (HCA, 2016). The UK Government looks to fund good quality housing in well-designed schemes. In order to receive government funding the scheme will need to demonstrate (HCA, 2016): (1) *value for money*, including minimising costs during construction and over the life of the home through efficient procurement, construction and management, maximising other cost contributions (for example cross-subsidy from market sales), and minimising land costs; and, (2) *certainty of delivering the scheme within the forecast timescale*, taking into account the planning stage achieved, and the status of land ownership.

In an effort to guide HAs on how to develop value for money strategies and demonstrate the achievement of value for money (and subsequently increase success in their bids for achieving government funding), the Chartered Institute of Housing (CIH) have developed guidance (CIH, 2012). The CIH guidance includes: assessment of cost and cost drivers (factors that cause change in an activities cost), areas where savings can be made with the least impact on satisfaction, areas where improvements can be made with maximum impact on satisfaction; and, peer benchmarking and comparison. Government funded HAs need to publish relevant spend details (HCA, 2016). In summary, a HA's value for money strategy (to aid successful future grant bids) needs to place specific emphasis on both cost and home occupant satisfaction.

Where a HA is in receipt of a government grant and are providing social rented housing they are expected to ensure all homes are decent. To be 'decent', a dwelling should (DCLG, 2006a&b): (1) not contain any serious hazards (category 1 under the Housing Health and Safety (H&S) Rating System – e.g. damp and mould growth, excess cold, excess heat, carbon monoxide, electric shocks, fires, burns and scalds; and, asbestos); (2) be in a reasonable state of repair; (3) have reasonably modern facilities and services (e.g. kitchens and bathrooms); and, (4) provide a reasonable degree of thermal comfort. HAs are required to have plans and mechanisms for monitoring progress towards making their stock decent, and should be setting targets for tackling their non-decent housing and monitoring their progress.

2.3.3 Housing associations can obtain homes through Section 106 agreements and thus have less input into new home quality

In addition to government funding and developing their own homes, HAs can obtain homes through Section 106 agreements (Monk *et al.*, 2006). Section 106 agreements are planning obligations and legal contracts made under Section 106 of the 1990 Town and Country Planning Act and are used to prescribe the nature of development to comply with policy; compensate for loss or damage created by a development; and, mitigate a development's impact (HBF, 2015). In the case of affordable housing, government policy has explicitly put in place the use of planning agreements to facilitate developers' contributions (Monk *et al.*, 2006) with local planning authorities able to provide housing developers with an affordable housing obligation through the use of Section 106 (DCLG, 2013b).

Approximately 37% of the UK's supply of affordable homes is delivered through Section 106 agreements (House of Commons, 2016). The agreed affordable housing can be implemented either by the house builder providing what is needed to a standard specified in the agreement, or by the house builder paying a sum to the planning authority, which will then itself provide the affordable housing (Monk *et al.*, 2006). 'Affordable housing' provided by the house builder will be sold to a HA at a discounted price (Broxbourne Government, 2015). When obtaining housing through Section 106 agreements HAs will have less input in the design and specification of homes; and, inspection of homes during construction when compared to HA built properties and therefore the build quality and longevity of the home may be reduced (Tower Hamlets, 2015).

2.3.4 Housing associations tend to manage their own build stock

There are around 1,700 registered HAs in the UK (HCA, 2017). These HAs own circa 2.7 million homes, consisting of 2 million general needs homes, 0.3 million specialist housing for the elderly, and 0.1 million supported homes for vulnerable people (Walker, 2017). It is important to note that HAs manage and maintain their housing stock (NHF, 2017). HAs in the UK spend around £9 billion per year on repairs and maintenance (CIH, 2011).

The UK HAs are diverse in their size and construction activity. In respect of size, the 71 largest HAs own more than 10,000 homes; 268 HAs own between 1,000 and 9,999 homes; and, the remaining HAs (around 1361, the majority) own fewer than 250 homes (Walker, 2017). With regards to construction activity circa 50% of the largest HAs in the UK construct homes for private sale (Mullins, 2010), completing approximately 2,200 homes in 2014 (Walker, 2017). These private sale homes are in addition to the homes the HAs construct and acquire for shared ownership/affordable rent to subsidise their affordable housing activities (Mullins, 2010). In contrast to the larger HAs' construction activity, circa 83% of HAs are not developing or acquiring any homes at all, and are solely focussed on managing their existing build stock (Walker, 2017).

Due to the significant volume of homes HAs are currently managing coupled with the significant expenditure on repair and maintenance, quality (and thus reduced repairs and maintenance) is an important consideration for those who construct and/or acquire new homes. For example, Catalyst HA has committed to provide more quality homes as part of their 2020 goals (CHG, 2017). The emphasis of quality for new homes by HAs is further evidenced by research by the National Housing Federation (NHF, 2016) who found that HAs are providing some of the highest quality homes in the UK.

2.3.5 Comparison of the key differences between housing associations and volume house builders

When considering HAs (their key features are discussed in detail in sections 2.3.1 to 2.3.4) in relation to volume house builder there are four key differences that arise. These four differences are briefly discussed below.

First, volume house builders typically build new homes for private sale (e.g. Barratt, 2017; Taylor Wimpey, 2017; Persimmon, 2017). HAs may build new homes for private sale, shared ownership, and affordable rent. HAs may also procure homes from volume house builders through Section 106 agreements (for shared ownership and affordable rent); and, some HAs may not construct homes but will simply rent their existing stock out (e.g. Mullins, 2010; Walker, 2017).

Second, volume house builders seek maximum profit, often at the expense of producing higher volumes of new homes and reduced volumes in geographical locations where sales are unlikely (Archer and Cole, 2016). In contrast, HAs are non-profit distributing whereby they reinvest any profit they make for their social purpose of developing future homes and maintaining existing ones (CIH, 2015; Farmer, 2016).

Third, volume house builders are either funded by shareholders (e.g. Persimmon, 2017) or privately funded (e.g. Hopkins, 2017) whereas HAs are typically (to an extent) in receipt of government funding (NAO, 2005). The government funding HAs receive typically comes with additional quality requirements where the HA homes should be free from defects and to a 'decent' standard (DCLG, 2006a&b). 99% of HAs' housing stock meets the Decent Homes Standard (Walker, 2017). In contrast, 98% of homes purchased from volume house builders contained defects (HBF, 2017).

Finally, HAs have a long-term interest in their houses whereas volume house builders do not (Archer and Cole, 2016). This long-term interest means that HAs construct higher quality, more energy efficient, larger homes. For example, HA homes have larger kitchens than private homes in general (CLG, 2008). For instance, in respect of energy efficiency HA homes have an average Standard Assessment Procedure (SAP) rating of 66.2 compared to the national average of 60 (NHF, 2016). For example, HAs construct homes that are designed to reduce the burden of repair and maintenance; and build homes to additional standards such as the life time homes standard and secured by design (e.g. Guinness, 2017).

2.4 Mechanisms to ensure the quality of new homes in the UK

There are four main mechanisms of ensuring the quality of new homes in UK house building: compliance with Building Regulations and a warranty provider's standards to ensure the 'build' quality during construction; the Consumer Code to ensure the 'service' quality; and, the new home warranty to ensure 'build' quality post-completion.

2.4.1 Building Regulations

All new homes built in the UK should be constructed to meet the relevant Building Regulations (e.g. HMSO, 1984). The Building Regulations are the minimum set of requirements a new home is required to meet (Smith *et al.,* 2013) to certify that reasonable standards of H&S are ensured for building users (Baiche *et al.,* 2006).

In England and Wales there are “approved documents” to guide house builders on how to achieve compliance with the Building Regulations (England and Wales Government, 2016). In Scotland there are “technical handbooks” (Scottish Government, 2016); and, in Northern Ireland there are “technical booklets” (Northern Ireland Government, 2016).

In order to enforce the Building Regulations, during the construction of a new home, an inspection procedure consisting of the examination of work on site in accordance with the Building Regulation criteria takes place (Smith *et al.*, 2013). The inspection procedure can be undertaken by either an approved inspector in England and Wales (e.g. NHBC, MD Warranty Support Services Limited, Butler and Young Residential Ltd, Checkmate), or someone from the local authority building control service (this applies to the entire UK) (HMSO, 2010). The inspector will typically inspect the plots at key stages. For example, NHBC’s (2016b) six key stage inspections at drains, foundations excavated, superstructure, pre-plaster, pre-handover or Checkmate’s (2016) three key stage inspections at foundations, pre-plaster, and completions. Where defects are identified, the building inspector will produce a checklist that require correction by the house builder, in order for the home to be finalled for completion (Baiche *et al.,* 2006).

2.4.2 Warranty Standards

In addition to the Building Regulations requirements, nearly all new homes in the UK have a warranty in place, as it is a requirement of mortgage lenders (CIC, 2010).

In the UK there are a number of warranty providers, for example, Premier Guarantee, Local Authority Building Control (LABC) Warranty; and, NHBC (CIC, 2014a). New home warranties typically offer ten years of post-completion cover (in addition to certain cover before completion) and is split into two sections: cover during the first two years (builder’s liability period) and cover during years 3-10 (NHBC, 2012; Checkmate, 2017; Build-Zone, 2017; Premier Guarantee, 2013; and, LABC Warranty, 2017). Under the terms of the warranty the house builder is responsible for rectifying any breach of the requirements within the builder’s liability period and any breach that may result in a warranty claim in years 3-10 will ultimately affect the builder's premium rating (renewal fee) (NHBC, 2011).

In order for a new home to receive the warranty, the house builder is required to build to the warranty provider's requirements which often exceed the Building Regulation requirements. NHBC (2017b) have their book of "standards", whilst other major warranty providers including Checkmate (2017), Q Assure Build (2017), Premier Guarantee (2017); and, LABC Warranty (2017) have their own 'technical manuals'. During construction the warranty provider will undertake 'standards' compliance inspections (Auchterlounie, 2009) at key stages. If any failures to satisfy the warranty provider's requirements (defects) are found the house builder is required to rectify them to receive the warranty.

2.4.3 Consumer Code

In addition to the warranty cover, in April 2010 the Consumer Code (the Code) for Home Builders came in to force, setting mandatory requirements that home builders must meet with regards to marketing and selling homes, as well as conducting after sales customer service. The Code is designed to ensure home buyers are treated fairly, have sufficient provision of information in respect of expected service levels, how to make decisions and where to access fast, low-cost dispute resolution actions if needed. The Code is linked to the warranty provider (a requirement for builders to abide by the Code when taking out the warranty under the warranty providers rules) and is predominantly concerned with issues arising within the first two years of purchase which fall outside the scope of the warranty provider's cover (CCHB, 2010).

2.4.4 New home warranty

The warranty (and associated code) provides a level of protection to the home occupant. By way of explanation, within the construction industry construction work takes place under a number of forms of contract, for example, the New Engineering Contract (NEC), Joint Contracts Tribunal (JCT) contract, and Institution of Civil Engineers (ICE) contract. Each of these contracts typically contains clauses whereby defects need to be rectified. For example the JCT major project construction contract (JCT, 2011) stipulates that *"…During the Rectification Period the Employer may instruct the Contractor to remedy any Defect. The Contractor shall comply with any instructions within a reasonable time and at no cost to the Employer...*".

In the house building industry the house builder is usually the employer and the majority of work is subcontracted out (Craig, 2007). From a home occupier's point of view there is arguably limited protection available, as new homes are exempt from the Sale of Goods Act (HMSO, 1979) as well as the Consumer Rights Act (HMSO, 2015). Previous research suggests that there is a reliance on the goodwill of the house builder to rectify defects as there is nothing inherent within the contract to force the house builder to rectify the defects (Sommerville and McCosh, 2006). Further, the same research has argued that new home warranties have limited value, and described them as *"a licence to take additional funds from the already hard-pressed home buyer [occupier] and the industry participants"* (Sommerville and McCosh, 2006: 19). However, the overview provided above clearly outlines that under the terms of the warranty (a tripartite agreement between the home occupant, house builder and warranty provider) (e.g. NHBC, 2012; Premier Guarantee, 2013), the house builder must return to rectify any defects during the first two years post-completion (the builder's liability period), and any claims resulting from defects that occur during the warranty period have an effect on the house builder's renewal fee.

Despite the numerous mechanisms to "ensure" the quality of new homes (i.e. Building Regulations, Standards etc.) and the protection offered to home occupants by the warranty and consumer code, new home quality (especially reducing defects) is an area under scrutiny, that the UK Government identified as needing improvement (e.g. APPG, 2016).

2.5 Definitional debate on defects

Defects in construction have been subject to research internationally under a number of guises: for example, defects (Georgiou *et al*., 1999; Josephson and Hammarlund, 1999; Watt, 1999; and Ilozor *et al.,* 2004), faults (Assaf *et al*., 1995; and Abdul-Rahman, 1995), failure (Ahzahar *et al.,* 2011; and Porteous, 1992), errors (Ilozor *et* *al.,* 2004), and rework (Love *et al*., 1999; Love and Smith, 1999; and Fayek *et al.,* 2003). The differing ‘defect’ descriptions within the building context appear to be being used interchangeably in research relating to the same phenomenon (imperfections in buildings) (Macarulla *et al.*, 2013).

In the UK new-build housing context, imperfections in buildings have been described as defects, non-compliance, errors and snags.

A 'defect' is defined, by the Building Research Establishment (BRE) as a shortfall in performance occurring within the life of the product, element or dwelling (BRE, 1988). The NHBC define a defect as “the breach of any mandatory NHBC Requirement by the Builder or anyone employed by or acting for the Builder” (NHBC, 2012: 3), similar to the non-compliance definitions. Baiche *et al.* (2006) and Pan and Garmston (2012) also infer a 'non-compliance' to be a failure to adhere to Building Regulations, or approved standards. A 'snag' is argued by Sommerville and McCosh (2006) to be the same as 'errors' and 'defects' within a new house.

Due to the differing labels, Sommerville (2007) argues the need for a standard lexicon, suggesting a lack of consistency in terminology as a factor that constrains research into UK new-build housing defects. The author agrees with Sommerville (2007) to an extent, in that the use of differing definitions to describe what is essentially the same phenomenon of imperfections in buildings results in the need for a somewhat irrelevant discussion about whether there are indeed differences between ‘snags’ and ‘non-compliance’ and ‘defects’, when in reality the researchers are all looking at aspects of construction that have not been done correctly irrespective of their adopted label. If research adopted the same definition for research into defects in new homes in the UK this would negate the need for inane discussions over whether a snag is a defect, and a defect is a non-compliance etc. Further, by adopting a relevant and suitable definition for defects future research may also research the constructed home in relation to the requirements it was actually meant to be built in accordance to. For this reason the author argues that there is one definition that is most suitable for research into new-build housing defects in the UK. For this research the author’s understanding of a defect is *“the breach of any mandatory NHBC Requirement by the Builder or anyone employed by* *or acting for the Builder"* (NHBC, 2012:3). The NHBC definition is the most appropriate for a number of reasons: over 80% of new homes are covered by an NHBC warranty. The requirement for receiving that warranty is that the builder (and anyone acting on their behalf) builds to NHBC's standards. Defects and/or valid warranty claims will ultimately have an effect on the builder – through either recompense, or an increase to the builder's premium rating. Finally, the NHBC standards and defect definition is widely accepted and acknowledged by the UK house building industry as it is part of the warranty contract they sign up to.

In summary, this section has debated the array of labels used to describe defects and identified the NHBC's definition as the most appropriate definition to be adopted for this research. Defects have been subject to research across many countries under a number of terms. The terms appear to be being used interchangeably to describe imperfections in buildings. In the UK context there have also been a plethora of definitions to describe new-build housing defects. Now that defects have been defined, the next section explores how defects are detected and rectified within new-build housing in the UK and identifies the key stakeholders involved.

2.6 Overview of defect detection and rectification within new-build houses and the key stakeholders involved

How defects are detected and remediated in the UK new-build housing sector can be generally grouped into three phases: the construction phase, the builder's liability period (years 0-2 post-completion), and the warranty period (years 3-10 post-completion) (see Figure 2.2). The justification for the need to include the warranty period can be found in Section 2.4. Within these three phases, four key stakeholders were identified: home occupants, house builders, warranty providers, and building inspectors. These stakeholders and their involvement within the process are discussed below.

During a new home's construction, an inspection procedure involving examination of work on site takes place to assess whether compliance with the Building Regulations has been achieved (Wilson and Rhodes, 2016). The inspection procedure can be undertaken by either a building inspector from the local authority or an independent approved inspector (e.g. MDIS, NHBC) (CIC, 2014b). During construction, building inspectors frequently identify defects and produce checklists that require correction by the house builder (Baiche *et al.,* 2006). As work progresses on site, the house builder also undertakes quality inspections and if defects are identified the house builder will rectify them (Sommerville *et al*., 2004). For new homes covered by a warranty, additional inspections are carried out by the warranty provider (e.g. Premier Guarantee, NHBC) at key stages (e.g. foundations, superstructure) to ensure compliance with the warranty provider's standards (Auchterlounie, 2009). If any deviations are found the house builder is required to rectify them to receive the warranty.

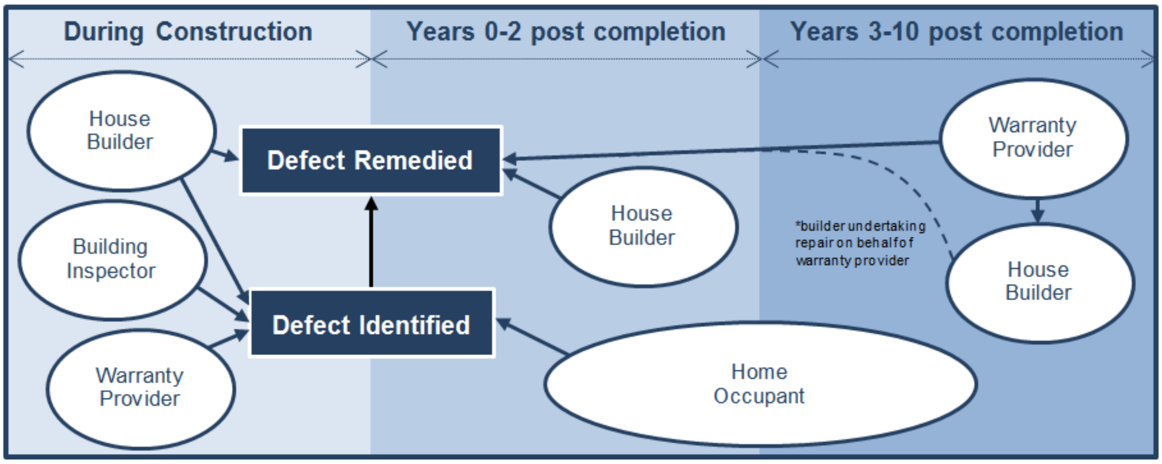

Figure 2.2: Overview of defect detection and rectification within new-build houses in the UK

During the builder's liability period (years 0-2 post-completion), the house building industry undertakes a snagging process (identifying defects) which is heavily reliant on the home occupant to report any defects back to the house builder (Sommerville *et al.,* 2004). The house builder is required to rectify defects under their liability, which is a requirement under the warranty (Premier Guarantee, 2013; NHBC, 2012).

Beyond the first two years, most new homes are subject to a warranty period of a further eight years. The warranty provider covers building defects during the warranty period (NHBC, 2012; Premier Guarantee, 2013). During this period, the home occupant is required to notify the warranty provider of any defects, and offer the warranty provider an opportunity to inspect his/her home. Upon acceptance of a valid claim, the warranty provider will make the necessary arrangements to have the defect remedied by either themselves, or offer the house builder the opportunity to rectify the defect to protect their renewal fee from increasing due to the cost of claims (NHBC, 2012 & 2011). It is worth noting that where properties are owned by HAs, they may undertake the repairs (Walker, 2017).

In summary, this section outlined defect detection and remediation in the UK house building industry, along with the key stakeholders involved. The review of how defects are detected and remedied identified a number of key stakeholders involved at different stages: house builders, warranty providers, building inspectors, and home occupants. The review has also indicated that a warranty is an important tool for rectifying post-completion defects. The next section seeks to distinguish the impact that defects may have on the stakeholders involved in defect detection and remediation (home occupant, house builder, building inspector, and warranty provider) as well as explore any potential considerations for targeted defect reduction.

2.7 The potential impact of defects as identified by the construction defect research

A review of existing construction defect literature has identified a number of common aspects which have the potential to cause negative impacts to a variety of stakeholders involved with construction projects, including: H&S implications (Baiche *et al.*, 2006; Smith *et al.*, 2013), cost (Love and Li, 2000; Rosenfeld, 2009), and general disruption (Davey *et al.*, 2006; BEC, 1991). Each of these aspects are discussed below.

2.7.1 Health and safety implications

The reduction of defects has the potential to improve construction site H&S and reduce danger for site workers (Macarulla *et al.*, 2013). Reducing defects can also decrease H&S concerns post-completion. More specifically, reducing defects that contravene Building Regulations (as opposed to more aesthetic snagging issues) can reduce potential danger to home occupants. Building Regulations compliance certifies that reasonable standards of H&S are ensured for building users (Baiche *et al.,* 2006).

2.7.2 Cost implications

Remediation of defects occurring during the construction stage and the builder's liability period is suggested to cost the builder on average between 2.3% and 9.4% of the production cost (Josephson and Hammarlund, 1999; Love and Li, 2000). During the warranty period, the cost of defect remediation in Australia is argued to be circa 4% of the contract value (Mills *et al.,* 2009). In 2015 in the UK the NHBC (NHBC, 2015) spent £87 million on resolving warranty claims. The specific cost of defects can be grouped into five categories: the cost of investigating defects (for house builders and warranty providers), the cost of repairs (for house builders and warranty providers), effect of warranty repairs on house builders, the cost for resolving complaints resulting from defects (for house builders and warranty providers), and the cost of regulatory non-compliance (for house builders and building inspectors).

Investigation costs: defects can be investigated by the house builder, by an external party such as a warranty provider, or in some cases by both parties (Rosenfeld, 2009; NHBC, 2012). During construction and the builder's liability period the house builder will investigate defects that occur (Sommerville *et al.*, 2004). During the warranty period the warranty provider will undertake the investigations. The warranty provider can potentially request the house builder to assist during the investigations on warranty claims. If the house builder fails to assist the warranty provider during the investigations the warranty provider can recover the investigation cost directly from the house builder (NHBC, 2011).

Repair costs: three specific costs have a large bearing on the overall costs of repairs (Mills *et al.*, 2009; Rosenfeld, 2009): the cost of labour, materials, and equipment. On average, it costs £100 for an operative to repair a defect in the UK (HouseMark, 2012:8). However, it should be noted that different defects cost varying sums to remedy; for instance, remediation of external water penetration is generally more costly than plumbing (Mills *et al.,* 2009). The repair costs during the builder's liability period are typically incurred by the house builder. The cost of warranty repairs are also identified as a potential cost (Rosenfeld, 2009) and are typically incurred by one of two parties: the warranty provider or the house builder. During the warranty period the warranty provider is liable for the repair. Upon acceptance of a valid claim, the warranty provider will make the necessary arrangements to have the defect remedied (NHBC, 2012). Studies show that the warranty provider spends large sums of money rectifying defects (Mills *et al.,* 2009).

Effect of warranty repairs on house builders: due to costs incurred on warranty repairs, warranty providers keep records of claims history where the warranty provider has undertaken the repair in order to calculate the house builder's renewal fees. However in a number of cases the house builder will choose to undertake repairs on warranty claims themselves in order to protect their renewal fee from increase due to claims related costs (NHBC, 2011).

The cost of complaints: defects can potentially cause complaints from the home occupants (Sommerville *et al.,* 2004). Handling complaints resulting from defects has the potential to cause additional costs, including legal costs and compensation. Furthermore, handling complaints also consume house builder's time as they are required to urgently deal with complaining home occupants instead of undertaking their daily activities (Rosenfeld, 2009). Warranty providers are not immune to customer complaints either. For the 2013 financial year the Financial Ombudsman Service (FOS, 2013) reported a 60% increase in home occupants complaining about a home warranty provider's service.

The cost of regulatory non-compliance: during construction, a building inspector must take all reasonable steps to ensure that the Building Regulations requirements have been met (DCLG, 2012). If building inspectors fail to fulfil their contractual obligations the client can sue them for breach of contract (ACAI, 2013). When undertaking construction work the primary responsibility for achieving regulatory compliance, however, remains with the house builder (HMSO, 1984). Under the Building Act (HMSO, 1984) if a person carrying out building work contravenes the Building Regulations, he/she may be taken to the magistrates' court and ordered to pay a fine for the contravention. In specific circumstances, under a new-build warranty the warranty provider will provide cover for defects that contravene Building Regulations where they present a danger to the H&S of the home occupant (NHBC, 2012).

2.7.3 Disruption implications

New-build housing defects generally cause disruption to both home occupants and house builders (Davey *et al.,* 2006). The following three specific aspects are discussed below: disruption to the house builder's construction programme; disruption to the house builder in arranging for trades to return; and, disruption to the home occupant in needing to allow trades to return.

Disruption to the house builder's construction programme: defects occurring during the construction process can cause disruption to the house builder's construction programme and remediation of defects has the potential to cause delays in handover (Sommerville *et al.,* 2004). The disruption to the house builder is typically through resource usage. For example, site management may be required to investigate the causes of defects that arise on site while labour and equipment may be deployed to remedy defects instead of undertaking the programmed work (Rosenfeld, 2009).

Disruption to the house builder in arranging trades to return: handling post-completion defects has the potential to cause disruption to a house builder (Rosenfeld, 2009). Disruption to house builders can include time spent travelling to investigate and remediate defects, and having to arrange for trades to return to properties to undertake repairs (Davey *et al.,* 2006).

Disruption to home occupants in needing to allow trades to return: post-completion defects are argued to cause disruption to home occupants by way of operatives having to return to, and be granted access to, their homes (Davey *et al.,* 2006).

In summary, this section has identified the potential impact that defects could have on the key stakeholders involved in their detection and remediation. The existing research provides valuable evidence by identifying a number of defect related consequences with the potential to cause H&S concerns, cost implications and disruption. The research, however, can be susceptible to discussing defects only in a general context. Individual defects have differing potential impacts on both the house building industry (house builders, warranty providers, and building inspectors) and home occupants, such as divergent levels of inspection, varying repair durations, fluctuating demand on labour and equipment, and the unstable levels of communication and service the combination of these aspects will invariably cause. Further, a number of the identified factors are closely interrelated and can involve a number of stakeholders. For example, a post-completion defect that is a non-compliance with the Building Regulations has a number of related implications: first, cost implications for undertaking the repair, and/or any potential fines for the contravention; second, potential H&S implications due to Building Regulations compliance being to ensure that reasonable standards of H&S for building users are achieved; and, finally, disruption implications by the way of operatives having to return to the property, and be granted access by the customer to rectify the situation. What has become apparent from the prevailing literature relating to the potential impact of defects in construction is that there has been a lack of research that has explored the importance of the respective impacts. Therefore there is very little empirical data on which potential impacts are important to the people involved in their detection and rectification. Thus there is a need to better understand which impacts of defects are *actually* important to the key stakeholders involved in their detection and remediation from construction on site until the end of the warranty period. The next section predominantly reviews the existing research relating to defects in new homes in the UK.

2.8 The current focus of research into UK new-build housing defects and recommendations made to reduce their prevalence

Due to the potential impact of defects, there has been a large amount of research relating to defects and their reduction. This section begins with an overview of the current focus of construction defect research, followed by a brief overview of international new-build housing defect research. The chapter then specifically focusses on defects in new homes in the UK and the recommendations made to reduce defects.

Research into new-build housing defects in the UK is comparatively limited. There are two potential problems of this lack of explicit research into UK new-build housing defects. First, a large number of publications tend to focus on defects within the wider construction sector (e.g. Porteous, 1992; Latham, 1994; Josephson and Hammarlund, 1999; Love and Li, 2000) or non-new-build housing (e.g. Page and Murray, 1996; Olubodun, 2000). Second, new-build housing defect research is largely non-UK based and tends to focus in, Australia (e.g. Georgiou *et al*., 1999; Ilozor *et al*., 2004; Mills *et al*., 2009) and Spain (e.g. Macarulla *et al.*, 2013; Forcada *et al*., 2016) for example.

2.8.1 Wider construction sector

In the UK and internationally, defects have been researched in the wider construction sector for decades. This construction defect research has focussed on: the number of defects (e.g. Josephson and Hammarlund, 1999; Abdul-Rahman, 1995), the causes of defects (e.g. Love and Li, 2000; Love and Edwards, 2004; Josephson and Hammarlund, 1999; Andi and Minato, 2003; Andi and Minato, 2004), the cost of defects when they occur (e.g. Love and Edwards, 2004; Josephson and Hammarlund, 1999; Abdul-Rahman, 1995), the effect they have on the satisfaction of the occupants (Goins and Moezzi, 2013); and, how to classify defects for analysis and evaluation purposes (e.g. Oliveira Pedro *et al.*, 2008; Porteous, 1992; Che-Ani *et al.*, 2011). The construction defect research has placed its focus on large scale and general construction projects such as: office buildings (Goins and Moezzi, 2013), warehouses (Love and Li, 2000), schools (Josephson and Hammarlund, 1999; Boothman and Higham, 2013); highway, bridge and tunnel construction (Abdul-Rahman, 1995; Andi and Minato, 2004), public toilets (Che-Ani *et al.*, 2011); and hospitals (Taggart *et al.*, 2013).

When considering the number of defects in construction, Josephson and Hammarlund (1999) observed between 283 and 480 defects during construction on a range of building types, including schools, museums, and university buildings. In contrast, Abdul-Rahman (1995) observed 72 defects on a single highway construction project. This variation in defect volumes suggests that the number of defects is dependent on the complexity and type of construction that was observed.

With regards to the causes of defects two predominant causes were found: workmanship on site (Josephson and Hammarlund, 1999; Love and Li, 2000), and design errors (Josephson and Hammarlund, 1999; Love and Li, 2000; Love and Edwards, 2004; Andi and Minato, 2004). For example, Josephson and Hammarlund (1999) generally found that the causes were often difficult to identify but attributed a lack of motivation for the majority of the defects observed which resulted in design errors, materials errors, and poor workmanship on site. Love and Li (2000) extended this understanding further by elaborating that different projects tended to have one predominant source of defects such as: design errors and changes (in one project) and construction errors originating from poor detailing and workmanship (on another project). Andi and Minato (2004) delved down deeper to look at the different causes of design defects, finding that incorrect calculations, incorrect loading, and inadequate design detailing were the main types of design defects, however found constructability to be responsible for only 3% of the defects that occurred. This finding of constructability suggests that the issues of workmanship found by Love and Li (2000) and Josephson and Hammarlund (1999) were more related to a lack of ability of trades than the constructability of designs.

In respect of the cost of defects, research tends to predominantly concentrate on one of two aspects: the general cost of defects in construction projects (Josephson and Hammarlund, 1999; Love and Li, 2000); and, the cost of defects based upon where they occurred (Abdul-Rahman, 1995). Different researchers use differing measures to calculate cost. For example, Josephson and Hammarlund (1999) found that defects cost between 2.3% and 9.4% of the production cost, with no correlation between the volume of defects and the overall repair costs, whereas Love and Li (1999) discovered that the cost of defects was between 2.4% and 3.15% of the original contract value. In contrast, Abdul-Rahman (1995), uncovered that 48.2% and 12.1% of the tender value related to subcontractors and designs respectively. This variation in findings indicates two issues: a) that the type of defect occurring (or construction type used) has more bearing on the cost of defects than the general frequency; and, b) that the percentage cost of defects differs depending on what baseline it is calculated to (e.g. tender price, production price, contract value). The specific costs of defects were discussed in more detail in Section 2.7. In reference to the effect defects have on occupant satisfaction, Goins and Moezzi (2013) found issues of thermal performance in office buildings, where occupants were too hot during hot weather or too cold during cold weather. More importantly, Goins and Moezzi (2013) uncovered a lack of feedback mechanisms in place which became a barrier to dealing with complaints and improving satisfaction.

Finally, regarding the classifaction of defects, it is argued that unstructured and informal recording of defects and other information makes it difficult to avoid defects (e.g. Taggart *et al.*, 2013). In order to overcome unstructured and informal recording of defects standardisation is often argued as a solution to bring uniformity (e.g. Straub, 2009; Che-Ani *et al.*, 2011). This standardisation tends to come in the form of a classification system. There are two main schools of thought for the classification of defects: a) classifying defects based upon the reason for their occurrence (e.g. Porteous, 1992); and, b) categorising defects by the area of the building that they occur and assigning a level of importance to that area (e.g. Straub, 2009; Che-Ani *et al.*, 2011; Oliveira Pedro *et al.*, 2008). Porterous (1992) for example, argues that all defects can be rationalised into two main causes: natural occurrences, and human errors. Natural occurrences include aspects such as: dampness, movement, and chemical/biological changes. Human errors include: defective designs, ignorance, buildability, and poor communication. Porteous's (1992) classification of defects resonates with the causes of defects literature discussed earlier in this section. The second school of thought has moved the classification of defects on further from generic causes of defects to the specific areas of a building that the defect has occurred. For example, Oliveira Pedro *et al.* (2008) developed a classification system consisting of 37 building areas from structure, to ceilings, to ventilation services. Straub (2009), for instance, explains the Dutch Standard for Condition Assessment of Buildings, which categorises defects by the area in which they occur, such as doors and windows. Che-Ani *et al.* (2011) extends the classification further when they categorise both the building area (location), for example roof; and, the building element/component, for instance rainwater collector. A number of these classification systems have attempted to assign a level of importance to the defects experienced and rate the general condition of the building. Che-Ani *et al.* (2011) for example, use a subjective method which consists of taking the condition of the building area observed and rating it on a scale of 1 (good) to 5 (delapidated). The system then asks the user to determine the priority of the repair by rating it on a scale of 1 (normal – cosmetic issues) to 4 (emergency – issues that could cause structural failure or danger to the building's occupants). Based upon the scores assigned for the condition (1-5) and repair priority (1-4) the building is then given a score by multiplying the two factors together. Oliveira Pedro *et al.* (2008) attempt to remove some of the subjectivity from the defects classification systems and assessments by using predetermine weights for the building area. Oliveira Pedro *et al.* (2008) use two measures: the severity of the defect that has occured measured on a five point scale of minor to major with a score of 5 being attributed to minor issues and a score of 1 to major issues; and, a 6 point weight of the building element where the defect is being experienced (scale of 1 to 6). For example, structure has a weight of 6 and fire safety issues have a weight of 1. The system then calculates an overall defects score, which is simply the total of scores (the severity of defects: 5 to 1 scale) divided by the total weights of the 37 elements (scores of 1 to 6). Whilst these assessment systems provide valuable insight into how to categorise defects and assign a level of importance, these assessments appear to rely on the authors assumptions as to which building elements and what types of defects are important.

This section has reviewed the construction defects literature. Whilst the construction defects literature offers valuable insights into construction defects, it is important to note that these defects are experienced on bespoke large-scale projects, consisting of a range of construction techniques, procurement methods, levels of client input, and different complexity, threrefore the knowledge developed from researching the occurrence of defects in these projects may not be comparable or transferrable to a housing situation. International new-build housing defects are reviewed next.

2.8.2 International new-build housing

In the international context, defects in new homes have been subject to research during the construction stage, during the first two years post-completion, and during the warranty period. For example, Love (2002) audited the indirect cost of repairing defects that occurred during construction phase of building new homes in Australia whilst Johnson and Meiling (2009) reviewed the number and types of defects experienced in homes manufacturered offsite during construction and the first two years post-completion in Sweden. Finally, Mills *et al.* (2009) identified the most prominent sources of warranty claims in Australia, including foundation failures, roof leaks, and external water penetration. The international new-build housing defect research tends to research the individual stages in isolation (or only a combination of construction and the first two years post-completion at best). Forcada *et al.* (2016) suggest the need to consider defects during construction, during the first two years post-completion, and defects beyond the first two years. Based upon the findings from the respective pieces of research, the authors recommend that those involved with house building should “learn” from past performance. Macarulla *et al*. (2013) for example, argue that if house builders analyse their defect performance they can gain an understanding of the nature of defects occurring and develop strategies to reduce them in Spain. In Australia, Love (2002) argues that construction organisations need to take responsibility for their own actions by auditing costs associated with defects and implementing appropriate improvement strategies to reduce the costs. Finally, in Sweden, Meiling *et al.* (2014) found that learning from defects (when implemented successfully in practice) can reduce their incidence in offsite manufactured homes. In order for house builders to learn from their past performance, more specifically defects, some commentators have argued the need for defects classifciation systems to standardise the classification of defects (based upon the area in the building they occur) and aid the house builders in their analysis by reducing instances of poorly structured data (e.g. Georgiou, 2010; Macarulla *et al.*, 2013) – an issue identified in the construction defect research in the wider construction sector. Despite the consistent learning prescription there is disagreement by the respective authors over which defects should be focussed on. Ilozor *et al.* (2004) emphasise that there is a need to concentrate on defects that are low in number, if only to ensure safety. Whereas Georgiou *et al.* (1999) propose that individual defects with high associated costs should be considered high priority. Love (2002) further implies that cost is an important motivator for defect reduction. Whilst the unique nature of the UK house building industry (e.g. the reliance on traditional construction, the lack of home occupant involvement in the design and specification, and the reliance on HAs and speculative house builders for the supply of new homes) raise questions over the transferability of this knowledge, the research approach, learning prescription and lack of agreement by researchers on which defects should be targeted for reduction purposes is echoed in the UK new-build housing defect literature, as discussed below.

2.8.3 UK new-build housing

Research into new housing defects in the UK can be generally grouped into four aspects: (a) the stage in which the housing project is studied; (b) the level of analysis, (c) the findings; and, (d) the recommendations to reduce defects. Each aspect is discussed below.

(a) The stage in which the housing project is studied

The UK housing defect literature tends to focus on a particular stage of a house building project, without a whole project perspective being considered (the construction phase, the builder's liability period: years 0-2 post-completion, and the warranty period: years 3-10 post-completion). The stages mainly studied by previous research are the construction phase (e.g. Atkinson, 2002) and the builder's liability period (e.g. Craig, 2007), yet the occurrence of defects within new-build houses is not limited to these two stages, either generally or in isolation. In addition to focussing on a particular stage, the prevailing literature draws upon small sample sizes. For example, Atkinson (2002) observes a single housing site while Baiche *et al*. (2006) investigate 11 local housing developments. These studies provide valuable detail in depth but are limited in the representativeness of the results (to the general population).

One area of research that does investigate large sample sizes (covering a wide range of house builders and geographical areas) is that which focuses on defects occurring within the first two years of a property's life (builder's liability period) (e.g. Sommerville and McCosh, 2006; Craig, 2007). The investigation of defects that occur within the first two years tends to produce results that indicate that the majority of problems in new homes are related to aesthetics, for example the general finish of the property (e.g. Auchterlounie, 2009; Sommerville, 2007). Some support for the aesthetics idea is Craig's (2007) finding that making good, paint, cleaning, sealant and grout are the prevalent 'snags' in UK new homes.

The occurrence of defects within new-build houses is, however, not limited solely to the first two years post-completion. Outside of the first two year period, new-build houses are subject to a further eight year warranty period (Sommerville and McCosh, 2006), where the warranty provider will keep a record of claims as part of their risk assessment procedures (Auchterlounie, 2009). Within the warranty period there are indications of defects associated with building fabric and structure being reported to the warranty provider. According to the NHBC (NHBC, 2013), defects occurring during years 3-10 of the NHBC warranty include foundations, substructure and ground floors, superstructure, roofs, services, fixtures and finishes, and ancillary buildings and external works (see Figure 2.3 below). The results support the findings from the international literature (e.g. Mills *et al.*, 2009) and indicate a different defect trend from the 'aesthetic' issues reported in the first two years. It also confirms new-build properties are not defect free the moment they move outside of the builder's liability period (two years).

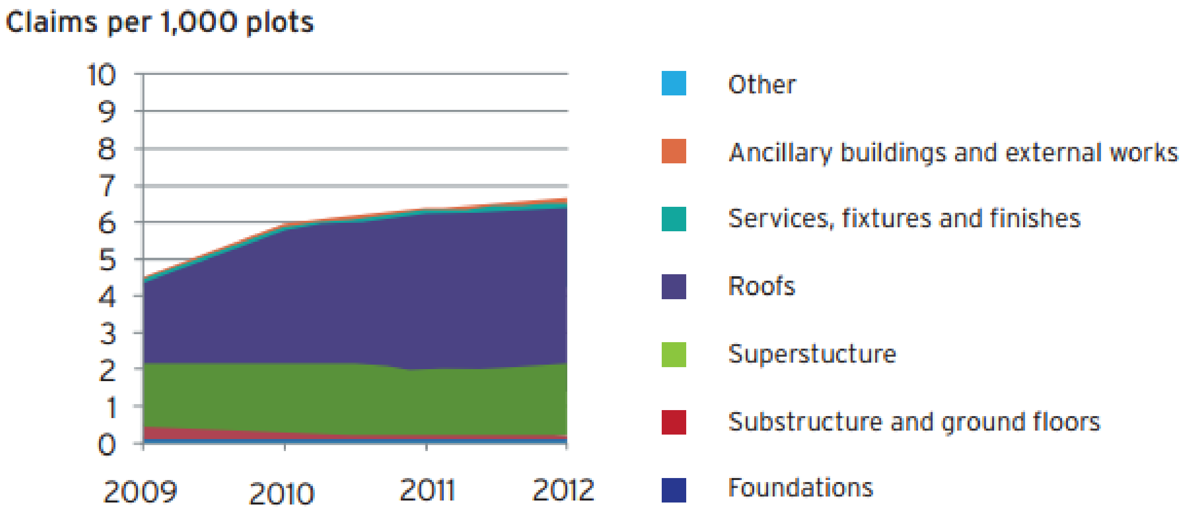

Figure 2.3: Defects occurring during years 3-10 of the NHBC warranty (NHBC, 2013)

By focussing predominantly on defects during construction or the builder's liability period, the extant scholarship tends to only explore the involvement of the builder, home occupant, and/or building inspector in defects (and remediation) as well as limiting itself a small section of a new house's life. Similarly to Forcada *et al.*'s (2016) recommendation in the international literature, there is a need for the UK new-build housing defect research to consider defects during construction, during the first two years post-completion, and defects beyond the first two years.

(b) The level of analysis

Generally, the UK new home defect literature focuses on industry level analysis as opposed to individual house builders. The industry level analyses can provide useful aggregated insights (e.g. Atkinson, 2002; Barker, 2004; Callcutt, 2007; Auchterlounie, 2009), but can be prone to assuming that all house builders have the same characteristics and associated performance. There are notable exceptions that do acknowledge the heterogeneous nature of the new-build housing sector. Sommerville *et al*. (2004), for example, highlight the multitude of methods that individual house builders use when recording and undertaking the snagging process. Similarly, Sommerville and McCosh (2006) argue that there is a clear difference in quality from one house builder to the next. Of the publications that differentiate between organisations and their respective processes (excluding Davey *et al*., 2006), the majority prescribe a *'standard'* solution for all house builders (e.g**.** Egan, 1998; Roy *et al*., 2003; Sommerville *et al*., 2004). This prescription of a standard solution shows commonality with the construction and international new-build housing research suggestions. The appropriateness of a 'standard solution', given the varied nature of house builder types and practices, however, is an empirical question which has not been adequately investigated.

(c) The findings and how they are used

The research findings within the UK new-build housing defect literature are generally centred around: numerical occurrences of defects (e.g. Sommerville and McCosh, 2006), responsibility for defects taking place (e.g. Atkinson, 2002), the type of defects occurring (e.g. Baiche *et al*., 2006), and the links between defects and home owner satisfaction (e.g. Auchterlounie, 2009). The existing research findings suggest that generally authors are able to establish the number, types, cause, and home owner satisfaction relationship of defects. However, a common feature running through the majority of the UK new-build housing defect literature is how findings and recommendations are seldom actively reported back to the house builder to assist with their feedback and learning processes (e.g. Sommerville and McCosh, 2006; Auchterlounie, 2009).

(d) Recommendations to reduce defects

A number of recommendations to reduce defects have also been given within the literature, including: training for trades, standardised processes and products, predefined quality criteria, and learning from defects. Each will be discussed in turn.

Training for trades: It is argued that a mandatory training requirement resulting in the granting of a licence to carry out building works would improve the levels of skill and knowledge, and increase the ability for trades to achieve the desired levels of workmanship and ultimately reduce defects (e.g. Baiche *et al*., 2006). For example, gas engineers in the UK are required to be qualified and on a register to legally work on boilers, fires and all other gas appliances (Gas Safe, 2015). Despite the mandatory qualification and registration requirements for gas engineers, Craig (2007) extracted a number of defects related to gas installations from a leading snagging company's database, for example, boilers and flues. The defects identified suggest that a licence to carry out building work is unlikely to eradicate defects on its own.

Standardised processes and products: The adoption of standardised processes and products in the building process has been argued as a potential solution to reduce defects. Baiche *et al*. (2006), for example, point out that the adoption of standard details would reduce complexity within the building process and increase familiarity from one site to the next, and ultimately would achieve defect reductions within the current construction environment. Lees and Sexton (2014) have established that house builders currently utilise standardised design and production plans and practices which are repeated from development to development. The combination of standardisation and repetition currently employed within the house building industry and high defect levels suggests that standardised processes and products may not be a viable solution to eradicating defects.

Predefined quality criteria: It has been recommended that house builders should establish a set of quality criteria to deliver to their customers on a consistent basis. Customers should be made aware of these criteria, and as such they can judge the finished product, the home, against that predefined criteria. This approach is argued to reduce the level of subjectivity with regards to defects and ultimately reduce their incidence (e.g. Auchterlounie, 2009). Under the terms of most new home warranties, the house builder is required to build to the warranty provider's requirements. Any deviation from the warranty provider's predefined criteria would constitute a defect (e.g. NHBC, 2012) [Note: NHBC provide a warranty on 80% of UK new homes]. As circa 95% of new homes in the UK will be covered by a warranty (e.g. Sommerville and McCosh, 2006; DCLG, 2016; NHBC, 2013) the majority of new homes are already being constructed to a prescribed set of quality criteria, which the home buyer will be able to access. Despite the *"predefined"* quality criteria in place there are still high numbers of defects in new homes.

Learning from defects: Learning from defects is considered as a means for solving the persistent defect problems in the UK new-build housing sector (a sentiment shared in the international context). Auchterlounie (2009) states that the UK house building industry should implement a feedback system to enable the builders to assess their current systems and their outputs. Roy *et al*. (2005) emphasise that re-examining and modifying working practices has the potential to reduce quality failures. Baiche *et al*. (2006) conclude the above ideas by arguing continuous review, research and feedback as a means of reducing housing defects in the UK. Davey *et al*. (2006) further advise that sharing good practice and the developments of others has the potential to improve processes to aid defect reduction.

A number of government and industrial reports have been published to guide how house builders can improve their new-build housing performance. The 'Home building' report, published by the NAO (NAO, 2007) suggests that by tracking and measuring the performance of different construction techniques and processes year on year, house builders can compare one technique against another in order to make improvements in performance. The NAO (2007) further recommend that a house's quality performance assessment should include analysing the number of warranty claims and number of defects within the property. The 'Management of post-completion repairs' report, published by the NHBC Foundation (2011) advocates an approach of: recording and analysing defect data, feeding the outcomes of the analysis in to the design and construction of a home to amend procedures and ultimately make improvements based upon what has been learnt. Finally, the All Party Parliamentary Group (APPG) (2016) suggest that house builders need to be open about mistakes and learn from them. Together these ideas suggest that the 'learning perspective' has been recognised as a means of reducing defects in new homes, however, the literature provides very little insight into how house builders *actually* learn from defects.

From the review of recommendations to reduce defects in new homes it would appear that the training of trades, standardised processes and products, and predefined quality criteria are an ongoing priority for the UK house building industry, yet the persistent problem of defects remains. The one remaining recommendation ‘learning from defects’ at an organisational level, in this case, the process of how house builders currently learn from defects, remains under-researched. Even though there is a general belief that the house building industry and home occupants can benefit from defect reduction and the authors can establish (at individual time points) the type, cause and numbers of defects occurring; and, provide consistent general recommendations to reduce them, there is disagreement by the commentators over which types of defects the house building industry needs to focus on (when considering defects on a basis other than frequency alone) (similar to the international literature). Baiche *et al.* (2006), for example, argue that focus should be placed upon reducing individual defects in areas deemed detrimental to the H&S of home occupants. In contrast to the H&S focus, Sommerville *et al.* (2004) argue that the house building industry is predominantly financially motivated and that only high expenditure on defect rectification will motivate it to reduce defects. Davey *et al.* (2006) acknowledge that reducing defects could save money, but further assert that disruption caused by remediation is an important consideration. Sommerville (2007) argues that we have the situation in house building defect research where researchers are able to identify the issues causing defects and the size of the problem, but are unable to determine whether the defect, or any particular aspect of it, is significant or not. The NAO (2007) suggests that practitioners need to consider the volume of defects as well as the impact they have.

In summary, this section has reviewed the existing research relating to defects in new homes and identified ‘learning from defects’ at an organisational level (i.e. organisational learning) as an under-researched area. Learning from defects to reduce their occurrence is a common normative recommendation within the UK and international new-build housing defects literature. Learning from defects has been argued to have success in offsite manufactured and traditional homes in other countries (e.g. Sweden and Spain). There is, however, a lack of research that has explored how UK house builders actually learn from defects in practice. Further, there is scarce amount of insight and understanding into which potential impacts of defects (cost, H&S, and disruption) are actually important to those who experience them (house builders, warranty providers, building inspectors, and home occupants – see Section 2.6). The argument to this point is that considering defects that occur during construction, the builder's liability period, and the warranty period as well as exploring the impact of defects would offer new insight and understanding about the defect occurrences in new homes, the range of stakeholders who experience them and the impact defects cause; as well as developing the capability to determine what is significant and what should be the specific areas of focus for defect reduction. The capability to understand defects from construction to the end of the warranty period (circa ten years) would complement the exploration of how house builders learn from defects and would aid industry and individual practitioners in their efforts of targeted defect reduction. The next section evaluates the OL literature to identify a suitable model to guide this research (how housing associations learn from defects at an organisational level).

2.9 Organisational learning

Organisational learning (OL) has been recognised as a source of company competitive advantage and is a term frequently utilised within the general management literature. Argyris (1977) argues OL to be a process of detecting and correcting error. Fiol and Lyles (1985) develop the OL concept to go beyond detecting and correcting errors with the argument that organisations are cognitive units that are capable of observing their actions, investigating the effects of alternative actions, and modifying their actions to improve performance. Neilson (1997) extends the concept further to add a knowledge dimension to articulate OL to be the continuous process of creating, acquiring, and transferring knowledge accompanied by a modification of behaviour to reflect new knowledge and insights.

Nevis *et al.* (1995) argue that all organisations engage in some form of learning and have formal and informal processes and structures for the acquisition, sharing, and utilisation of knowledge. Nevis *et al.* (1995) further offer a useful typology of the different approaches to OL where they describe seven learning orientations and their polar opposites which are: (1) knowledge source – preference for sourcing knowledge internally versus externally; (2) product-process focus – emphasis on gaining knowledge of what products/services are compared to how the organisation develops and delivers products/services; (3) documentation mode – whether knowledge is something individuals possess as opposed to being publicly available know-how; (4) dissemination mode – formal organisation wide methods of sharing learning (referred to in this research as codification) versus informal methods, such as casual daily interaction (referred to in this research as personalisation); (5) learning focus – incremental/corrective learning compared to transformational/radical learning; (6) value-chain focus – emphasis on investing in learning production activities as opposed to sales/service activities; and, (7) skill development focus – focus on developing individuals' skills versus team/group skills.

The construction literature relating to OL tends to draw upon the general literature as the basis of their OL definitional discussions. For example, Opoku and Fortune (2011) adopt Lopez *et al*.'s (2005) definition describing OL as a dynamic process of creation, acquisition and integration of knowledge aimed at the development of resources and capabilities that contribute to organisational performance. The suitability of OL in a construction setting has, however, often been questioned due to the largely project-based nature of the construction industry. Gann and Salter (2000) assert that project-based methods of production in construction create a strong requirement to understand knowledge flows to help facilitate the integration of experiences from an organisation's projects into its continuous business processes. Winch (1998), however, argues that most construction project problem-solving techniques are adapted using tacit knowledge and applied to a situation to meet specific client needs, and therefore it is difficult for them to be learned, codified and applied to future projects. Furthermore, the way in which many construction firms acquire and make use of knowledge is often poorly developed, resulting in firms gaining experience at an individual level, yet are unable to translate that to an organisational level (Barlow and Jashapara, 1998). Barlow and Jashapara (1998) go on to argue that those involved in construction projects are not afforded sufficient opportunity to feed experience they have gained from previous projects into future ones. It is suggested that existing feedback systems in place within the construction industry are unstructured and informal, and as a result, ineffective (e.g. Scott and Harris, 1998). In order to provide structured and formal knowledge sharing mechanisms to enable previous experiences of the project co-workers to be exchanged and assist in enabling OL, Knauseder *et al*. (2007) argue that construction companies should look for opportunities to bridge project boundaries and enhance the tacit knowledge base of the workforce (and organisation) to promote learning and organisational memory (OM). OM is defined as *"the means by which knowledge from the past is brought to bear on present activities"* (Stein and Zwass, 1995:89). Huber (1991:107) further stresses the critical role of OM as *"the basic processes that contribute the occurrence, breadth, and depth of organisational learning."* OM may be stored in a range of repositories, both human and artefact (Robey *et al*., 2000). There are two extremes in relation to how to manage knowledge (and create OM) in OL, the personalisation approach, and the codification approach (Lo and Ng, 2015). The personalisation approach can be described as a "people-to-people" approach which has an ultimate aim of promoting the transfer of knowledge (Lin, 2011). In contrast, the codification approach can be described as a "people-to-document" approach which aims to extract knowledge from individuals and store them in a formal means (Hansen *et al.*, 1999). For example, OM may consist of computer-based OM for storing and retrieval of information by individuals (e.g. Huber, 1991). OM can also be held and updated through codifying modifications within company processes in order to enable the transmission of the new routines (e.g. Berkhout *et al*., 2006). Ozorhon *et al*. (2005) further stress the need for construction firms to develop the necessary skills and systems to ensure that explicit knowledge is formed and committed to OM. Codification and personalisation approaches can deliver different benefits for an organisation and that one is not always better than the other (Liu *et al.*, 2013). For example, a codification approach enables people to extract information from a repository at any time (after its creation), whereas a personalisation approach is limited to the availability of the person (or people) with the relevant knowledge (Lee and Van den Steen, 2010). For instance, codification can only transfer explicit knowledge whilst personalisation can transfer both explicit and tacit knowledge (Hahn and Mukherjee, 2007). Due to the differing benefits of the respective approaches authors have emphasised that the approaches can work together and it is often argued that organisations should adopt a mixed strategy (Liu *et al.*, 2013; Kumar and Ganesh, 2011). Hansen *et al.* (1999) note the importance of utilising the most suitable approach (or combination of approaches) for the organisation.

The potential for OL to achieve defect reduction in construction, however, is further evidenced through its application to successfully detect and reduce errors in a number of project-based industries, such as: reducing surgical errors in the health sector (e.g. Vashdi *et al*., 2007) and reducing errors in aircraft maintenance in the aviation industry (e.g. Federal Aviation Administration, 2009).

In the construction literature, a number of OL models have been presented. For example, Chan *et al*. (2005) propose a multi-facet conceptual model of OL to help understand OL challenges at the construction project level. This model is made up of five facets. First, ‘contextual facets’ are the external factors that management have either indirect control or no control over. Second, ‘policy facets’ distinguish formal and informal steps taken by senior management to promote OL. Third, ‘psychological facets’ are the shared beliefs that a team is safe for interpersonal risk taking and the commitment to an organisation. Fourth, ‘cultural facets’ are the norms that are likely to create valid information and the commitment to take corrective action. Finally, ‘structural facets’ are the organisations learning mechanisms. This model however has not been empirically tested. Knauseder *et al*. (2007) move away from offering a conceptual model and take a broader approach to demonstrate evidence of different learning approaches based on quantitative empirical data drawn from 51 construction projects. Three learning approaches for enhancing OL are identified. First, ‘organising for learning’ to enable the exchange of experiences to expand individual knowledge bases. Second, ‘experimenting’ with new materials and working styles. Finally, ‘networking’ for sharing experiences between others to bridge boundaries and enhance learning. Finally, Berkhout *et al*. (2006) propose that OL can be seen as a cycle that can be modelled from four main constructs (see Figure 2.4). First, ‘signal recognition and interpretation’ is where an occurrence is recognised as a novel situation which indicates that existing organisational routines (Nelson and Winter, 1982) are inappropriate or ineffective. Second, ‘experimentation and search' is the process of initiating adaptation of organisational routines. Adaptation typically occurs in two forms: trial and error to modify existing actions and observe their impact on a small scale; and, searching internal and external sources for relevant experience and knowledge that can be applied to the given situation. Third, 'knowledge articulation and codification' is the process of exposing potential adaption options to an evaluation process in order to select the option most suitable to the organisation. Upon selection of an appropriate option the modified routines are codified in company documentation, processes, software, targets etc. in order to transmit the new routine throughout the organisation. Finally, 'feedback' from experience is sought to validate that the proposed alternative routine remains viable, finally returning to the beginning of a new cycle by way of a new stimulus.

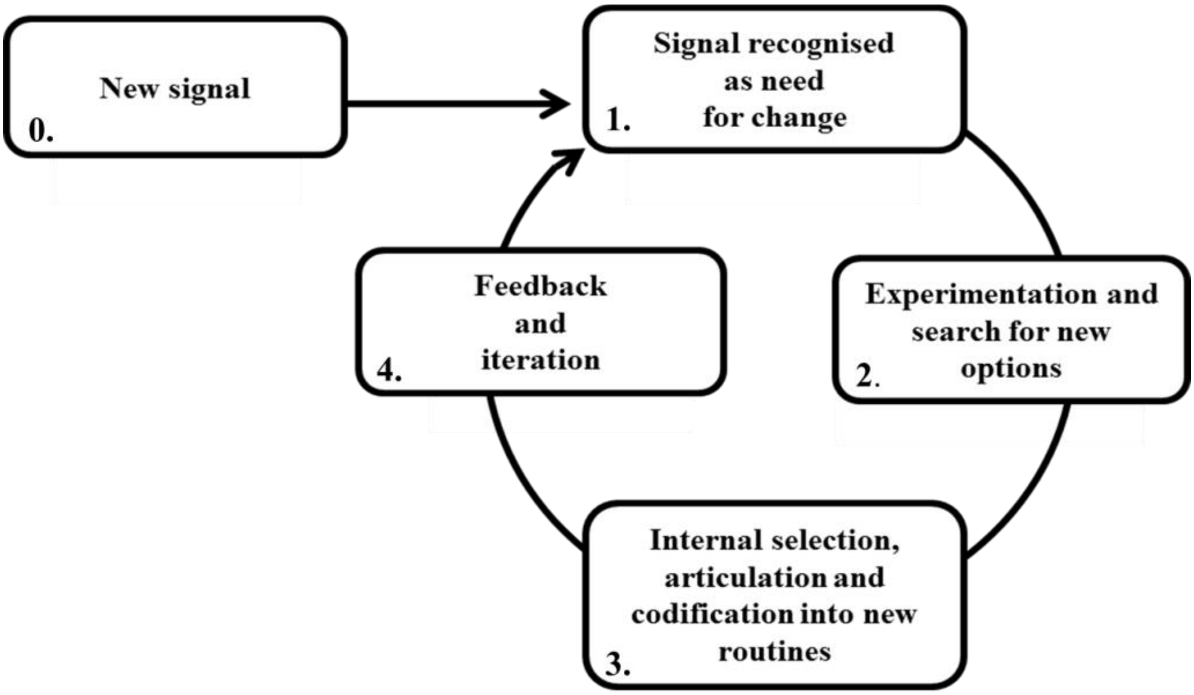

Figure 2.4: Organisation learning model in housing building (adopted from Berkhout et al., 2006)

Research into OL in project-based organisations and research into OL in the construction sector (due to its project-based characteristics) has found that different types of construction projects (and projects in general) tend to develop different learning approaches that recognise local conditions and idiosyncratic challenges (Hobday, 2000; Knauseder *et al*., 2007). House building is a specific type of construction activity which is quite distinct from other forms of construction in terms of the types of market, the resource inputs, and the organisation of the process (Gann, 1996). Gann (1996) goes on to explain that house building is process driven and closer to manufacturing than it is to other forms of construction projects. Egan (1998) and Knauseder *et al*. (2007) reiterate that housing projects are characterised by their focus on process. Housing projects (and house building) consists of a set of well-planned processes, using similar products and elements, based on repetitive activities that must be finished in order for the next one to start. Essentially, the process of constructing homes is itself repeated from project-to-project.

Berkhout *et al*.'s (2006) OL model has been identified as the most suitable model to guide this research. The justifications for this model's adoption are as follows. First, the adopted OL model resonates with house building industry's process oriented characteristics. Second, the OL model has previously been tested within a house building environment. Third, the model has been used to guide and analyse interviews from a range of functional departments within HAs and house builders. Finally, the model has been utilised to demonstrate how the house building industry responds to persistent problems (in the case of this research defects).

2.10 Chapter summary and significance of research aim and objectives

The review of literature relating to the UK house building industry has identified house building as a significant contributor to the construction sector. There is, however, a significant housing deficit. The UK new-build housing sector is reliant on private house builders and HAs for supply. Private house builders have started to increase their supply of new homes (Section 2.2) with HAs aiming to increase their volumes; however quality (and defects) is an area of concern from construction until the end of the warranty period (Section 2.4).

Defects have been researched under a number of categories in both the wider construction sector and international housing for years; however research into UK housing defects is comparatively limited - but still provides valuable insight. The extant research into UK new-build housing defects is able to identify when defects occur, the types of defects that occur, the costs associated with repairing defects, and the reasons for their occurrence. Building upon those findings, a number of commentators have made consistent recommendations to reduce defect prevalence. The recommendations, in particular, for the training of trades, standardised processes and products, and predefined quality criteria are an ongoing priority for the UK house building industry, yet the persistent problem of defects remains. It was found that the one remaining recommendation ‘learning from defects’, in this case, the process of how house builders currently learn from defects, remains under-researched. Learning at an organisational level (i.e. OL) is often argued as a means of enabling organisations to produce higher level assets and gain competitive advantage. The translation of OL principles have, however, not been fully achieved in the new-build housing sector. The potentiality of OL to provide a framework for house builders to learn from and reduce defects is under-developed area (Section 2.8). A review of literature relating to the suitability of OL in a construction setting has identified a suitable model as the theoretical basis to explore learning from defects in a housing environment (Section 2.9).

Whilst providing valuable insight into defects and providing a clear research opportunity (learning from defects), the literature, however, takes the normative position that the reduction of defects would generally benefit the house building industry, but is unable to provide any consensus on where defect reduction focus should be. So, first, in order to better understand who defects affect, a review of literature relating to how defects are detected and rectified within new-build houses was undertaken (for the period covering construction on site until the end of the warranty period – 10 years post-completion). The review identified four key stakeholders who regularly experience defects: the house builder, the warranty provider, the building inspector; and, the home occupant (Section 2.6). Finally, to identify the areas that the house building industry and individual practitioners should concentrate on and where the defect reduction (and learning) focus should be a review of existing construction defect literature was undertaken. The review identified a number of common aspects which had the potential to cause negative impacts to a variety of stakeholders involved with construction projects, including: cost, potential H&S/regulatory non-compliance, and disruption. The literature was silent on what is considered important to those who experience defects (Section 2.7) and provided very little guidance on what the house building industry (and individual practitioners) should focus on for defect reduction and/or learning purposes.

At the same time as identifying the research opportunity, within the UK house building industry an exciting practical application for this research became evident. HAs who make an important contribution to the UK's housing supply had been experiencing a decline in funding from the UK Government. In order to receive government funding for shared ownership homes and affordable housing, HAs are required to bid for funding for specific schemes. In order to successfully win government funding, HAs need to provide homes to a decent standard (i.e. with no serious defects) and also prove that their developments provide "value for money". HAs can demonstrate their ability to achieve value for money by continuously assessing and learning from their past performance. Learning from their past performance involves reviewing previous developments and looking for areas where cost savings can be made with the least impact on home occupant satisfaction. In addition, HAs should be looking for areas where improvements can be made that will have a maximum positive impact on home occupant satisfaction.

In the next chapter, the research methodology employed will be discussed.

3 Research methodology

3.1 Introduction

This chapter provides discussion on the design and operation of the methodology used in this research. The chapter is structured as follows:

(1) The researcher's philosophical position is outlined (Section 3.2).

(2) A number of potential approaches are outlined. Finally, the adopted action research approach is discussed and justified (Section 3.3).

(3) The overall action research process used in this research is outlined (Section 3.4).

(4) The unit of analysis for the research is presented (Section 3.5).

(5) A discussion of the different research techniques/methods is presented, including the sampling strategies for the data collection as well as the different data analysis techniques (Section 3.6).

(6) A discussion of how the research has been validated is presented (Section 3.7).

3.2 The researcher's philosophical position

Research philosophy is an over-arching expression that relates to the generation of knowledge and the nature of that knowledge. The adopted research philosophy contains important assumptions about the way in which the researcher views the world, and these suppositions underpin the research approach and the chosen methods within that approach (Saunders *et al*., 2009). Saunders *et al.* (2009) go on to explain that researchers will make assumptions about the realities encountered in their research (ontological assumptions), assumptions about human knowledge (epistemological assumptions), and assumptions about the extent and ways the researcher's own values influence their research process (axiological assumptions) along the way. The ontological, epistemological, and axiological assumptions which underpin this research are discussed below.

‘Ontology’ can be defined as *“…the study of being. It is concerned with 'what is', with the nature of existence, with the structure of reality as such…”* (Crotty, 1998:10). The ontological boundaries are realism (social entities exist in reality external to social actors) and idealism (social phenomena is created from the perceptions and consequent actions of social actors) (Guba and Lincoln 1994). The aim of this research is to better understand how UK housing associations (HAs), in practice, learn from past defects. This aim places the research’s ontological position towards idealism, in as much as learning from defects is a social phenomenon created from the perceptions and consequent actions of social actors.

‘Epistemology’ is how we know what we know (Crotty 1998) and relates to general assumptions of what signifies satisfactory knowledge within the field of study and the best way to study the world (Saunders *et al.*, 2009; Bhattacherjee, 2012). Epistemology is based upon two main extremes: positivism (a recognisable social reality where the end product of research can be law-like generalisations) and interpretivism (understanding the differences between humans within their roles as social actors) (Saunders *et al.*, 2009). The reason for adopting an interpretivist epistemology is twofold. First, the research seeks to comprehend and explain the social world of learning from defects from the perspective of individual experience and, recognises that learning from defects in HAs is a product of unique social interpretations and cannot be simply rationalised to general cause-effect relationships. Second, as HAs are unique with differing individuals, structures, cultures, priorities and processes, there is no ‘one size fits all’ solution to achieve learning success. The researcher, however, recognises that one of the techniques used in this research (questionnaire) is a positivist technique; but, it is useful to note that the researcher is embedded in the housing sector as a practitioner thus heightening his sensitivity to the interpretation of the data.

‘Axiology’ refers to judgment and values, including the role that the researcher’s own values play at all stages of the research process. The boundaries of axiology are objective (value-free) and subjective (value-biased) (Saunders *et al.*, 2009). The researcher's axiological position is somewhere between ‘value–neutral’ and ‘value-biased’, whereby the researcher acknowledges that he has brought his own subjectivity to the research. However, the research has been designed robustly and as transparently as was practicable and should be able to be understood and replicated by other researchers, to an extent.

The selection of a paradigm is not a matter of free choice and is based upon the assumptions made (Bickman and Rog, 2009). These assumptions place this research in the interpretivist paradigm.

3.3 Research approach: action research

When undertaking research there were are a number of approaches available to the researcher, including: case study, mixed methods, ethnography, and action research (e.g. Remenyi *et al.*, 1998; Saunders *et al.*, 2009). Each approach is briefly defined below and its applicability for this research discussed.

A case study approach offers a fruitful method for detailed investigation and research of a specific real-life setting which enables the researcher to offer underlying explanations from the case (Widdowson, 2011). Yin (2009) argues that you would use a case study approach because you deliberately wanted to cover contextual conditions, believing that they might be highly pertinent to your phenomenon of study. A case study approach was not considered suitable for this research because there was no capability to induce change.

A mixed methods approach is based on the central premise that the combination of quantitative and qualitative approaches provides a better understanding of research problems than the respective approaches on their own (Creswell and Plano Clark, 2007). In a mixed methods study the qualitative or quantitative data may be equally emphasised or be predominantly quantitative or qualitative (Creswell, 2014). A mixed methods approach was not considered suitable for this research because there was no capability to induce change.

An ethnography approach is a systematic approach to learning about the social and cultural life of communities, institutions, and other settings (LeCompte and Schensul, 2010). Ethnography involves telling a credible story from the voice of the people in their own local context, typically relying on verbatim quotations and thick descriptions of events (Fetterman, 2010). Ethnographic researchers are typically "invited" into the research setting and cannot control what happens in their situation of choice (LeCompte and Schensul, 2010). LeCompte and Schensul (2010) go on to explain that the ethnographic researcher needs to build trust with the research participants over time. An ethnographic approach was also not considered appropriate for this research for two reasons: First, on a practical level, the implication of continually observing a number of participants from a range of different organisations over a prolonged period of time was not considered realistic for this EngD study from a resource perspective. Finally, there was no capability to induce change.

Action research (AR) was a term first devised by Lewin (1946) who described it as a comparative research on the conditions and effects of various forms of social action, leading to social action. AR is understood to be an approach which *"simultaneously assists in practical problem solving and expands scientific knowledge, as well as enhances the competencies of the respective actors, being performed collaboratively in an immediate situation using data feedback in a cyclical process aiming at an increased understanding of a given social situation, primarily applicable for the understanding of change processes in social systems and undertaken within a mutually acceptable ethical framework"* (Hult and Lennung, 1980:247).

In recent years AR has been recognised as a valuable approach for conducting construction research (e.g. Lu and Sexton, 2009; Azhar *et al.*, 2010; Connaughton and Weller, 2013). The strengths of AR are that it can promote organisational change, focussed towards the furtherance of participants, along with more standard research outputs including: description, understanding, and explanation (Robson, 2002). In addition AR can facilitate the development of techniques to provide know-how to create settings for organisational learning (OL) (Susman and Evered, 1978). Zuber-Skerritt and Perry (2002) argue that AR can enhance the learning within an organisation and also make a contribution to a body of knowledge.

The criticisms of AR are that it is a "soft option" with abundant limitations (e.g. Koshy, 2005). McKay and Marshall (2001) raise the issue that AR could be regarded as being little more than consultancy-work, for example. Charles and Ward (2007) argue that through intervention, the researcher is part of the study and therefore the subjectivity and bias of the research are questionable, for instance; whereas Hales and Chakravorty (2006) argue that conclusions from a small number of cases have limited generalisability. These criticisms of AR take a positivist position. Zuber-Skerritt and Perry (2002) argue that AR can be differentiated from 'traditional' research as the two have different paradigms. Traditional 'positivist' research (natural science) has a hard boundary that separates the researcher from the system being researched and the system is reduced to one or a few parts, with the rest being assumed to be constant. Conversely, AR an 'interpretative' (social science) approach recognises and involves systems that the researcher is inevitably part of without clearly defined boundaries between the researcher and the system. Susman and Evered (1978) also argue that AR can base its legitimacy as science in philosophical traditions that are different from those which legitimate positivist research. As the researcher's philosophical assumptions place this research in the interpretivist paradigm (see Section 3.2) the positivist notions of rigor and thus criticisms of AR, such as reliability, internal validity, and generalisability, do not apply in a similar manner (Bhattacherjee, 2012).

An AR approach was considered the most appropriate approach for this research which aimed to empirically investigate how UK HAs learn from defects experience in general; and, more specifically, to induce change (new defect assessment tools and learning systems) in a social setting (a HA who wish to improve the way they learn from defects) in order to reduce targeted defects and improve OL. In addition, the capability for AR to overcome the gap between theory and practice through its proactive nature (e.g. Connaughton and Weller, 2013) is one of the main justifications for its use as is the capability for AR to enhance organisational learning and make a contribution to a body of knowledge.

3.4 Overall action research process used in this research

Section 3.3 discussed the research approach. This section concentrates on the overall AR process, which is provided in Figure 3.1. A cyclical process view of AR is used in this research. The cyclical process view of AR is resonated by Susman and Evered (1978) in the general literature and by Lu and Sexton (2009) in the construction literature who further differentiate the five-phase process of:

problem/opportunity diagnosis, action planning, action taking, evaluating and specifying learning. First, the ‘problem diagnosis’ phase involves identifying an improvement opportunity. Second, the ‘action planning’ phase specifies the organisational actions to advance the intervention. Third, the ‘action taking’ phase is the implementation of the action plan. Fourth, the action evaluation phase is an activity to determine whether the applied interventions have been successful in comparison to the criteria set out in the action planning stage. The final phase, ‘specifying learning’ is to reflect on the gained knowledge from the AR. This research was designed around the five phases of the adopted AR cycle.

This research starts with an exploratory design during the diagnosis phase whereby the impact of defects on the key stakeholders involved in their detection and remediation are explored via a questionnaire, and multiple HAs are studied to better understand their learning processes through interviews and analysis of organisational documentation. This early exploration during the diagnosis then leads on to focus on one HA during the final four phases of the AR to design and implement AR interventions. The AR phases are discussed in more detail below.

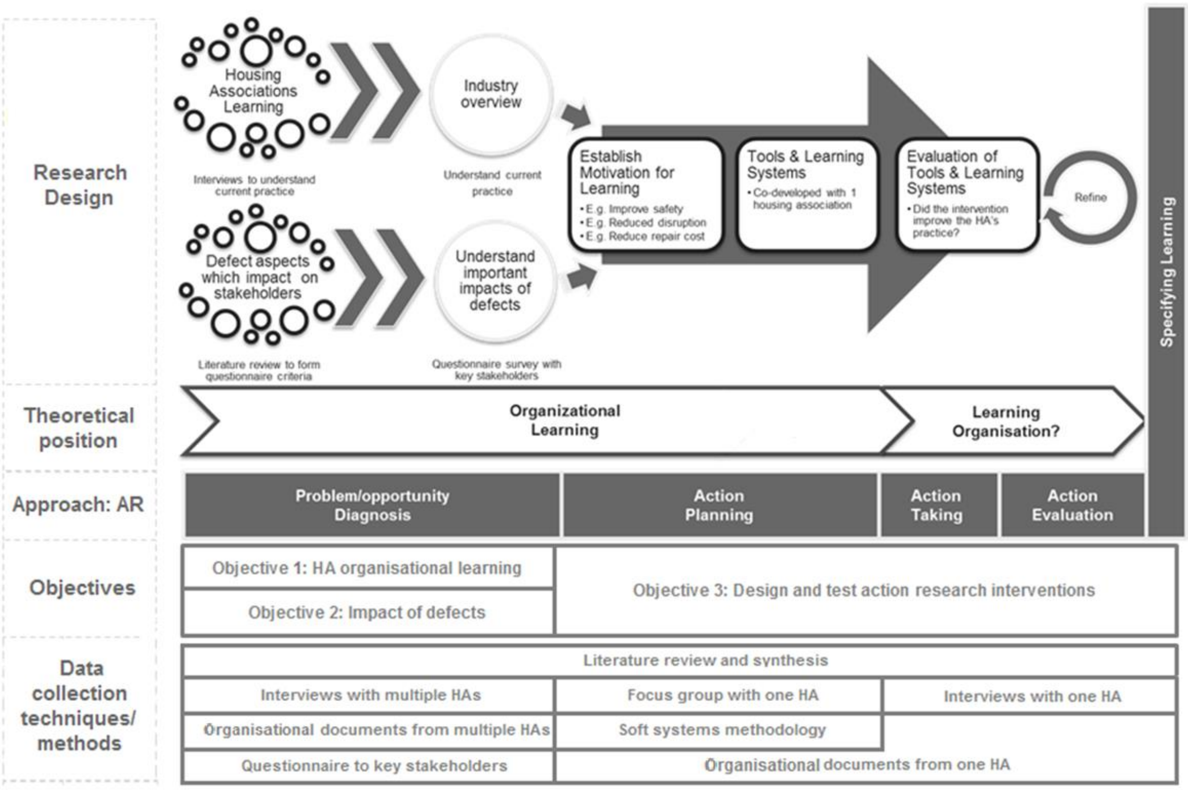

Figure 3.1: Overall action research process

3.4.1 Diagnosis

The diagnosis phase took place between May and September 2015. Two tasks were carried out in the diagnosis phase. These two tasks satisfied objectives one and two, and contributed towards objective three. The two tasks are discussed in more detail below.

Task one (objective 1)

The first task was to ‘gain insight into which impacts of defects are actually important to the key stakeholders involved in their detection and remediation from construction on site until the end of the warranty period’ (objective 1). Data for task one was collected through an electronic questionnaire survey (Section 3.6.2) which sought to explore the respondents’ views around the health and safety (H&S) implications of defects, the various costs associated, and the potential disruption caused. Task one took place between May and June 2015.

Task two (objective 2)

The second task was to 'understand HAs’ localised defects analysis procedures, and their current knowledge feedback loops to inform future practice’ (objective 2). Data collection for task two came from case study HAs (self-selected by the participants) and was qualitative in nature. Data was collected through semi-structured interviews (Section 3.6.3) and through the analysis of relevant organisational documents, e.g. defects management procedures and defect records (Section 3.6.4). Task two took place between June and September 2015.

The survey and interview phases contributed towards to the first two research objectives and informed objective three 'Design and test action research interventions to develop new defect assessment tools and learning systems to reduce targeted defects’. Objective 3 is discussed in more detail in the remaining AR phases below.

3.4.2 Action planning

The action planning phase took place between September and November 2015. During the action planning phase a defects management system was started to be developed with one HA (Objective 3). HA02's defects management system was explored through a focus group (Section 3.6.5), using soft systems methodology (Section 3.6.5). The HA's defects management system was found to be performing poorly, so a modification to HA02's defects management system was planned. The HA confirmed they would take action.

3.4.3 Action taking

The action taking phase took place between November 2015 and September 2016. From the action planning phase, four main activities were planned with HA02: changes to the data they capture, changes to their data analysis, the development of a bespoke defects management system with live data reporting dashboard (by the HA's in-house Information Technology (IT) team) to both manage the repair process and identify opportunities for learning; and the introduction of a new satisfaction survey to be sent to home occupants at the end of each repair. During the action taking phase regular contact was maintained with the HA. During the action taking phase the HA implemented three changes to improve their practice. How the action taken was evaluated is discussed in the action evaluation phase below.

3.4.4 Action evaluation

The action evaluation phase started in October 2016. Two stages of evaluation were carried out. The first evaluation point involved telephone conversations with the HA to explore whether the changes made were improving the HA's defects management and learning practices in the short-term. For the second action evaluation point a follow-up interview (semi-structured) (Section 3.6.3) took place in February 2017 at the HA's premises. The purpose of the interview was to evaluate the effectiveness of the changes made in respect of their ability to improve the HA's defects management and learning practices in the long-term.

3.4.5 Specifying learning

After each phase of the AR, a reflexive account on the knowledge gained from the action research is given.

3.5 Unit of analysis

The previous section discussed the overall action research process used in this research. This section discusses the unit of analysis. The unit of analysis is the ‘what’ or ‘whom’ is being studied (Babbie, 2012) and can refer to an individual, group, organisation, social artefact, or social interaction that is the target of the investigation (e.g. Bhattacherjee, 2012; Babbie, 2012). The unit of analysis taken for this research is the ‘defects management team’ (see Figure 3.2). This research was interested in how UK HAs, in practice, learn from past defects in an effort to reduce the prevalence of defects in future new homes, through understanding HAs’ localised defects information capture and analysis procedures, and their current knowledge feedback loops to inform future practice as guided by the OL model (see Section 2.9). The defects management team are the link between the business environment and site environment. The defects management team receive the defects information from home occupants and their own investigations on occasion in the site environment and they then use this information (in the business environment) to manage the repair process (deliver against the HA’s strategy, priorities etc.). In addition, the defects management team also translate the defects occurring in new homes (the defects information) into influenced organisational behaviour to shape the HA’s future strategy, priorities etc.

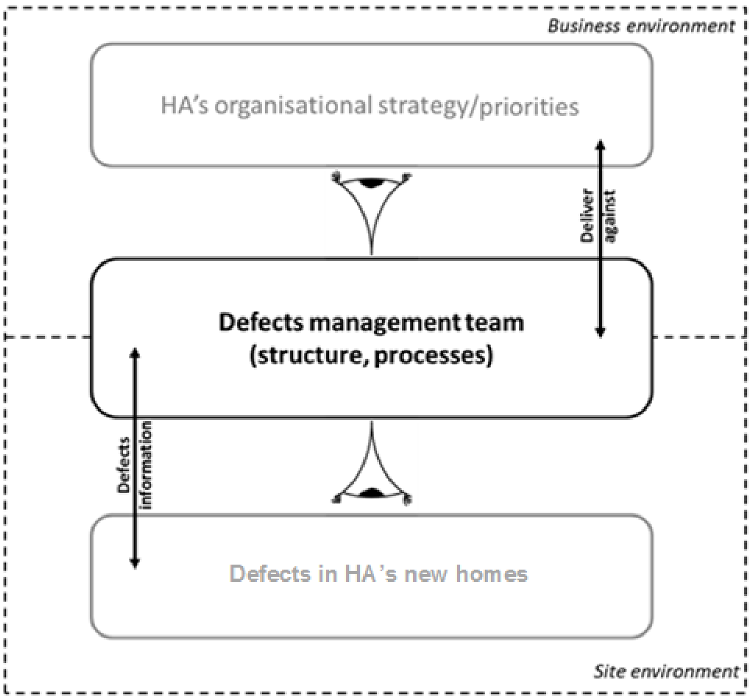

Figure 3.2: Unit of Analysis

During the diagnosis phase 12 defects management teams were investigated. During the action planning, taking and evaluation phases, one defects management team was studied.

3.6 Research techniques/methods

The previous section discussed the unit of analysis for the research. This section concentrates on the research techniques deployed during the phases of this AR project. The respective research techniques and a list of the phases they were used in are outlined in Table 3.1 below.

Table 3.1: Research techniques used during AR phases

AR phase	Research techniques
Diagnosis	• Literature review and synthesis • Questionnaire survey • Semi-structured interviews • Organisational documentation
Action Planning	• Focus group • Soft Systems Methodology
Action Taking	• Semi-structured interview • Organisational documentation
Action Evaluation	• Semi-structured interview

A literature review and synthesis was used during the diagnosis phase of this research. For task one of the diagnosis phase data were collected through an electronic questionnaire survey, which was used to explore the opinions and attitudes of key stakeholders in the new-build housing defect detection and remediation process in the UK on a Likert-type scale with respect to the impact of defects. During the diagnosis (task two), action taking, and action evaluation phases of the AR data were collected through semi-structured interviews. During the diagnosis, action taking, and action evaluation phases of the AR additional data were collected via organisational documentation. During the action planning phase data were collected via a focus group with HA02. Finally, due to the desire to take action to improve and the ill-defined problem, the principles of soft systems methodology (SSM) were deemed suitable for the action planning phase of the research. The respective research techniques, including their sampling strategies and analysis techniques are discussed in more detail below.

3.6.1 Literature review and synthesis

A literature review is a method of identifying, evaluating, synthesising and critically analysing the existing body of literature produced by researchers, scholars, and practitioners on the topic being studied. The literature review is undertaken with the goal of bringing the reader up-to-date with the current literature on a topic and forming the justification for future research in the area (e.g. Cronin *et al*., 2008; Fink, 2010). For example, Bryman (2012) argues that the literature review is the point in the research where the researcher can develop an argument to justify that there is little or no research in their proposed area. Cohen *et al*. (2011), for instance, suggest that the literature review should identify gaps to be explored and set out the key issues in that area and why they are key issues. In addition, the literature review should establish a theoretical framework for the research (Cohen *et al.*, 2011). The literature review for this research embraced two main areas: defects in construction (mainly house building) and organisational learning (OL). The review of defects in construction identified that defects have the potential to cause a number of impacts to a range of stakeholders. The review identified a lack of research into UK new-build housing defects; and further identified learning from defects (at an organisational level) as a key area for research. Building upon the OL from defects area of focus, the OL literature review included an examination of the general management literature, construction specific literature; and ultimately concluded in the adoption of a suitable OL model for research into OL in house building.

3.6.2 Questionnaire survey

A questionnaire consists of a number of questions typed in a definite order on a form (Kothari, 2004). There are different types of questionnaire, such as internet-based methods or postal methods (e.g. Adams and Cox, 2008; Kothari, 2004). Whilst both types of questionnaire are frequently used in research, it is argued that internet-based methods are better suited to very personal and sensitive issues as participants are more often willing to give more honest answers to a computer than to a person or on a paper questionnaire (Phellas *et al.*, 2012). Phellas *et al.* (2012) go on to explain that internet-based surveys are very economical, very fast, can allow large numbers of respondents to be questioned, and are capable of overcoming any barriers in relation to geographical location. The problems with internet-based questionnaires are that respondents may respond several times or pass questionnaires along to friends to answer; furthermore, many people dislike unsolicited email. Questionnaires are popular and fundamental tools for acquiring information on perception (Bird, 2009). The most common type of opinion and attitudinal questions ask respondents to rate aspects on a Likert scale (Adams and Cox, 2008). It is not uncommon for questionnaires to combine closed questions with open-ended questions (Kothari, 2004).

The questionnaire used during the diagnosis phase contained 15 closed and three open questions. 15 closed questions were drawn from the literature review relating to the potential impact of defects, and sought to explore the respondents' views around the health and safety (H&S) implications of defects, the various costs associated, and the potential disruption caused to home occupants and house builders. In addition three open questions were included to explore any additional potential impacts of defects that were not identified in the prevailing literature. The survey asked the respondents to prioritise the pre-determined impacts of defects on a scale of 'Not a priority', 'Low priority', 'Medium priority', 'High priority' to 'Essential'. The justifications for using internet-based questionnaires are that the survey sought to identify the opinions and attitudes of a large number of respondents from a range of geographical locations in respect to a sensitive issue (in this case defects). To overcome the potential problem of respondents responding several times the survey used the SurveyMonkey tool and limited the responses to one per person. The survey was distributed in May 2015 through a web link with a covering email which set out the purpose of the survey as well as research ethics safeguards. The questionnaire was piloted to test for clarity and usability before the main survey was carried out. The survey targeted the four key stakeholders involved in detecting and rectifying defects in new homes identified in the literature. The full survey can be seen in Appendix 1.

Sampling strategy

A sample is a smaller but hopefully representative collection of units from a population used to determine truths about that population (Field *et al.*, 2012). More specifically, sampling involves selecting a sample from a larger population and expecting the information gained from that sample to enable judgements about the larger population (Sharma, 2015).

The questionnaire distribution list for objective one was drawn from the National House Building Council’s (NHBC) records as the NHBC is the UK's leading standard-setting body and provider of warranties for new homes, and is the UK’s largest independent building inspection service who is responsible for over 50% of the building control market (NHBC, 2015). The researcher was given controlled access by the NHBC to probe their datasets, including a list of registered builders, a list of their warranty staff, a list of their building inspectors, and details of home occupants who had previously had defects rectified under their warranty. The NHBC warranty typically offers 10 years of post-completion cover (in addition to certain cover before completion) and is split into two sections: cover during the first two years (the builder’s liability period) and cover during years 3-10 (the warranty period) (NHBC, 2012). Under the terms of the warranty the house builder is responsible for rectifying any breach of the requirements within the builder’s liability period and any breach that may result in a warranty claim in years 3-10 will ultimately affect the builder’s renewal fee (NHBC, 2011).

The average response rate for internet-based questionnaires is argued to be circa 30% (Nulty, 2008). Response rates in questionnaires tend to be maximised when respondents have an interest in the subject of the research (Phellas *et al.,* 2012). Nulty (2008) suggests repeat reminder emails as a method of boosting online survey response rates. Zúñiga (2004) advocates at least three reminders to boost response rates. The survey was distributed to 2,003 people drawn from the NHBC’s database, including 817 of the 2,983 home occupants who have had a defect rectified under their warranty during the financial year 2013-14; 161 warranty provider’s staff, 209 building inspectors; and, 816 of the 2,892 active house builders on the NHBC’s register. The duration of the survey was one month with three follow-up email reminders. The sample size was calculated as shown below.

Formula used to calculate sample size (Bartlett *et al.,* 2001): $No = (t)^2 x (s)^2 / (d)^2$

Sample size calculation parameters (Bartlett *et al.,* 2001):

t = confidence (95% = 1.96)

d = margin of error (3%)

s = standard deviation (5/4 = 1.25)

no = number of responses needed for an adequate sample for the above parameters

Sample size calculation:

$$No = (1.96)^2 x(1.25)^2/(5x0.003)^2 = 267$$

Correction factor calculation (Bartlett *et al.,* 2001): Correct number (n) = no/(1+no/actual population)

Building inspector = 267/(1+267/209) = 117

Warranty provider = 267/(1+267/161) = 100

Builders = 267/(1+267/2892) = 244

Home owners = 267/(1+267/2983) = 245

The overall response rate for the survey was 15% with a total of 292 responses. Whilst the response rate was not as high as anticipated the sampling strategy and responses still provided insight into a previously unexplored phenomenon and allowed the researcher to gain a level of perception from the respondents.

Data analysis

The questionnaires generated large volumes of quantitative data. The data was analysed using simple statistical analysis, by identifying the mode within the responses. As the questionnaire sought to order people's level of priority (from five categories e.g. not a priority to essential) with regard to the potential impact of defects, the questionnaire design produced an 'ordinal' level of measurement (Rosenthal, 2012) in which it was not possible to quantify the size of the gap between the categories or determine if the sizes were equal (as with many Likert-type surveys). Often researchers will ignore ordinality and numbers such as 1, 2, 3, representing the ordered categories will be treated as numbers having metric properties, a procedure which is incorrect (Joreskog and Moustaki, 2001). The ordinal data was analysed by calculating the percentage of each of the five categories (e.g. not a priority, low priority, medium priority, high priority, and essential) within a total number of a particular set of stakeholders (e.g. house builders) for the individual impacts of defects. The results were displayed using diverging stacked bar charts (Heiberger and Robbins, 2014).

3.6.3 Semi-structured interviews

Interviews are said to be a conversation between an interviewer and interviewee with the purpose of eliciting information (Moser and Kalton, 1971). Remenyi (2012) further explains that the objective of the interview is to acquire data or evidence to be used to help answer the research question. There are many types of interview available to researchers: structured, semi-structured and unstructured (Bell and Waters, 2014). Structured interviews use a set of predetermined questions and a standardised technique for recording the responses (Kothari, 2004). Semi-structured interviews use some pre-formulated questions, but require no strict adherence to them and recognise that new questions may emerge during the discussion (Myers, 2008). Unstructured interviews do not follow any predefined questions or standardised techniques for recording information (Kothari, 2004). Bell and Waters (2014) explain that structured and semi-structured interviews allow for data to be easily recorded, summarised and analysed, whereas unstructured interviews require a great deal of expertise to control and a large amount of time to analyse. Barriball and While (1994) argue that semi-structured interviews are best suited for exploring the perceptions and opinions of respondents with regard to complex and sensitive issues (for example, how HAs learn from defects) as they enable probing for more information and clarification of answers. Another advantage of a semi-structured interview is that a framework is established; therefore recording and analysis are simplified (Bell and Waters, 2014).

When using interview techniques it is important that the informant has the knowledge to answer the type of questions which will be asked (Remenyi, 2012; Bhattacherjee, 2012) and in this scenario an approach where the interviewer takes on the role of a student who is asking questions from an expert is the easiest and quickest to pick up and implement (e.g. Adams and Cox, 2008). The effectiveness of the interview also depends on the questions the researcher puts to the informant (Remenyi, 2012).

1. During the diagnosis phase questions were drawn from the adopted OL model as well as previous recommendations for learning from defects in the extant literature. Table 3.2 outlines the OL constructs based on Berkhout *et al.* (2006), and the interview questions asked to gain insight into the HAs' defect management and learning processes during the diagnosis phase (a full copy of the interview schedule can be found in Appendix 2).

Table 3.2: Summary of interview schedule for diagnosis phase

OL Constructs	Interview questions
0. New signal	Can you provide me with an overview of your defects management process?
	Do you record post-completion defect data?
	At what level of detail is the data captured?
	Do you use any categories to classify defects? If so, what categories are chosen?
1. Signal recognised as need for change	Do you analyse defect data? If so, what do you analyse?
	How frequently is the analysis undertaken?
	Why do you analyse defect data?
	How do you decide that the findings present a need for a change?
2. Experimentation and search for new options	If a change is needed, how do you identify adaptation options?
3. Internal selection, articulation and codification into new routines	How are adaptation options decided and selected, and by who?
	Once selected, how are the new processes communicated around the organisation?
4. Feedback and iteration	When implemented, how do you monitor the new processes to make sure they are viable and remain viable?

2. During the action taking phase of the research three questions were asked:

   Q1: "What changes have you made to your spreadsheet so far?"

   Q2: "How is the development of your new bespoke defects management system progressing?"

   Q3: "What changes have you made to your data analysis techniques so far?"

The questions were asked simply to get an update on the HA's action taking based on the planned action.

3. During the second phase of action evaluation, six questions were planned for the interview, however, only the first three questions actually got asked because the interview digressed from the schedule due to organisational change:

   Q1: "How is the bespoke system progressing?"

Q2: "Are you still planning on introducing a satisfaction survey for repairs?"

Q3: "I can see that you have made changes to your defect data collection and analysis procedures but not introduced a satisfaction survey for repairs, why did you adopt those recommendations (and not others)?"

Q4: "Have the changes provided you with a better understanding of what is going wrong within your properties?"

Q5: "Have the changes helped you to improve your defects management and learning? If so, which changes have been most beneficial, and how have they helped you to improve?"

Q6: "In addition to the changes made, are there any aspects you would look to further develop in the future?"

Questions 1, 2, and 3, sought to explore which changes had been made compared to the recommendations made during the action planning phase, and why those had been made compared to other areas not adopted. Questions 4, 5 and 6 aimed to better understand how the changes made helped (if they did) the HA to improve their defects management and learning practices.

The setting for the interview can also influence its success (e.g. Kothari, 2004; Adams and Cox, 2008). Kothari (2004) argues that every effort should be made to create a friendly comfortable atmosphere, so that respondents feel at ease when talking to the interviewer. It is further argued that the more natural the setting for the participants, the more likely they are to give naturalistic responses (Adams and Cox, 2008). Bell and Waters (2014) suggest that interviewees who agree to be interviewed for research are doing the researcher a favour, therefore they deserve consideration. Johnson (1984) goes on to explain that interviewees are unlikely to appreciate interviews that take longer than expected. Remenyi, (2012) explains that an interview duration of one hour is typically a satisfactory period of time in which a considerable amount of data can be collected without being too tiring or time consuming for the researcher or informant.

Data collected during interviews is largely verbal, therefore the researcher needs to capture it as quickly and accurately as possible (e.g. Kothari, 2004; Bhattacherjee, 2012). There are a number of ways of recording interview data, for example recording the interview (visually or audio), taking interview notes, or box ticking (e.g. Bhattacherjee, 2012; Dawson, 2007). The benefits of recording interviews are that they produce a comprehensive record of the interview (Dawson, 2007). Interview notes, however, are deemed essential and will normally be taken as the informant is speaking (Remenyi, 2012). Bhattacherjee (2012) further emphasises that interview notes will be the only record of the interview should the recording equipment fail. The other advantages of taking notes are, that it is low cost and also may stimulate the interviewee to provide further information (as they will see the researcher/interviewer taking notes down and will realise that they are talking about an important point) (Dawson, 2007). The main disadvantages of taking down notes is that it is difficult and will often lead to incompleteness (Remenyi, 2012), and as note taking requires concentration it may be difficult for the researcher to fully engage with the interview and probe for more information (Dawson, 2007).

The weaknesses of interviews are: that they are time consuming, and expensive (Kothari, 2004), that they are a highly subjective technique and there is a danger of bias (Bell and Waters, 2014); and, that the presence of the interviewer may also over-stimulate the interviewee into fabricating responses to make the interview more interesting (Kothari, 2004).

This research used semi-structured interviews. The justification for choosing semi-structured interviews is that they are well suited for exploring the perceptions and opinions of respondents (in this case HAs) with regard to complex and sensitive issues (in this case defects), as they enable probing for more information and clarification of answers. Furthermore, semi-structured interviews had been used to good effect in conjunction with the adopted OL model to understand how functional departments within HAs and house builders learn from and respond to persistent problems (e.g. Berkhout *et al*., 2006). The interviews were initially arranged via an e-mail which set out the premise of the interviews along with research ethics safeguards; following this email the interviewees were self-selected by the HA due to their expert knowledge of and involvement in the defects management process, and their involvement in introducing change within their respective organisations – this is explained in further detail in the sampling strategy section below. As this research sought to explore HAs' working practises (and subsequent changes to that practice) from the experts involved, the student-expert interview approach was adopted, and for practical reasons (and to be sympathetic to the interviewee) the interview structure ranged from one-to-one to one-to-many, and the notes taken during the interview were combined as a record against the single HA. Further, the interviews lasted around one hour and in search for true-to-life responses, the interviews took place at the participants' company headquarters. During the interviews field notes were taken as consent for audio recording was not given by the participants.

Sampling strategy

Objective two involved researching HAs to understand their learning processes through semi-structure interviews and organisational documents (discussed in section 3.6.4 below), and data collected was qualitative in nature.

In respect to the number of HAs required for this part of the research, saturation is argued as important to achieve excellent qualitative work (e.g. Morse, 1995; Bhattacherjee, 2012). Saturation can be defined as the point at which no additional data are being found whereby the (researcher) can develop properties of the category (Glaser and Strauss, 1967:65). It is proposed that saturation typically occurs at around 12 participants in groups of the same kind (in this case HAs) (Guest *et al.*, 2006). For reasons of saturation 12 HAs were used for this research. Contact details of 26 senior managers of HAs were obtained from the following sources: the National Housing Federation (NHF), the Housing Forum; and, a repair and maintenance consultancy who deals specifically with affordable housing. An email was sent to senior managers of 26 HAs, which set out the premise of the research (and proposed interviews) along with research ethics safeguards. From the 26 emails, 10 senior managers showed interest in the research. In one case, the senior manager forwarded the initial email onto other relevant housing association groups, which helped to recruit the final two HAs. The smallest two HAs used in this study developed up to 500 new homes per year, four HAs between 500 and 1,000, two HAs between 1,000 and 1,500, three HAs between 1,500 and 2,000, and the largest HA developed between 2,000 and 3,000 homes per year. The HA sample set provided geographical coverage for the whole of England with eight HAs developing homes in the south of England, four in the midlands, one in the north of England, three in London, and one HA developed homes nationwide.

The 12 senior managers who showed interest in the research forwarded on the researcher's email to the members of their organisation who had expert knowledge of and involvement in the defects management and learning processes (defects management team). A representative from the defects management team then made contact with the researcher to arrange a suitable date for the interview. The defects management team member then arranged for others in the organisation who were important to the HA's learning from defects to attend the interview. Table 3.3 below outlines the profile of the HAs and interviewees.

Table 3.3: Profile of HAs and interviewees

No.	Description	Participant(s) role(s)
HA01	Developer of between 500 and 1,000 new affordable homes per year in the London area	New Homes Manager
HA02	Developer of between 500 and 1,000 new affordable homes per year in the south of England	Administrator Head Clerk of Works Quality Manager Asset Manager
HA03	Developer of between 1,500 and 2,000 new affordable homes per year in the south of England and midlands	Quality Manager
HA04	Developer of between 500 and 1,000 new affordable homes per year in the south of England and midlands	Customer Care Manager Development Director
HA05	Developer of between 500 and 1,000 new affordable homes per year in the London area	Customer Care Manager
HA06	Developer of between 2,000 and 3,000 new affordable homes per year in the south and north of England	Head of Quality
HA07	Developer of between zero and 500 new affordable homes per year in the London area	Head of Strategy
HA08	Developer of between 1,000 and 1,500 new affordable homes per year in the south of England	Development Manager
HA09	Developer of between 1,000 and 1,500 new affordable homes per year in the south of England and midlands	Customer Care Manager
HA10	Developer between 1,500 and 2,000 new affordable homes per year in the south east of England and midlands	Head of Quality
HA11	Developer of between zero and 500 new affordable homes per year in London and the south east of England	Head of Quality New Homes Manager Development Director
HA12	Developer of between 1,500 and 2,000 new homes per year nationwide	Asset Manager Customer Care Manager

Data analysis

Interviews produce large volumes of qualitative data. The qualitative data was analysed using thematic analysis. Thematic analysis is a method of identifying, analysing and reporting themes within data (Braun and Clarke, 2006); thematic analysis can be utilised to find solutions to real world problems, and can be used to study topics as opposed to individual experience (Guest, 2012). This research seeks to better understand the topic of how HAs learn from defects, and improve a selected HA's learning capabilities, therefore the ability of thematic analysis to study topics and find solutions to real world problems is advantageous. Thematic analysis has been demonstrated to have a high degree of clarity (Fereday and Muir-Cochrane, 2006). The advantages of thematic analysis are; flexibility, ability to summarise key features in a large body of data, highlight similarities and differences within data sets, and can generate unanticipated insights (Braun and Clark, 2006). The limitations are that thematic analysis may fail to identify some of the data containing subtle differences (i.e. nuances) (Guest, 2012).

The themes identified to analyse the data were positioned around the OL constructs and the questions related to those. For example, for the 'new signal' construct the question of 'at what level of detail is the data captured?' identified a number of recurrent themes including: 'address' (the address of the property experiencing the defect), 'completion date' (the date that the property was completed), 'scheme ID' (the identification number for the scheme in which the property is in), and 'contractor' (the name of the contractor responsible for the build).

3.6.4 Organisational documentation

Organisational documentation is commonly used in research. Organisation documents enable the researcher to triangulate the research participants' accounts against a formal source (Lu and Sexton, 2009). Defect records have been utilised in previous research (e.g. Olubodun and Mole, 1999; Sommerville and McCosh, 2006) and have been argued as a suitable sample for defect analysis (Craig, 2007). Georgiou *et al*. (1999) further argue that defects records provide objective information with regards to the magnitude, cost and cause of defects, therefore making them an ideal source of data for research into defects. Table 3.4 below outlines the company documentation used during the different phase of the AR. Extracts from the documents provided can be seen in Appendix 3.

Table 3.4: Organisation documents obtained

AR Phase	HA No.	Document	Description
Diagnosis	HA01	Overview of defects log	Visual demonstration of HA's defects management IT systems, network areas and data captured; and, reports produced.
		Change control process document	Document outlining HA's formal change control process.
	HA02	Presentation	PowerPoint presentation providing overview of HAs defects management processes.
		Overview of processes and IT systems	Visual demonstration of HA's defects management IT systems, network areas and data captured; and, reports produced.
		Defects log	Exports of HA's defects log (record of all defect data and actions).
		Defects investigation procedure	Document outlining HA's formal defects investigation procedure.
	HA03	Company document	Document containing HA's defect measures, including budget for repairs and defect reporting processes.
	HA04	Defects log	Exports of HA's defects log (record of all defect data and actions).
		Company report	List of project measures for showing current performance for a given period.
	HA05	Defects log (blank)	An export of HA's defects log (record of all defect data and actions), containing no defect data, but showing headings for data typically captured.
	HA07	Defects log	Exports of HA's defects log (record of all defect data and actions).
	HA08	Defects log	Exports of HA's defects log (record of all defect data and actions).
		Company report	List of project measures for defects and graphs showing current performance for a given period.
		Post-handover defects management procedure	Document outlining HA's formal defects management procedure.
	HA12	Overview of processes and IT systems	Visual demonstration of HA's defects management IT systems, network areas and data captured; and, reports produced.
		Defects log	Exports of HA's defects log (record of all defect data and actions).
Action taking	HA02	Defects log	Exports of HA's modified defects log (record of all defect data and actions).
Action evaluation	HA02	Defects log	Exports of HA's modified defects log (record of all defect data and actions).

Sampling strategy

The HAs who took part in the semi-structured interviews were asked to provide company documentation where possible (see section 3.6.3 for the HA sampling strategy).

Data analysis

Organisational documentation produces large volumes of qualitative data. The qualitative data was analysed using thematic analysis as outlined in section 3.6.3.

3.6.5 Focus groups

Focus groups are in-depth group discussions coordinated to explore a particular set of subjects (e.g. Kitzinger, 1994; Bell and Waters, 2014) and identify a range of perspectives on a topic from the perspective of the participants themselves (Hennink and Leavy, 2014). Focus groups offer rich amounts of data and different perspectives on a given topic through interaction, and serve as a useful tool for gaining insight into different views and dynamics within a group context, for example consensus and disagreement (Litosseliti, 2003). In addition, focus groups are able to produce collective narratives on the issues that move beyond individual perspectives to generate a group perspective on the issue discussed (Hennink and Leavy, 2014) (in this case what HA02's defects management and learning systems were meant to enable them to do).

There are two broad types of focus groups: a structured approach which results in more engagement between moderator and participants; and, a less rigid approach which results in more engagement between participants (e.g. Morgan, 2002; Liamputtong, 2011). Morgan (2002) goes on to explain that, depending on the research topic and theoretical approach, both approaches can be adopted within the social sciences. In a focus group setting, the moderator should facilitate discussion rather than direct it. The moderator (often also the researcher) typically introduces the topic and assists the participants to discuss it, encouraging interaction and guiding the conversation, thus playing a major role in obtaining good and accurate information (Liamputtong, 2011). In a focus group setting, the communication between the participants themselves should be the emphasis (Gaiser, 2008; Liamputtong, 2011). In focus groups a purposive sampling strategy should be used for selecting group participants (Rabiee, 2004), where participants are selected on criteria that they would have something to say on the topic and would be comfortable interacting with each other and the moderator (Richardson and Rabiee, 2001). Liamputtong (2011) further emphasises that the focus group participants should be chosen because they are capable of providing valuable contributions. Krueger (1994) also argues that rich data can only be produced if the group participants are prepared to wholly engage in the discussion. For reasons of rich data capture it is argued that focus groups work best when a comfortable, permissive environment is created, where the moderator encourages comments of both negative and positive type, without making judgements about the responses (Liamputtong, 2011). The focus group took place at the HA's headquarters and aimed to explore the situation the stakeholders identified as problematical to understand the HA's issues in order enable them to reach accommodations (the participants themselves) to bring about change (this focus group used the less rigid approach).

Focus groups allow the researcher to take a less directive and dominating role, and through the utilisation of open ended questions, and without the pre-set boundaries or clues for response categories; individuals are able to say what they really think (Krueger and Casey, 2014). Focus groups should use clear, short and simple questions to ensure they are easily understood and participants can respond, and remember. The questions should be open and unidirectional to allow participants to share their views, whilst staying on topic in the discussion. The method of questioning should sound informal and conversational to create discussion, and most importantly the questions should be designed to promote discussion (Hennink and Leavy, 2014). During the action planning focus group, the participants were asked the following two questions:

> Q1: "What is your current system supposed to enable you to do?"
>
> Q2: "What activities would be required in order to achieve the described system?"

Hennink and Leavy (2014) argue that focus groups should last around one to two hours because longer sessions may lead to participant fatigue whereby the value of the information declines. Finally, focus group discussions can be recorded in multiple ways: field notes, memory, flip charts, audio recording, and video recording (Krueger and Casey, 2014). The most common ways focus groups are recorded in social science are by using an audio recorder and a note-taker's written summary (Hennink, 2007). Video-recording of focus group discussions is not common in social science research as there is often little reason to capture a visual record of the discussion in addition to the audio-recording (Hennink and Leavy, 2014). Audio-recording focus groups are preferred to note-taking alone as it offers a verbatim record of the discussion, and increases data quality (Hennink, 2007), however the note-takers summary is important because it will be the only record of the discussion should the recording device fail or participants refuse permission to record the discussion (Hennink and Leavy, 2014). The action planning focus group lasted around two hours, and during the focus group notes were taken as consent for audio recording was not given by the participants.

Soft systems methodology

During the focus group soft systems methodology (SSM) was used to guide the action planning. SSM is defined as “an organised, flexible process for dealing with situations someone sees as problematical, situations which call for action to be taken to improve them, to make them more acceptable, less full of tensions and unanswered questions” (Checkland and Poulter, 2006:4). Problematical situations contain people who are trying to act purposefully, with intention (in this case managing and learning from defects). SSM is well suited to ill-structured real world problems (in this case improving how the HA manages and learns from defects with no clear improvement opportunity) (Khisty, 1995). SSM is aimed at bringing around an end to the “problem” through accommodations to enable action to be taken to improve the situation with a focus on implementing change. SSM provides a set of principles which can be both adopted and adapted (in any way which suits the specific nature of each situation in which it is used) for use in any real-world situation in which people are intent on taking action to improve it (as is the case with the HA presented in this research) (Checkland and Poulter, 2006). SSM is applied as a participative process whereby a facilitator works with the problem stakeholders (Green, 1999). The drawbacks of SSM are that it requires large input and participation from those involved over a sustained period of time. Moreover, when applying the SSM, the researcher needs to acknowledge himself/herself as an active part of the problematical situation and not a neutral observer (Green, 1999). The use of SSM as an approach to assist stakeholders to achieve a common understanding of the problematical situation in construction has been demonstrated in Green’s work (1999). Green’s work (1999) suggests SSM has potential to improve value management practice in the early stages of a construction project. SSM, in its idealised form, is designed as logical sequences of four stages (Checkland, 2000):

(1) Finding out about a problematical situation: The problematical situation is typically explored through the development of a rich picture to document the overview of the business situation (Paul *et al.*, 2013), in order to identify relevant systems of concern (Green, 1999). A rich picture is used as pictures can be taken in as a whole and help to encourage holistic rather than reductionist thinking about a situation (Checkland, 2000). The key tasks in finding out about the problematical situation are to undertake exploratory discussions with people in the problematical situation to identify the main stakeholders and the situation (and potential issues) at present (Checkland, 2000).

(2) Formulating some relevant purposeful activity models: Purposeful activity models used in SSM are intellectual devices, which can be used to help structure an exploration of the problematical situation being addressed (Checkland, 2000). A purposeful activity model is a model of the activities which fulfil the respective stakeholders' world-views and form an ideal system state (Ramage and Shipp, 2009). To build a purposeful activity model, a clear definition of the purposeful activity is required (Checkland, 2000), in SSM known as "root definitions". Root definitions develop each stakeholder view as a sentence (Paul *et al.*, 2013). The differences between these definitions can be compared to identify where they overlap and where they are in conflict with each other, which can lead to the development of a consensus model which can be used to explore possible improvements to the existing situation (Paul *et al*., 2013). The primary aim of purposeful activity models are to stimulate cogent questions in debate about the current/real-world situation and the desirable changes to it (Chekland, 2000).

(3) Debating the situation: The starting point of debating the situation is to compare the purposeful activity models (i.e. the ideal system state) to the current/real-world situation (Green, 1999). The differences between the models and the current/real-world situation provide a fruitful arena to discuss conceivable changes to the problematical situation (Khisky, 1995). For example, what change is needed, why it is needed, how it can be achieved, what action is required, and who will take the

action (Checkland, 2000). The aim of the debate is to identify changes which would improve the situation and are regarded as both desirable and (culturally) feasible which respective stakeholders can live with (Checkland, 2000), and accommodate between conflicting interests which will enable action-to-improve to be taken.

(4) Taking action: When stakeholders accept changes to be systemically desirable and culturally feasible (Khisky, 1995) then the final activity of the SSM approach is taking action to improve the problematical situation (Green, 1999).

The SSM approach adopted in this research was positioned around activities two and three of the described approach (Checkland, 2000) (Figure 3.3): (1) finding out about a problematical situation; (2) formulating some relevant purposeful activity models; (3) debating the situation; and, (4) taking action in the situation to bring about improvement.

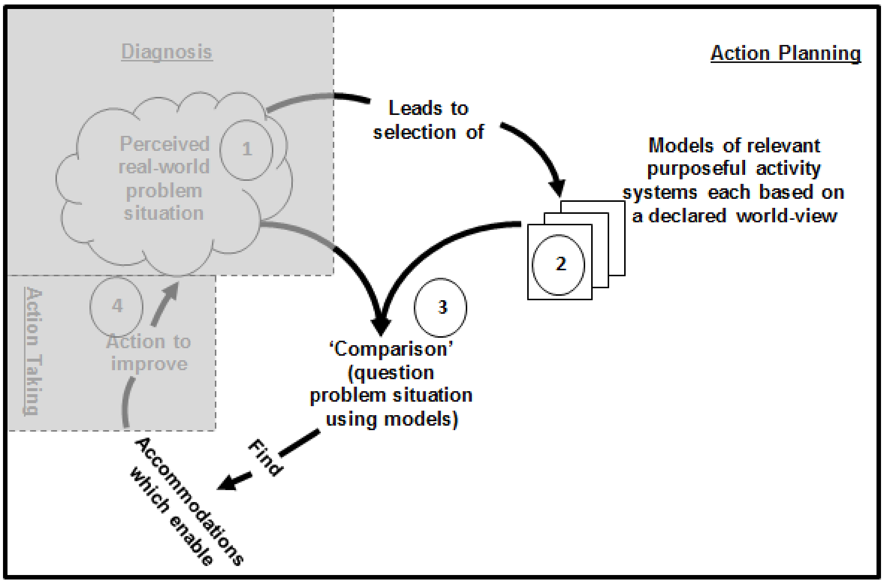

Figure 3.3: Soft system methodology model (adapted from Checkland, 2000)

The reason for adapting the SSM to only using activities two and three of the described approach was because activities one and four overlapped with the diagnosis and action taking phases of the AR approach. Practically speaking the researcher had already found out about the problematical situation during the diagnosis phase of the AR cycle and decided to adopt the SSM principles due to the HA's intent to take action and the lack of a clearly defined problem. In activities (2) formulating a relevant purposeful activity model and (3) debating the situation a focus group took place in October 2015 with three participants from the HA's asset management arm: the Head Clerk of Works, the Aftercare Administrator, and the Asset Manager; with the researcher as the moderator. The aim of the focus group was to explore the situation the stakeholders identified as problematical to understand the HA's issues in order enable them to reach accommodations and identify desirable and feasible changes. The action planning focus group started with the facilitator (the researcher) outlining his understanding of the HA's current situation (based upon the diagnosis phase) to ensure it was accurate. The individual participants were then asked to explicitly outline what their defects management and learning system was meant to enable them to do (their world views) (discussed in 3.6.5).

After identifying the individual stakeholder's world views, a purposeful activity model (one model as a level of consensus was agreed at an early stage) was developed to depict what the HA's defect management and learning system was meant to enable them to do. Developing the purposeful activity model involved asking the collective stakeholders to clearly outline what activities would be required (step-by-step) for the described system to work.

The purposeful activity model (the required activities) was then compared to their current system (the existing activities) in order to identify potential adaptation options to bring reality in line with what the system should be doing. After identifying the clear statement of what the HA's current system is and should enable them to do and arriving at desirable and feasible changes a number of potential options were discussed with the HA. The options were identified from other HAs' working practices (Section 4.2.2) and the impact of defects (Section 4.2.1). The other HAs' working practices provided the participants of the focus group with examples of different ways of managing and learning from defects and their practical application and perceived benefits of the respective options. The impact of defects findings provided the HA with an insight into what other key stakeholders involved in defect detection and remediation found important and provided the HA with a yard stick to measure their own priorities against.

Upon completion of the focus group, the researcher sent a follow-up email to all of the participants outlining the discussion of the focus group and areas covered, as well as providing brief recommendations to enable the HA to achieve their desired aims.

Sampling strategy

During the action planning the HA who was most interested in taking further part in the research and introducing change into their organisation was targeted (HA02). In addition, the HA who could have benefitted most from intervention was also targeted (HA05). The action planning focus group took place with three key stakeholders in HA02 who had a keen desire to improve their learning and defects management practices. The participants were the Aftercare Administrator, the Head Clerk of Works, and the Asset Manager: each involved directly in the defects management system and the identification of what is going wrong in their properties, consequently playing a crucial part in the HA's defect reduction attempts. HA02 was used for the taking and evaluation phases.

Data analysis

Focus groups produce large volumes of qualitative data. The qualitative data was analysed using thematic analysis (further details of thematic analysis can be found in section 3.6.3).

3.7 Validation

Validation can be described as whether the research design is sufficiently rigorous to provide support for decisive conclusions and desired recommendations (e.g. Bickman and Rog, 2009) (i.e. whether the research is trustworthy). In (primarily) qualitative studies validation consists of credibility, transferability, dependability and confirmability (e.g. Shenton, 2004; Guba, 1981). Credibility (internal validity) deals with the correspondence of the research findings in comparison to 'reality' (Merriam, 1998). Transferability (external validity and generalisability) is the process of establishing the domain to which a study's findings can be generalised (Yin, 2009). Dependability (reliability) involves demonstrating that the operations of a study can be repeated with the same results (Yin, 2009). Confirmability (objectivity) relates to how much the research's findings are the result of the experiences and ideas of the informants, rather than the characteristics and preferences of the researcher (Shenton, 2004). Table 3.5 below outlines how the research was validated.

Table 3.5: Overview of how the research has been validated

Validation criteria	**Aspect**	**Technique**	**Comment**
Credibility (internal validity)	Adopting established research techniques	Literature review	Review of defects in construction and OL literatures
		Focus group	One focus group with three participants
		Interviews	Semi-structured interviews with 19 interviewees from 12 HAs
		Organisational documentation	18 documents from eight HAs
		Questionnaires	Questionnaire responses from 292 respondents
		Soft Systems Methodology	The adoption of the principles of SSM during the focus group
	Triangulation	Use of multiple methods of data collection	Combination of data collection methods: interviews, questionnaires, focus groups, and company documentation
		Comparing qualitative data to a formal source	Compared the interview and focus group data to a formal source i.e. company documentation and defects records
	Member checks	Referring interview notes and focus group records back to participants to verify accuracy	An example of a response from HA10 below: "I am happy with the responses. Hope this helps, Head of Quality"
	Peer scrutiny	Opportunities for peer scrutiny and feedback sought	The findings from the diagnosis phase were published in Construction Management and Economics and The International Journal of Building Pathology and Adaptation. The findings from the action planning phase were published and presented at Association of Researchers in Construction Management conference
	Reflexive commentary	Structure of the AR to provide a reflection during each phase	Each phase of the AR findings are presented first showing practice followed by a reflection on that practice
Transferability	External validity and generalisability	Generalising results to theory	Adopting the position set out by Yin (2009) and generalising the results from this study to OL theory
		Saturation	Data collection from 12 HAs and saturation point reached
		Explicit research design	Producing a clear research design that other researchers can understanding
Dependability	Reliability	Explicit research design	Producing a clear research design that other researchers can understanding
		Drawing questions from literature	The questions were positioned around the adopted OL model and drawn from the existing recommendations to learn from defects
		Using the same questions for each HA	The same interview schedule was used in all 12 interviews
Confirmability	Objectivity	Drawing questions from existing literature	The interview questions were drawn from a literature review
		Referring interview notes and focus group records back to participants to verify accuracy	An example of a response from HA10 below: "I am happy with the responses. Hope this helps, Head of Quality"
		Comparing qualitative data to a formal source	Compared the interview and focus data to a formal source i.e. company documentation and defects records
		Soft Systems Methodology	Used SSM during the action planning phase to enable HA02 to explore their own problematic setting with the researcher as a facilitator

The four validation aspects are discussed in more detail below.

3.7.1 Credibility

In order to ensure the credibility of the research, the researcher can use a number of techniques, including: adopting established research techniques, triangulation, member checks, peer scrutiny, random sampling, tactics to help ensure informant honesty, and reflexivity of the researcher (e.g. Shenton, 2004). This research used the adoption of established research methods, triangulation, member checks, peer scrutiny, and the researcher's reflective commentary of the research project to increase credibility.

Adopting established research techniques

Yin (2009) argues the need to establish correct operational measures for the concepts being studied. Shenton (2004) argues that the techniques of data collection should be derived from those that have been successfully utilised in previous comparable projects (where possible). This research used a number of techniques to collect data, including a literature review (see Section 3.6.3), a focus group (see Section 3.6.5), interviews (see Section 3.6.3), organisational documentation (see Section 3.6.4), and questionnaires (see Section 3.6.2).

Semi-structured interviews are a common research technique and had previously been successfully used in conjunction with the adopted OL model to understand how functional departments within HAs and house builders learn from and respond to persistent problems. Further, the interview questions were drawn from the prevailing literature. Focus groups are another widely used research technique as they enable researchers to generate a group perspective – in this case what the HA's defects management system should be doing. Further, focus groups are regularly used in conjunction with SSM. Another commonly used research technique is organisational documentation, which allows a researcher to obtain a formal source of information. Finally, questionnaires are popular tools for acquiring information on perception.

For the questionnaire, the credibility is the extent in which the data collection instrument measures what it is intended to measure (Kimberlin and Winterstein, 2008; Brace, 2013). Credible questionnaires require that researchers ask whether the questions posed adequately address the objectives of the study, and whether those surveyed are capable of answering the question posed to them (Brace, 2013).

Brace (2013) goes on to explain that pilot studies are crucial to developing valid questionnaires. For the purposes of this research, the questionnaire sought to better understand which impacts of defects were actually important to those who experience them from construction on site to the end of the warranty period. To achieve this objective, the questionnaire criteria were drawn directly from existing literature to identify the potential impact of defects. Further, the key stakeholders to be surveyed were identified by reviewing the literature related to new-build housing defects occurring from construction on site through to the end of the warranty period, and drawn from NHBC records, therefore ensuring that they were capable of answering the questions.

The survey was pilot tested on small scale to check for accuracy and clarity prior to mass distribution and the participants were informed that their responses were confidential reduce social desirability bias (e.g. Brace, 2013). Finally, the results were presented as they were received and made no attempt to modify the stats to cater for any potential non-response bias.

Triangulation

In order increase the credibility of a qualitative study, the researcher can obtain multiple data sources and use different techniques (Adams and Cox, 2008; Guba, 1981), called triangulation (Bell and Waters, 2014). Triangulation is seeing the same thing from different perspectives (Laws *et al.*, 2013). In order to overcome methodological shortcomings different methods can be used in a group (e.g. Shenton, 2004). This research used a number of methods to collect data, including interviews, questionnaires, focus groups, and company documentation. When using interviews and focus groups, company documentation and records are frequently used as they allow the researcher to triangulate participant accounts against a formal source (Lu and Sexton, 2009). In this research project, in order to validate the qualitative data collection the researcher used archival records such as company documentation and defect records for triangulation purposes. In addition, the researcher was afforded the opportunity of sitting with staff from some HAs to gain a visual overview of their information systems. Table 3.6 outlines the documentation and qualitative data collected from the HAs.

Member checks

Lincoln and Guba (1985) recommend member checking as a way of improving rigour in qualitative research. Member checking can be used to validate the credibility of qualitative results (Doyle, 2007). Member checking is the method of returning an interview or analysed data to a participant (Birt *et al.*, 2016). In this research project, the qualitative study was partially validated using member checking. Following the interviews the notes were typed up and referred back to the participants to verify their accuracy and completeness; after the focus group an email was sent by the facilitator (researcher) to the participants providing an overview of the aspects discussed, so that the participants could check for clarity and respond if necessary.

Peer scrutiny

Opportunities for scrutiny of the project should be welcomed and feedback sought as fresh perspective may challenge the assumptions made by the investigator and enable the researcher to refine his or her methods, develop a greater explanation of the research design and strengthen his or her arguments (Shenton, 2004). This research has been subject to scrutiny from peers. The research has been presented at numerous conferences, seminars, and team meetings. The research has been assessed during reviews every six months. Finally, various aspects of the research have been subject to peer review during publication.

The researcher's reflective commentary

In addition to the outside scrutiny, the researcher should evaluate the project as it develops via a reflective commentary. The reflective commentary can be used to record the researcher's initial impressions of each data collection session and patterns appearing to emerge in the data collected (Shenton, 2004). Throughout every stage of the AR there is a section of "practice" and "reflection" where the researcher provides a reflective commentary on the respective stage.

Table 3.6: Overview of data collected from HAs

HA No.	Documentation/data obtained	Description
HA01	Interview data	Field notes from interview with one interviewee.
	Overview of defects log and IT systems	Visual demonstration of HA's defects management IT systems, network areas and data captured, reports produced etc.
	Change control process document	Document outlining HA's formal change control process.
HA02	Interview data	Field notes from multiple interviews with four interviewees from multiple business areas.
	Presentation	PowerPoint presentation providing overview of HAs defects management processes.
	Overview of processes and IT systems	Visual demonstration of HA's defects management IT systems, network areas and data captured, reports produced etc.
	Defects logs	Two exports of HA's defects log (record of all defect data and actions).
	Defects investigation procedure documentation	Document outlining HA's formal defects investigation procedure.
	Focus group	Field notes from focus group with three participants from the HA's aftercare team.
HA03	Interview data	Field notes from interview with one interviewee.
	Company report	Document containing HA's defect measures, including budget for repairs and defect reporting processes.
HA04	Interview data	Field notes from interview with two interviewees from multiple business areas.
	Defects log	Export of HA's defects log (record of all defect data and actions).
	Company report	List of project measures for showing current performance for a given period.
HA05	Interview data	Field notes from interview with one interviewee.
	Defects log (blank)	An export of HA's defects log (record of all defect data and actions), containing no defect data, but showing headings for data typically captured.
HA06	Interview data	Field notes from interview with one interviewee.
HA07	Interview data	Field notes from interview with one interviewee.
	Defects log	Export of HA's defects log (record of all defect data and actions).
HA08	Interview data	Field notes from interview with one interviewee.
	Defects log	Export of HA's defects log (record of all defect data and actions).
	Company report	List of project measures for defects and graphs showing current performance for a given period.
	Post-handover defects management procedure	Document outlining HA's formal defects management procedure.
HA09	Interview data	Field notes from interview with one interviewee.
HA10	Interview data	Field notes from interview with one interviewee.
HA11	Interview data	Field notes from interview with three interviewees from multiple business areas.
HA12	Interview data	Field notes from interview with two interviewees from multiple business areas.
	Overview of defects log and IT systems	Visual demonstration of HA's defects management IT systems, network areas and data captured, reports produced etc.
	Defects log	Export of HA's defects log (record of all defect data and actions).

3.7.2 Transferability

Whilst results of a qualitative study cannot be generalised with complete confidence beyond its immediate setting, this research adopts the position set out by Yin (2009) in that the results are generalised to theory (which is analogous to the way in which scientists generalise from experiments to theory) rather than to the whole population of HAs. Further, this research used 12 different HAs for saturation purposes (triangulating the data captured) and achieved theoretical saturation, whereby no new concepts were emerging from the data and the theories that did emerge from the date are well supported. Finally the researcher has provided an explicit research design to allow other researches to understand how to use it in other situations.

3.7.3 Dependability

This research has followed an explicit research design that other researches can follow. The interview and survey questions were drawn from the existing literature. Further, the interview protocol asked the same questions of all participants, which has enhanced the reliability of this research.

3.7.4 Confirmability

In order to maintain as much objectivity as possible this research identified the research opportunity through a literature review, drew the interview questions from previous recommendations to learn from defects (and the adopted OL model), where data was recorded during interviews and focus groups, the researcher member checked the participant accounts and also triangulated those accounts against a formal source where possible. In addition, SSM was used during the action planning phase to maintain a level of neutrality.

3.8 Chapter summary and link to next chapter

This chapter discussed and justified that adopted research methodology. The next chapter presents the research findings positioned around the adopted AR approach.

4 Key findings

4.1 Introduction

This chapter reports the research findings positioned around the action research (AR) phases. All of the AR phases start with a discussion of the practice followed by a reflection on the findings. The chapter is structured as follows.

(1) The findings from the diagnosis phase are presented (Section 4.2), first looking at the impact of defects (Section 4.2.1), followed by learning from defects (Section 4.2.2).

(2) The action planning phase is discussed, starting with securing access to housing associations (HAs) culminating in the action planned with HA02 (Section 4.3).

(3) The action taken by HA02 is outlined, including problems identified and interim solutions (Section 4.4).

(4) The action taken is then evaluated, both in terms of how the planned actions were implemented, and how effective those actions were in relation to improving the HA's learning (Section 4.5).

(5) Finally, the general knowledge gained during the AR is discussed in the specifying learning section (Section 4.6).

4.2 Diagnosis phase

The diagnosis phase lasted five months (May 2015 – September 2015). During the diagnosis phase two tasks were carried out. The first task was to gain insight into which impacts of defects are actually important to the key stakeholders involved in their detection and remediation from construction on site until the end of the warranty period. The second task was to understand HAs' localised defects analysis procedures, and their current knowledge feedback loops to inform future practice.

4.2.1 The impact of defects (practice)

The key stakeholders' perspectives on the impact of defects were explored via a questionnaire survey between May and June 2015. The questionnaire survey criteria were drawn from the literature, which identified a number of cost, disruption, and health and safety (H&S) related impacts of defects (see Section 2.7). The key stakeholders were house builders, warranty providers, home occupants and building inspectors. These key stakeholders were identified from a literature review relating to how defects are detected and remedied during construction, the builder's liability period and warranty period within new-build houses in the UK. The overall response rate for the survey was 15% with a total of 292 responses. The survey received 51 responses from house builders, 54 responses from warranty provider's staff, 44 responses from building inspectors and 143 responses from home occupants who had previously had defects remedied in their new homes. Whilst the response rate was not as high as anticipated and the results therefore may not be a true representation of the general population of interest, the sampling strategy and responses still provided insight into a previously unexplored phenomenon and allowed the researcher to gain a level of perception from the respondents. The survey was analysed by calculating the percentage of each of the five categories (e.g. not a priority, medium priority, essential) within a total number of a particular set of stakeholders (e.g. house builders, home occupants) for the individual impacts of defects, with results displayed using diverging stacked bar charts (Section 3.6.2). The key stakeholders' views on the impact of defects on H&S, followed by cost and disruption are discussed in detail below.

Health and safety

Whilst the questionnaire analysis was based upon fewer than anticipated responses, the analysis of the impact of defect on 'H&S' (Figure 4.1) suggested that all of the house building industry stakeholders (i.e. house builders (HB), warranty providers (WP), and building inspectors (BI)) shared a general belief that both site worker and home occupant (HO) H&S are important. However, the house building industry stakeholders appeared to deem the home occupant H&S aspect as more important than site workers. The house building industry stakeholders (house builders, warranty providers and building inspectors) indicated the impact of defects on home occupants H&S to be an 'essential priority' (71%, 50%, and 66%) and a 'high priority'

(22%, 41%, and 25%). Conversely, the house building industry stakeholders (house builders, warranty providers, building inspectors) suggested site worker H&S to be an ‘essential priority’ (67%, 41%, and 39%) and a ‘high priority’ (25%, 39%, and 16%).

In stark contrast, the home occupants appeared to see their own H&S as their highest priority overall, deeming it an ‘essential priority’ (42%) and a ‘high priority’ (26%). The home occupants suggested site worker H&S to be significantly lower than their own, considering it to be ‘not a priority’ (27%) and a ‘low priority’ (23%). Whilst the questionnaire data was not conclusive, there are indications that the home occupants’ H&S self-prioritisation was driven by the perception that the house building industry does not consider home occupant safety with the constructed home, as stated by one home occupant *“…the builder’s idea of a new house is one of astonishingly poor condition with numerous short-cuts and non-compliance to building regs…”* (HO1).

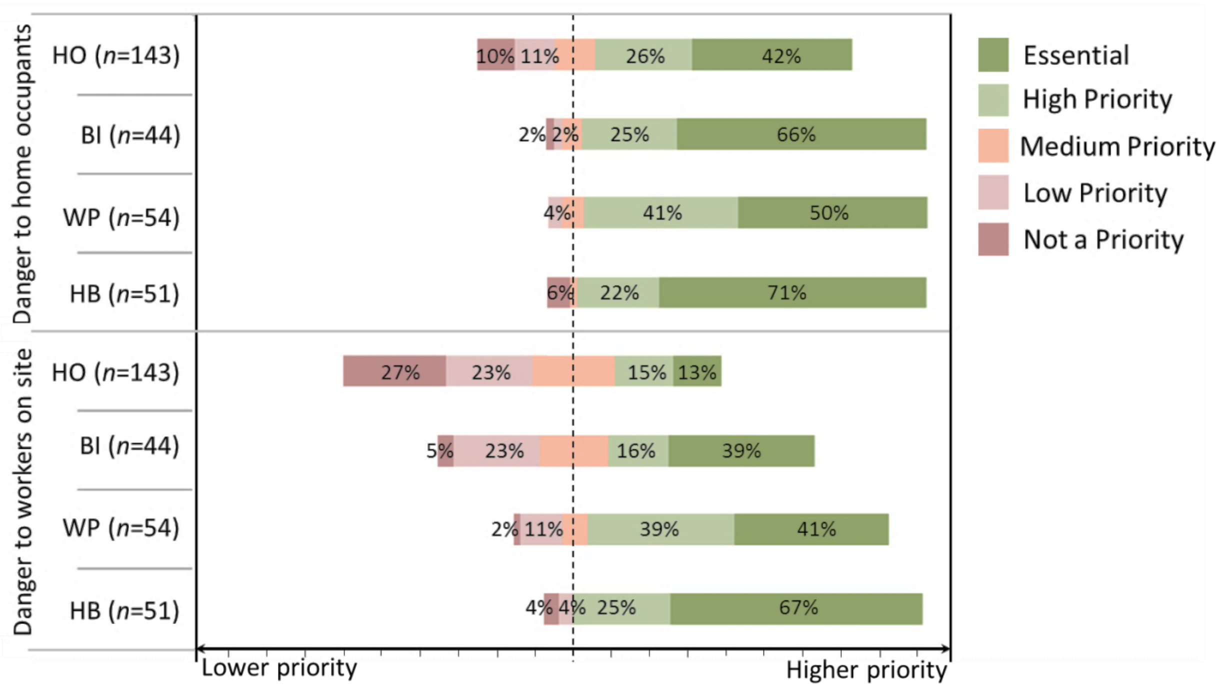

Figure 4.1: Impact of defects on H&S priority analysis

Cost

Moving onto ‘cost’ (Figure 4.2), the home occupants generally voted all costs as unimportant, i.e. ‘not a priority’ and ‘low priority’ (between 61% and 70%) as none of the costs directly affected them. The home occupants' self-focus in relation to cost appeared to stem from the belief that the house building industry is generally financially motivated as opposed to being customer motivated. One home occupant argued that *"… builders are increasingly turning to cheap low skilled workforce and materials looking for fast buck. They need to get back to the stage where they can be proud of what they produce…"* (HO2), although the questionnaire data was not conclusive.

In contrast to the home occupants, the house building industry stakeholders (building inspectors, warranty providers and house builders) had a varied cost prioritisation. The building inspectors appeared to generally view cost as a higher priority than the warranty providers and house builders. However, the building inspectors were clear in their responses that costs that either directly affected them or resulted from their errors were most important. The building inspectors voted both 'approved inspector fines for breach of contract' as 'essential' and 'high' priorities (19% and 33%); and, 'any warranty claims resulting from Building Regulation non-compliance' as an 'essential priority' (51%) and 'high priority' (30%). In a similar vein to the building inspectors, the warranty providers appeared to consider their own costs as generally more important. One interesting result was that the warranty providers voted their cost for resolving complaints as the most important cost impact, deeming it a 'high priority' (48%) and an 'essential priority' (15%). The warranty providers (in the limited number of responses), however, indicated little sympathy for any complaints against the house builder, voting builder complaint costs as a 'low priority' (32%) and 'not a priority' (19%). In contrast to the building inspectors and warranty providers, the house builders suggested less prioritisation for their own cost, generally considering the cost they incur to be a similar priority to the costs the other stakeholders incur. The house builders indicated 'reduced' cost focus was supported by one house builder who commented that *"…I do not see the issue of cost being a reason not to attend to a defect…"* (HB1). Despite the apparent rounded view of cost, one interesting result came in relation the builder's fines for regulatory non-compliance; this was deemed by the house builders as the highest cost priority, with 82% of respondents seeing it as either a 'high' or 'essential' priority.

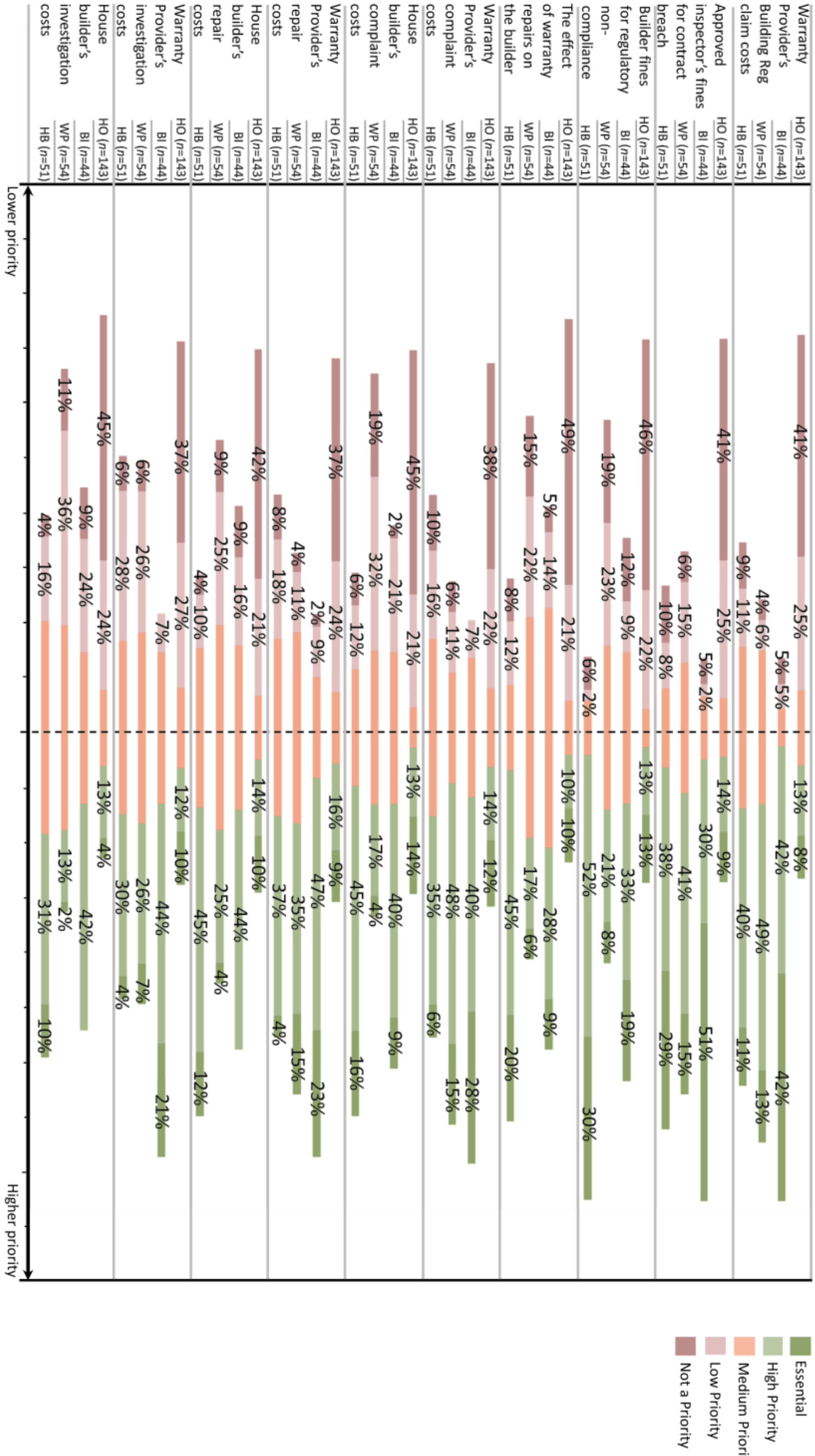

Figure 4.2: Impact of defects on cost priority analysis

Disruption

In relation to 'disruption' (Figure 4.3), the house building industry stakeholders (house builders, warranty providers, and building inspectors) appeared to show a home occupant focus and voted disruption to home occupants as the most important disruption impact, voting it as 'essential' (32%, 19%, and 37%) and 'high priority' (50%, 52% and 44%). This high prioritisation of home occupants was evident in one house builder's comment that *"…we try to look after the interests of our customer ensuring there is no risk to health and safety, disruption or cost to our customer…"* (HB2). Whilst the questionnaire data was not conclusive, interestingly, the house building industry stakeholders voted home occupant disruption higher than the home occupants themselves. The home occupants still suggested their own disruption as one of the most important impacts overall, seeing it as 'essential' (35%) and 'high priority' (34%). The home occupants' high prioritisation of their disruption appeared to come in relation to post-completion defects requiring a repair. Based upon the responses received, home occupants indicated that as the purchaser of the new home, when something has gone wrong they should be the main priority. This main priority requirement was supported by three home occupants who commented that *"…if the builder's construction is sub-standard, resulting in a successful claim, then the only priority is the householder…"* (HO3), *"…as a house buyer, if the building work was not completed properly in the first place, the builders/warranty provider must accept full responsibility to ensure it is rectified as soon as possible…"* (HO4); and, *"… the most import[ant] consideration for me is knowing that the repair will be carried out speedily, professionally and with minimum disruption…"* (HO5). There was further evidence of home occupants being caused additional disruption by inadequate remediation of defects, requiring return visits and causing additional disruption. The additional disruption was indicated by one home occupant who stated that *"… the work carried out by the workmen was not to a good standard and [they] had to come back a few times to fix [the defect] which caused a lot of disruption…"* (HO6).

There appeared to be a mixed view on disruption to house builders. The home occupants, building inspectors, and warranty providers suggested house builder disruption to be a lesser priority. The lack of sympathy from home occupants, building inspectors and warranty providers towards the house builder appeared to stem from the belief that the defects are the house builder’s own fault. For example, one warranty provider suggested that *“… most defects appear to be the result of poor workmanship due a lack of supervision...”* (WP1), whereas one building inspector argued that house builders are mainly production focussed with his comment that *“…a lot of the major builders are not really interested in the disruption to a home owner or fixing problems i[n] a timely manner. Production always takes priority…”* (BI1).

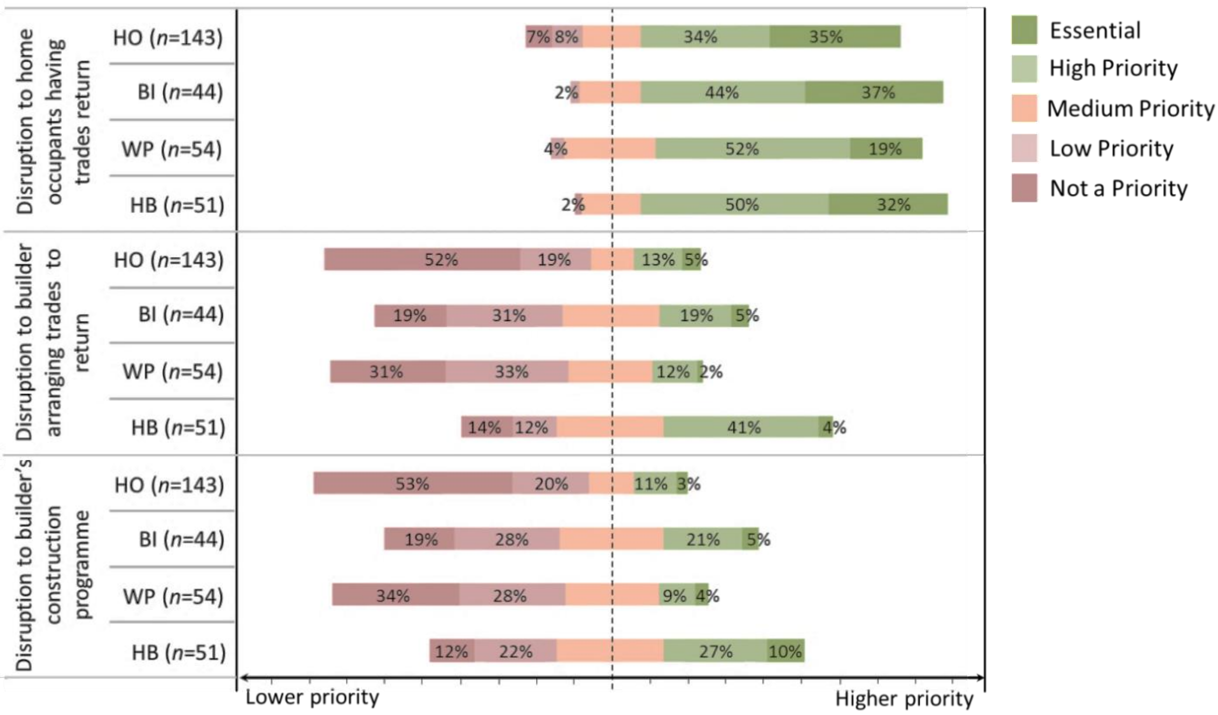

Figure 4.3: Impact of defects on disruption priority analysis

Through identifying the key stakeholders’ priorities, the survey also found indications that home occupants had a negative perception of the house building industry in general. This negative perception was supported by one home occupant who commented that *“… no other industry finds it 'normal' to deliver products with defects and fix them later. Imagine a mobile phone that didn't work, a manual car without a gear stick? The construction industry claims it is different. It isn't. It just has a stranglehold over tight property supply and is so poorly regulated that it isn't subject to competition to raise standards. We are building sub-standard properties that will barely last 20 years…”* (HO7).

Additional potential impacts identified from the survey

The results drawn from the open questions further identified new H&S, cost, and disruption concerns that defects may present. The new H&S concerns identified were: the danger defects pose to the general public (suggested by one home occupant and five warranty providers); and, the danger defects pose to third parties visiting construction sites (two building inspectors and two house builders). The new costs incurred uncovered were: the potential costs defects cause home occupants, such as time off work or paying a third party for the repair (identified by one house builder, three home occupants, and one warranty provider); and, the effect defects may have on the home's resale value (two home occupants). Finally, the additional disruption implications identified were: the home occupant not being able to use their property as intended (claimed by one home occupant), the need for the home occupant to be rehoused during remedial works (one home occupant and two warranty providers); and, the duration of the repair and the need for the home occupant to take time off of work to allow the house builder access to undertake the repair (four home occupants).

4.2.2 Learning from defects (practice)

HAs' localised defects analysis procedures, and their current knowledge feedback loops to inform future practice were explored via interviews with individuals involved in defects management and learning, and review of relevant company documentation of 12 HAs. The interviews took place between June and September 2015 at the HAs' premises and lasted around one hour. The interview questions were guided by the adopted OL model (see Section 2.9) and drawn from the previous recommendations of how HAs should learn from defects within the literature (see Section 2.8). The results presented are structured around the constructs of the adopted OL model (see Section 2.9): new signal; signal recognised as need for change; experimentation and search for new options; internal selection, articulation and codification into new routines; and, feedback and iteration. This section first focusses on the 12 HAs individual practice and then discusses the HAs collectively. The 12 HAs individual learning approaches are discussed in detail below.

__Individual case studies__

a) HA01 description

HA01 develop between 500 and 1,000 new affordable homes per year in the London area. The HA has a 'development arm' responsible for building new homes; and, a 'housing management arm' responsible for managing the build stock (including defects). HA01 seeks to learn from defects to enhance contractors' performance, identify improvement opportunities to reduce defects, and also increase the customers' levels of satisfaction. HA01's learning from defects can be described in five stages (0-4) as shown in Figure 4.4.

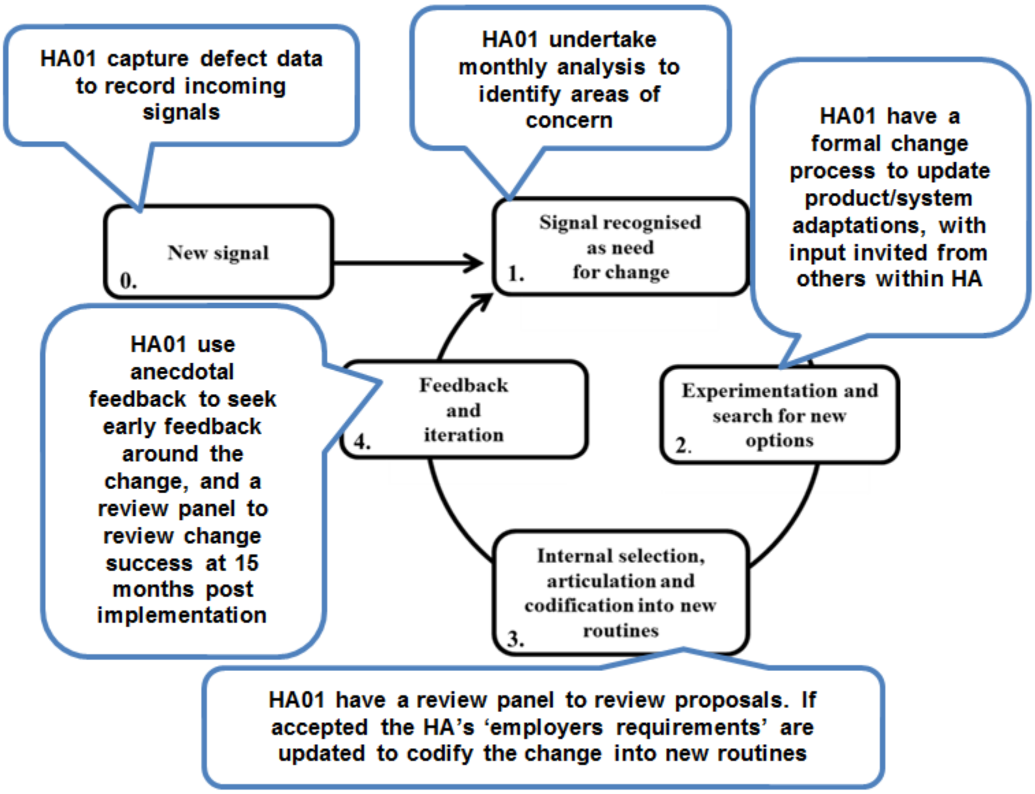

Figure 4.4: HA01 learning mapped on OL model

0. New signal: The home occupant contacts HA01 to report a defect by either calling the HA's call centre, or by submitting a form through the HA's website. HA01 captures the reported post-completion defect data within their standard spreadsheet. HA01 capture property details (address, completion date, scheme ID, and the contractor responsible for the build), the details of the home occupant reporting the defect; and, the defect details (including the date the defect was logged and a free-text description of the defect). The HA categorise the defect against a number of building elements, such as doors, heating and hot water. The building element categories were developed through consultation with external specialists in repair and maintenance. HA01 also categorise the urgency of the repair, labelling repairs as emergency, urgent and routine.

1. Signal recognised as need for change: The New Homes Manager (housing management arm) in HA01 analyse their defect data within their spreadsheet. The analysis is undertaken on a monthly basis. The analysis focusses on the overall number of defects in the HA's build stock, and the frequency of defects per property per month and per year. HA01 have key performance indicators (KPIs) of ½ a defect per unit per month and six defects per unit per year. If the number of defects per unit per month or per year fail to satisfy the HA's KPIs then action is required. When the KPIs are exceeded the HA will undertake a thorough review of the types of defects occurring. This thorough review involves analysing which building elements are experiencing defects most frequently.

2. Experimentation and search for new options: When a problematic area is identified, HA01 have a formal change process (to bridge the gap between the housing management and development arms of the HA), which is typically positioned around updating the HA's 'Employers Requirements' (ERs). In order to make a change to the ERs, staff are required to complete a pro-forma. This pro-forma requires the reasons for the desired change and the benefits of the change to be identified and explicitly outlined. Once the completed pro-forma is submitted to an administrator, the pro-forma will be forwarded to the Technical Manager (in the HA's development arm) who will review the submission to check the quality and offer any technical advice he feels suitable. Following the Technical Manager's review, the change proposal is distributed (via email) to a number of internal key stakeholders (for example, the Development Manager; Design Manager, and Quality Manager) to gauge the impact of the change and receive any additional input. The key stakeholders are typically selected by the Technical Manager based upon his knowledge of the HA and the proposed change.

3. Internal selection, articulation and codification into new routines: In order for a change to be accepted, the pro-forma is then sent to an authorising panel who will review the proposed change (in conjunction with the key stakeholders comments) and accept, reject or escalate the change proposal to directors when required. When a decision is made, the decision is logged and the person initiating the change request is notified. If the change is accepted then the HA's ERs are updated (every quarter). After the update has taken place the latest version of the HA's ERs are circulated to key internal stakeholders (for example, the Head of Housing Management, the Design Manager, the Development Manager and Development Director) via email.

4. Feedback: Finally, when a change has been implemented HA01 use a combination of anecdotal feedback and a review panel to review the success or failure of the implemented change. HA01 use anecdotal feedback at the early stages after the change has taken place. This anecdotal feedback is to generally gauge the stakeholders' feelings around the change. 15 months after the change has been implemented HA01 have a review panel that meets and discusses the lessons learnt.

b) HA02 description

HA02 are a provider of around 1,000 new affordable homes per year in the south of England and have a build stock of over 20,000 homes. The HA is committed to helping ease the UK's housing shortage by increasing the number of new homes they develop to rent, as well as for sale via shared and private ownership schemes. The HA has a 'development arm' responsible for building new homes; and, an 'asset management arm' responsible for managing the build stock (including defects). The HA seek to learn from defects to monitor contractor and product and system performance, as well as looking for improvement opportunities to reduce defects in their new homes and the associated repair costs to maximise profit to increase their production of new homes. HA02's learning from defects can be described in six stages (0-5) as shown in Figure 4.5.

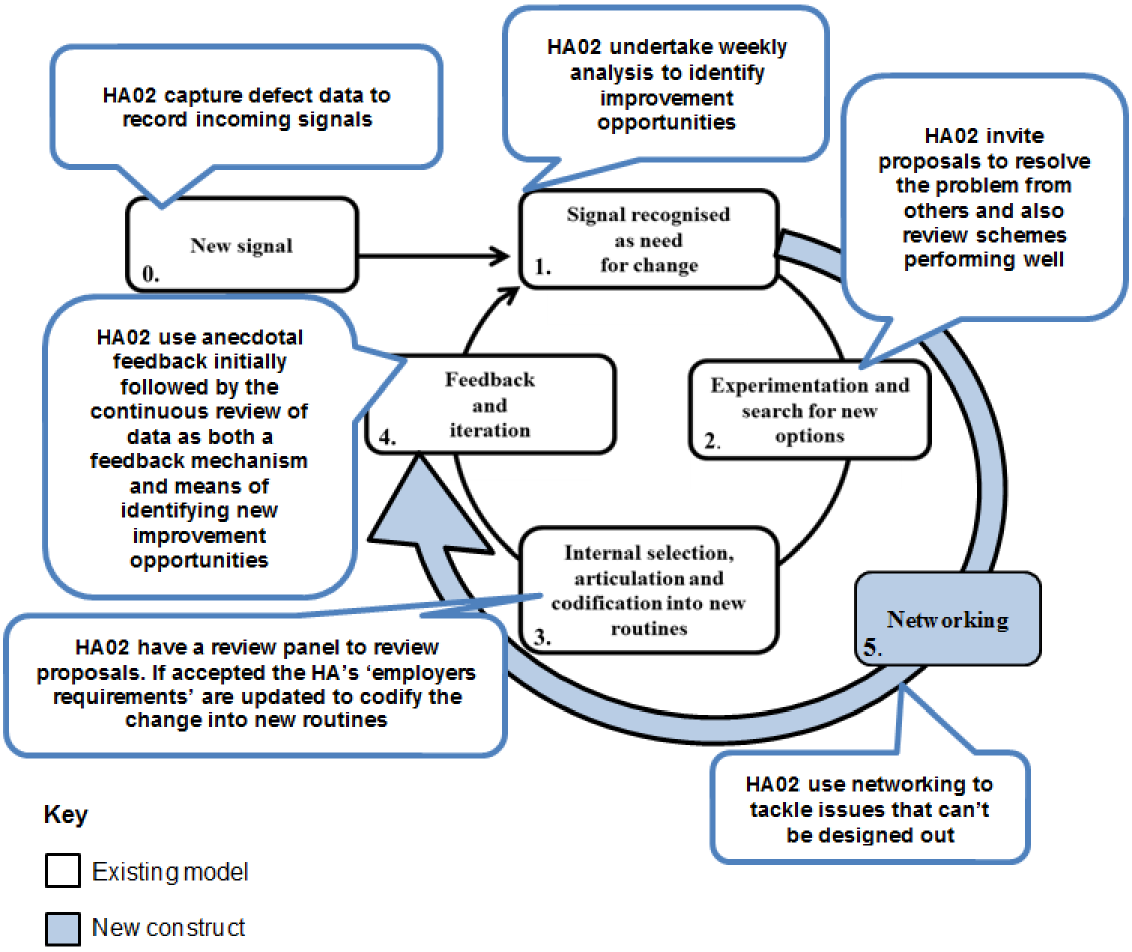

Figure 4.5: HA02 learning mapped on OL model

0. New signal: When the home occupant notices a defect in their new home, he/she contacts HA02's call centre to report that defect. The call centre then forward details of the contacts to the HA's aftercare team (asset management arm) via an email. The Aftercare Team Administrator then records the provided information within their standard spreadsheet (see Figure 4.6). The Aftercare Team Administrator typically records three themes and 18 fields of data: (1) the date the defect was reported; (2) the property details (the address, the property completion date, the associated scheme ID, the contractor responsible for the build, the type of construction – in the description of the defect field, and any associated warranty property details); and, (3) the details of the person reporting a defect. The 18 fields are: date logged, reference number, site/address/scheme, region, referred by, build date, warranty period expiration, warranty number, nature of the defect, local/national builder, key contact, status, case status, estimated savings, agreed actions, cost of making good, potentially valid warranty claim?; and, date warranty claim made. The Aftercare Team Administrator contacts the home occupant to discuss the defect further to gain additional information regarding the nature of the defect and then records this information within a free-text field in the spreadsheet. The Aftercare Team Administrator contacts a clerk of works to arrange an investigation on the case. When the investigation findings from the Clerk of Works are reported back, the Aftercare Team Administrator updates the details within the free-text description field within the spreadsheet. The following are examples of the defect data recorded under the “nature of the defect” field:

“Drainage problem, there has been 6 blockages in the same line at this address in the last 18 months, poorly laid pipework where the pipe leaves the property to the inspection pot, too many bends and very little fall.”

“Heating running costs, panel heaters, no night storage heaters (NSH)”

“Didn’t follow 'Robust details' when floor installed in timber frame property and the floor is bouncing – batton’s in the middle of the joists – progress to the NHBC claim don’t bother with the builder just to NHBC”

“Fire in shared owners block, lack of intumescent treatment at new build and closers, similar general needs block on development”

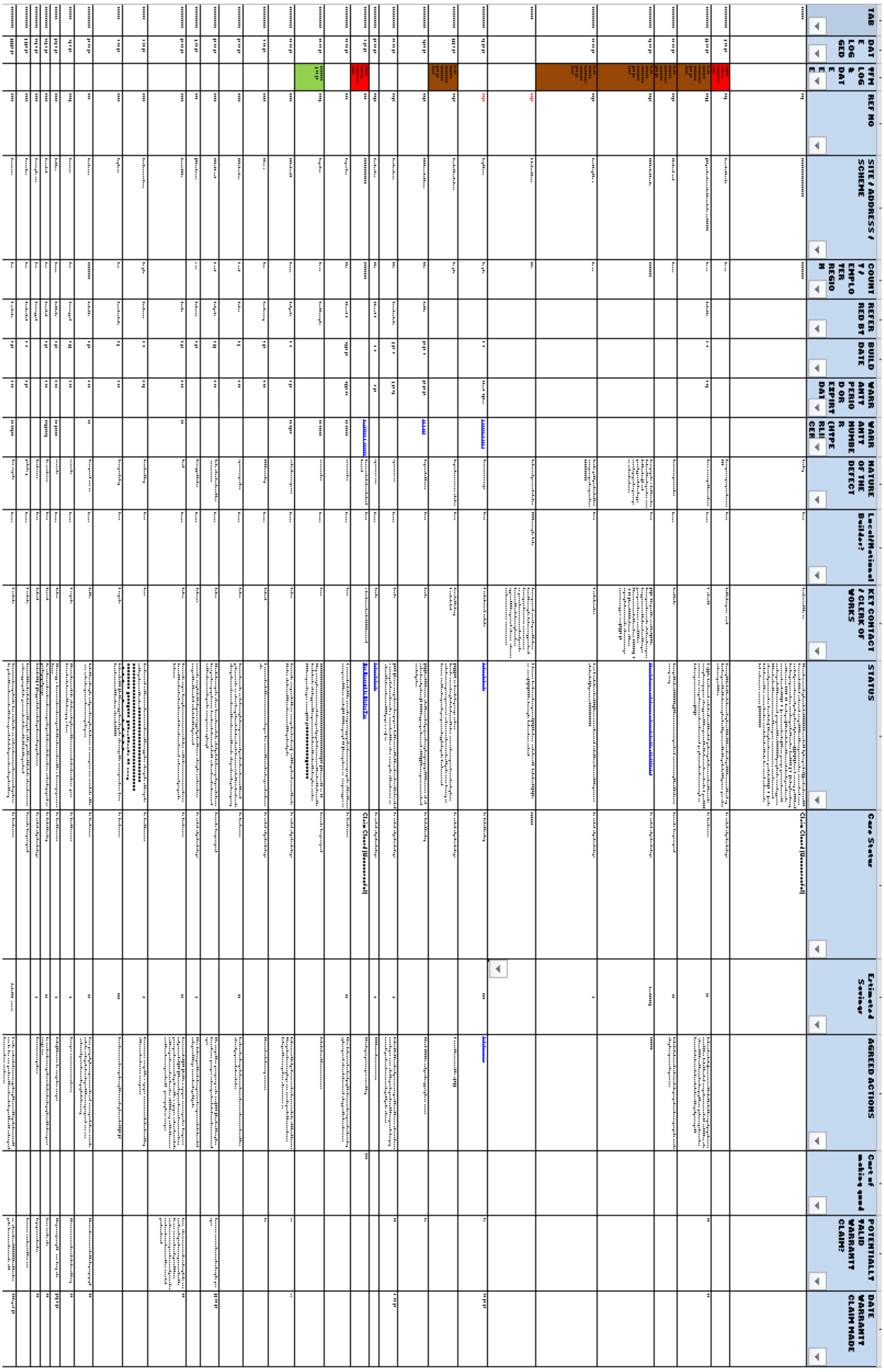

Figure 4.6: HA02's defects spreadsheet

A more detailed version of this can be found in Appendix 3 under the heading of 'extract from HA02's original defects log'.

1. Signal recognised as need for change: The Aftercare Team Administrator, Head Clerk of Works and Asset Manager in HA02 ‘manually’ analyses the defects recorded within their spreadsheet (Figure 4.6) to monitor contractor, and product and system performance to pick out any trends and identify improvement opportunities to reduce defects. HA02 try to identify defect trends and improvement opportunities from the strings of text recorded under ‘nature of the defect’. The analysis is undertaken on a weekly basis. The analysis reviews the cost of defects, the frequency of defects, and the types of defect occurring. The high volume and high cost defects are discussed at bi-monthly interdepartmental meetings between the Asset Manager and the Quality Manager. When specific defects are deemed major problems (a perceived level of importance by the individuals) the Quality Manager will seek solutions.

2. Experimentation and search for new options: Invitations are sent by the Quality Manager to the individuals within the development and asset management arms of HA02 to request proposals that can resolve the particular problem. In addition, the HA will also invite proposals from external sources (e.g. manufacturers), and review schemes that are generally performing well in the given problem area. The HA’s focus at this point is to design out defects through product and system changes.

3. Internal selection, articulation and codification into new routines: In order for a change to be implemented the HA have a leadership group (review panel), consisting of the most senior personnel from the HA (directors) who review the proposals and approve the most appropriate to the HA. As the HA’s focus at this point is to design out defects, when a change has been approved, it is incorporated into the HA’s ERs, which are updated annually. When a change has been implemented it is communicated internally via updates to the HA’s lessons log, and discussion at internal meetings. In addition, the HA’s Quality Manager communicates changes to contractors and manufacturers where appropriate.

4. Feedback: When the new edition of the HA’s ERs have been released (annually), HA02 use anecdotal feedback and the continuous review of data to evaluate the effectiveness of the change. HA02 use anecdotal feedback to identify any significant early concerns in respect of the change. However, HA02 are more reliant on the continuous review of data (data analysis) to determine whether the updated ERs have resolved the given issue (as well as a mechanism to identify new ‘improvement opportunities’).

5. In addition to the OL constructs identified by the adopted model, the study of HA02’s learning found that an additional OL construct was required. HA02 advocated ‘networking’ as an alternative to designing out defects through updates to the HA’s ‘employers requirements’. The networking was undertaken by way of the Head Clerk of Works (who is predominantly office based focussing on defects post-completion) feeding back the problem areas to site-based teams (typically the clerk of works, who are managed by the Head Clerk of Works who investigate new-builds and post-completion defects) as ‘areas to watch’ on current and future developments. The discussions are aimed at influencing the clerk of works’ behaviour on site to pick up more problems during construction. Based upon the HA’s current learning process the Head Clerk of Works believed that balconies were the HA’s biggest area of defects and should be the HA’s largest area of focus during construction.

c) HA03 description

HA03 develop between 1,500 and 2,000 new affordable homes per year in the south of England and the midlands. The HA has a development arm responsible for building new homes; and, a repair and maintenance arm responsible for managing the build stock (including defects). HA03 seek to learn from defects to monitor performance to help improve quality. HA03’s learning from defects can be described in six stages (0-5) as shown in Figure 4.7.

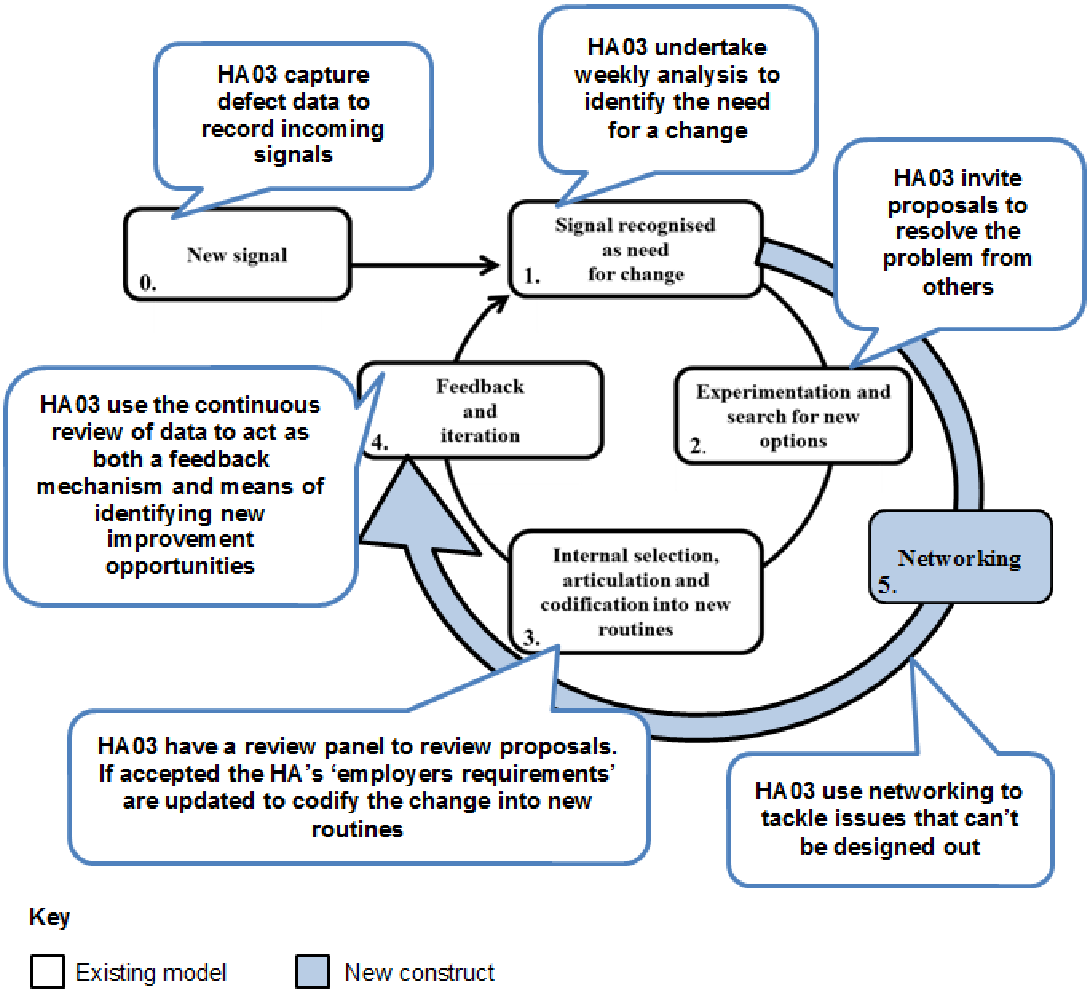

Figure 4.7: HA03 learning mapped on OL model

0. New signal: The home occupant contacts HA03's call centre (repair and maintenance arm) to notify the HA of a defect. The call centre operatives in HA03 record this post-completion defect data in a bespoke defects management system. HA03 record the nature of the defect, the date the defect was logged, a target date for remedial work to be completed by, and the home occupant details against the particular property experiencing the defect (which contains the developer responsible for the build, the address of the property, the property completion date, and the scheme name the property is in). HA03 categorise their defects by the trade required to resolve the defect (e.g. joinery, plumbing).

1. Signal recognised as need for change: The Quality Manager (development arm) of HA03 runs a report from their bespoke defects management system to analyse their defect data. The analysis is undertaken on a weekly basis, and looks at the frequency of defects, and whether repair targets have been achieved. The analysis is typically undertaken at the ‘developer level’ and reported back to senior management in the development arm. When specific defects are deemed major problems (a feeling of importance) by the senior management, changes will be sought.

2. Experimentation and search for new options: Invitations are sent by senior management to people within the development, and repair and maintenance arms of HA03 to request proposals that can resolve the particular problem. Typically, the proposals for change are in the form of product/system adaptations.

3. Internal selection, articulation and codification into new routines: In order for a change to be implemented, when proposed solutions are received (following the senior managers requests) they are discussed with the HA’s review panel. The HA’s review panel consists of senior personnel from the HA. The review panel will review and discuss the proposals and approve options that are considered appropriate to the HA. As the proposals typically relate to product/system adaptations, when a change has been approved, it is incorporated into the HA’s ERs. The HA’s ERs are updated annually.

4. Feedback: When the new edition of the HA’s ERs have been implemented, HA03 use the continuous review of data (data analysis) to determine whether the updated ERs have resolved the given issue, and also to identify new ‘major problems’.

5. In addition to the OL constructs identified by the adopted model, the study of HA03’s learning found that an additional OL construct was required. HA03 advocated ‘networking’ as an alternative to designing out defects through updates to the HA’s ERs. This was clear from HA’s Quality Manager who would undertake quality improvement discussions with senior management in a bid to guide future decision-making.

d) HA04 description

HA04 develop between 500 and 1,000 new affordable homes per year in the south of England and the midlands. The HA has a development arm responsible for building new homes; and, a repair and maintenance arm responsible for managing the build stock (including defects). HA04 currently use their learning process to monitor performance. HA04's learning from defects can be described in five stages (0-4) as shown in Figure 4.8.

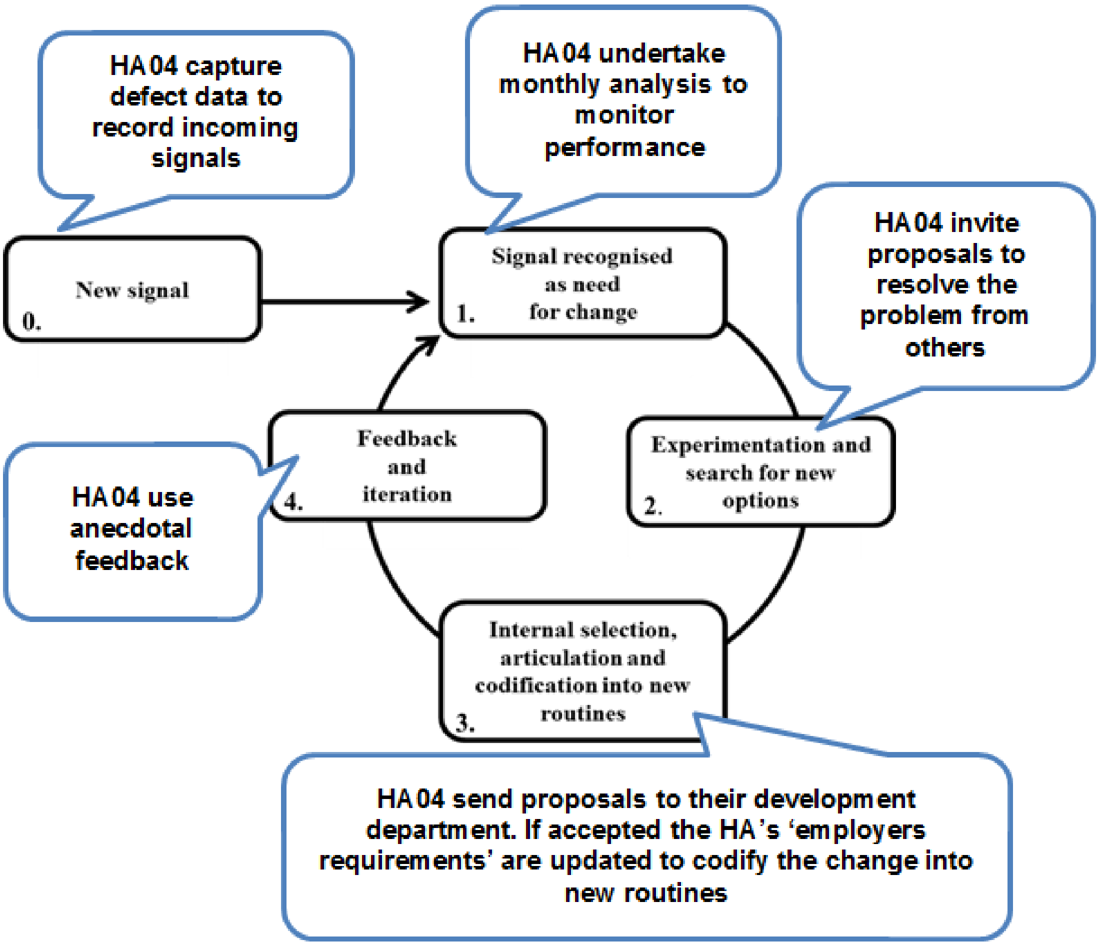

Figure 4.8: HA04 learning mapped on OL model

0. New signal: When the home occupant notices a defect in their new home, he/she contacts HA04's customer care team. The customer care team (repair and maintenance arm) records this post-completion defect data in an off the shelf defects management system. The customer care operative typically looks up the property address (which has the completion date, the scheme ID and the contractor responsible for the build against it), and records the home occupant details, the type of defect reported, the date it was logged, and the estimated remedial work dates. HA04 categorises defects by 'building area'.

1. Signal recognised as need for change: HA04's Customer Care Manager runs a report from their defects management system to analyse their defect data. The analysis is undertaken on a monthly basis, and looks at the cost, frequency, and where the current repairs sit when compared to their target date. The analysis is typically undertaken at developer level and reported back to senior management (the Development Director and Head of Quality) of the development arm. When specific defects are deemed a problem (a feeling of importance, or high volume of complaints) by the senior management, changes will be sought. HA04's most prevalent defects were related to internal services.

2. Experimentation and search for new options: Invitations are sent by the Head of Quality (development arm) to individuals within the 'development', 'repair and maintenance', and 'finance' departments of HA04 to request proposals that can resolve the particular problem. Typically, the proposals for change are in the form of product or system adaptations.

3. Internal selection, articulation and codification into new routines: When potential solutions have been received by the Head of Quality, in order for a change to be implemented, he discusses the proposal with their Development Director as the development arm are the team who can introduce the change. The Development Director and other relevant people from the development arm will review the proposal and discuss the option with the HA's finance department; and, approve it if deemed suitable. As the proposals typically relate to product/system adaptations, when a change has been approved, it is incorporated into the HA's ERs.

4. Feedback: When the HA's ERs have been updated, HA04 use anecdotal feedback to determine whether the updated ERs have resolved the given issue.

e) HA05 description

HA05 develop between 500 and 1,000 new affordable homes per year in the London area. The HA has a 'development arm' responsible for building new homes; and, a housing management arm responsible for managing the build stock (including defects). HA05's learning from defects (or lack of) can be described in one stage (0) as shown in Figure 4.9.

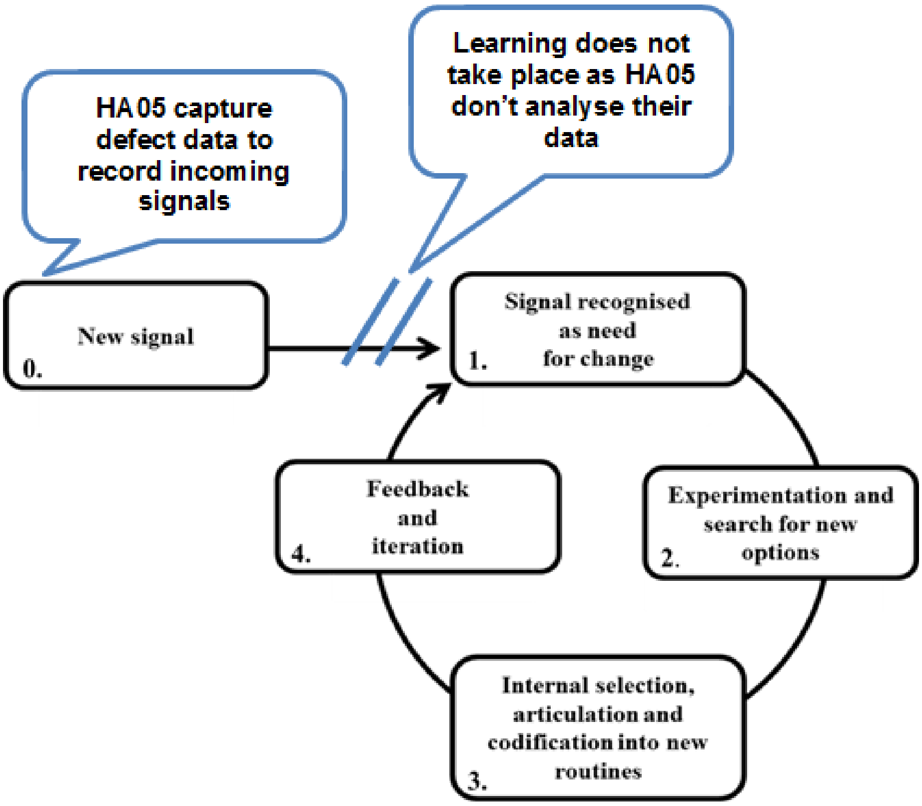

Figure 4.9: HA05 learning mapped on OL model

0. New signal: HA05's aftercare team (in the housing management arm) receives notifications of defects when a home occupant contacts their call centre or contractors directly. The aftercare team then capture the defect data in a standard spreadsheet. The spreadsheet captures the address details for the property experiencing the defect (including completion dates, the scheme the property is in, and the contractor responsible for the build), the details of the home occupant reporting the defects, the date the defect was logged, a description of the defect reported, the arranged date(s) for an operative to inspect the defect reported, the findings and photographs from the inspection, the details of the work required, any warranty/insurance information relevant to the situation, the start and completion dates for the repair; and, the repair costs. All of the data is recorded via manual text input.

1. Signal recognised as need for change: The Customer Care Manager in HA05 did not undertake any analysis, and reported that she could not identify any defect trends within their properties and therefore was unable to identify any improvement opportunities to reduce defects (no signals were able to be recognised as need for change).

HA05 had a clearly defined problem. HA05 did not analyse defect data and therefore could not identify improvement opportunities and opportunities to reduce defects in future properties.

f) HA06 description

HA06 develop between 2,000 and 3,000 new affordable homes per year in the north and south of England. The HA has a 'development arm' responsible for building new homes; and, an 'asset management arm' responsible for managing the build stock (including defects). HA06 seek to learn from defects to help identify improvement opportunities to reduce defects, reduce long-term costs and justify proposed changes as well as improving customer satisfaction. HA06's learning from defects can be described in five stages (0-4) as shown in Figure 4.10.

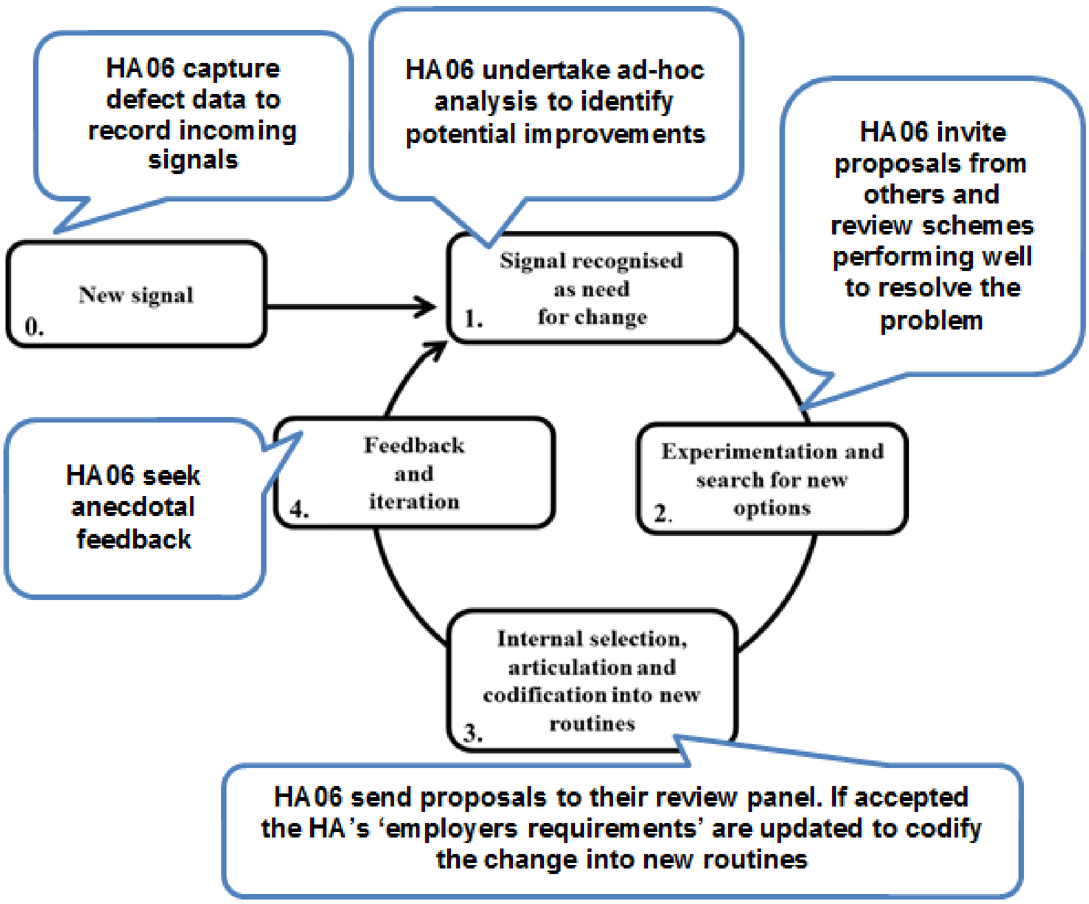

Figure 4.10: HA06 learning mapped on OL model

0. New signal: When the home occupant notices a defect in their new home, he/she contacts HA06's call centre (in the asset management arm). The call centre operative records this post-completion defect data in HA06's defects management system. The details of the home occupant reporting the defect, the date the defect was logged, and a free text description of the type of defect reported is recorded. In addition, the selection of basic categories for trade and damage against the property reporting the defect are also recorded. The recorded property details include the property address, completion date, the scheme ID, and the contractor responsible for the build. The HA has categories for trade and damage.

1. Signal recognised as need for change: The Head of Quality (asset management arm) exports HA06's defect data from their defects management system into a spreadsheet so he can analyse the defect data. The analysis is undertaken on an ad-hoc basis, and looks at the frequency and extent of problems (defect types).

When specific defects are deemed a problem (a feeling of importance, or high volume of specific defects) changes will be sought by the Head of Quality.

2. Experimentation and search for new options: The Head of Quality sends an open invitation to all the departments in the HA to request proposals that can resolve the particular problem (defect). Typically, the changes are aimed at improving the HA's design guide and ERs and are in the form of product/system adaptations. In addition to an open invitation, the Head of Quality reviews other projects to see if any products/systems used within those projects can be adopted to resolve the problem.

3. Internal selection, articulation and codification into new routines: When the Head of Quality has received recommended change options, in order for a change to be implemented he needs to discuss the proposal with the HA's review panel. The review panel will review the proposals and approve the change if it's deemed suitable. As the proposals typically relate to product/system adaptations, when a change has been approved, it is incorporated into the HA's ERs and design guides, which are updated annually. The updates of the changes are circulated to internal key stakeholders (e.g. the Design Manager, the Quality Manager, and the Assistant Development Director) via email.

4. Feedback: When the new edition of the HA's ERs are published and their design guide is updated, HA06 use anecdotal feedback to determine whether the updated ERs have resolved the given issue.

g) HA07 description

HA07 develop between zero and 500 new affordable homes per year in the London area. The HA has a 'development arm' responsible for building new homes; and, an 'operations arm' responsible for managing the build stock (including defects). HA07 seek to learn from defects to monitor performance and to reduce defects and improve future schemes. HA07's learning from defects can be described in five stages (0-4) as shown in Figure 4.11.

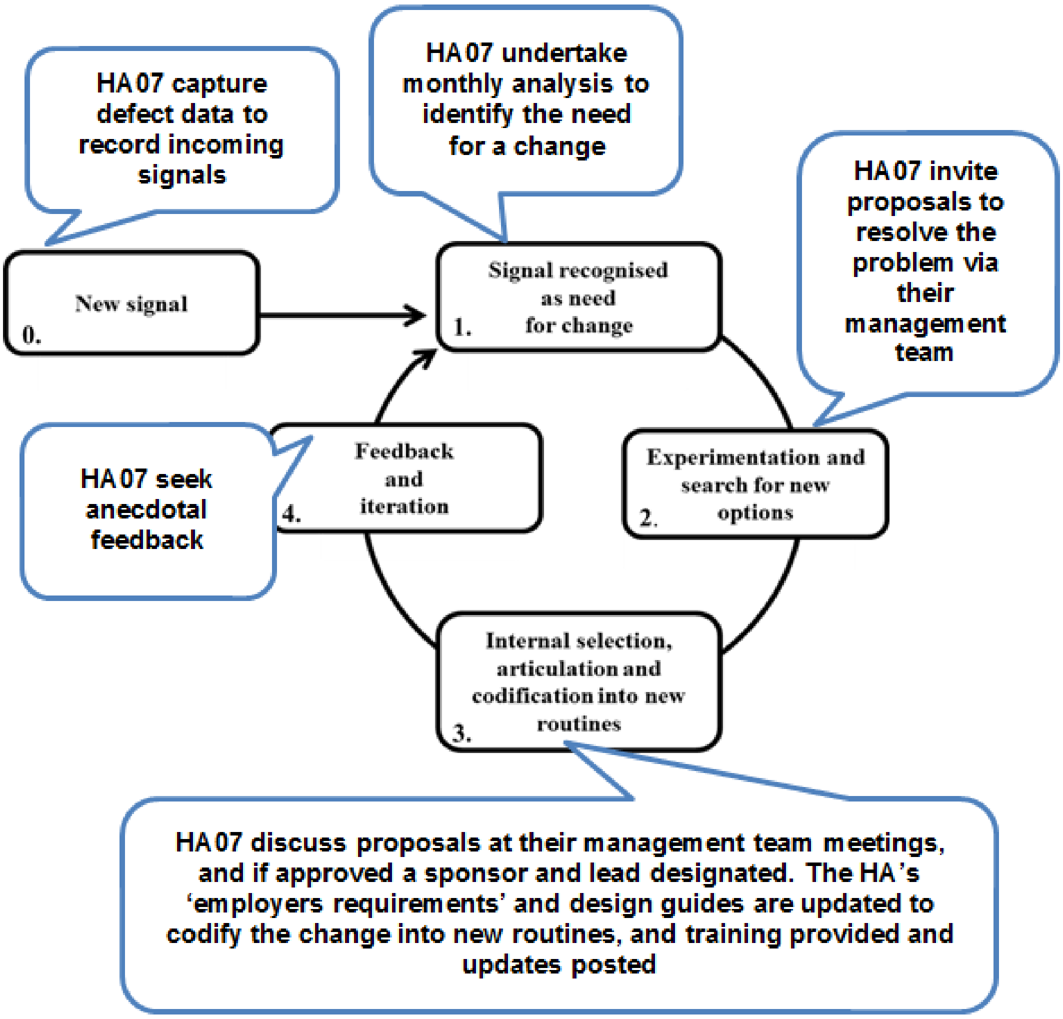

Figure 4.11: HA07 learning mapped on OL model

0. New signal: HA07 is notified of defects through home occupants calling their customer care line, which is staffed by three customer care representatives (from the operations arm). The customer care representative in HA07 records the post-completion defect data in a central database (which is saved on the HA's shared drive on their network and is accessible by the customer care representatives and anyone else who has access to that drive). In the database, the date the defect was logged is recorded, the type of defect that occurs is noted, the contractor responsible for the build is recorded, the details of the home occupant reporting the defect are noted, and the property that the defect has occurred in is used to log the report (including property address, the scheme ID, and property completion date). Once the repair has been completed, the home occupant is surveyed for satisfaction, and their level of satisfaction with the service provided is recorded. HA07 categorises defects by building area/component. The categorisation has been built up manually from the most frequent areas of failure reported to the HA.

1. Signal recognised as need for change: The Customer Care Manager (operations arm) exports the data from the database into a spreadsheet and analyses the spreadsheet monthly. The analysis looks into the rate of defects per unit per month, as well as the frequency of specific defect types, and frequency and type by contractors. HA07 also analyses customer satisfaction. The analysis is used to calculate performance against KPIs, to inform HA07's ERs and design guides. HA07 believe the defect rate per unit is a useful indicator of any emerging issues and the other analyses help them to illustrate any trends in performance or any issues with proprietary products that can then help with future schemes. The analysis is discussed at monthly management meetings (between the development and operations arms) and when specific defects are deemed a problem (a high volume of specific defects, or failure to meet a KPI) by the management team, changes are typically sought. HA07's most prevalent defects relate to internal services.

2. Experimentation and search for new options: When a change is deemed necessary by the management team (a combination of managers from the development and operations arms) potential solutions are invited from relevant internal people through the participants. Typically, the HA are seeking proposals for change in relation to updates to the HA's ERs or design guide.

3. Internal selection, articulation and codification into new routines: In order for a change to be implemented the HA needs approval from the management team. The management team will review the proposals and approve those that align with the HA's strategy. As the proposals typically relate to product/system adaptations, when a change has been approved, it is incorporated into the HA's ERs or design guides. A sponsor and project lead for the change will be nominated to oversee its implementation, and changes are further communicated via small training groups for those affected, updates to a lessons log, and then documents posted to the staff intranet.

4. Feedback: When the change has been implemented, HA07's management team will review this (and any other changes) on an annual basis for re-approval and continued implementation.

h) HA08 description

HA08 develop between 1,000 and 1,500 new affordable homes per year in the south of England. The HA has a 'development arm' responsible for building new homes; and, a 'customer services arm' responsible for managing the build stock (including defects). The HA can use any profit it makes from rental income and the sale of homes to maintain existing homes and help finance new ones. HA08 seek to learn from defects to reduce the number of defects, reduce the duration of repairs and improve customer satisfaction. HA08's learning from defects can be described in five stages (0-4) as shown in Figure 4.12.

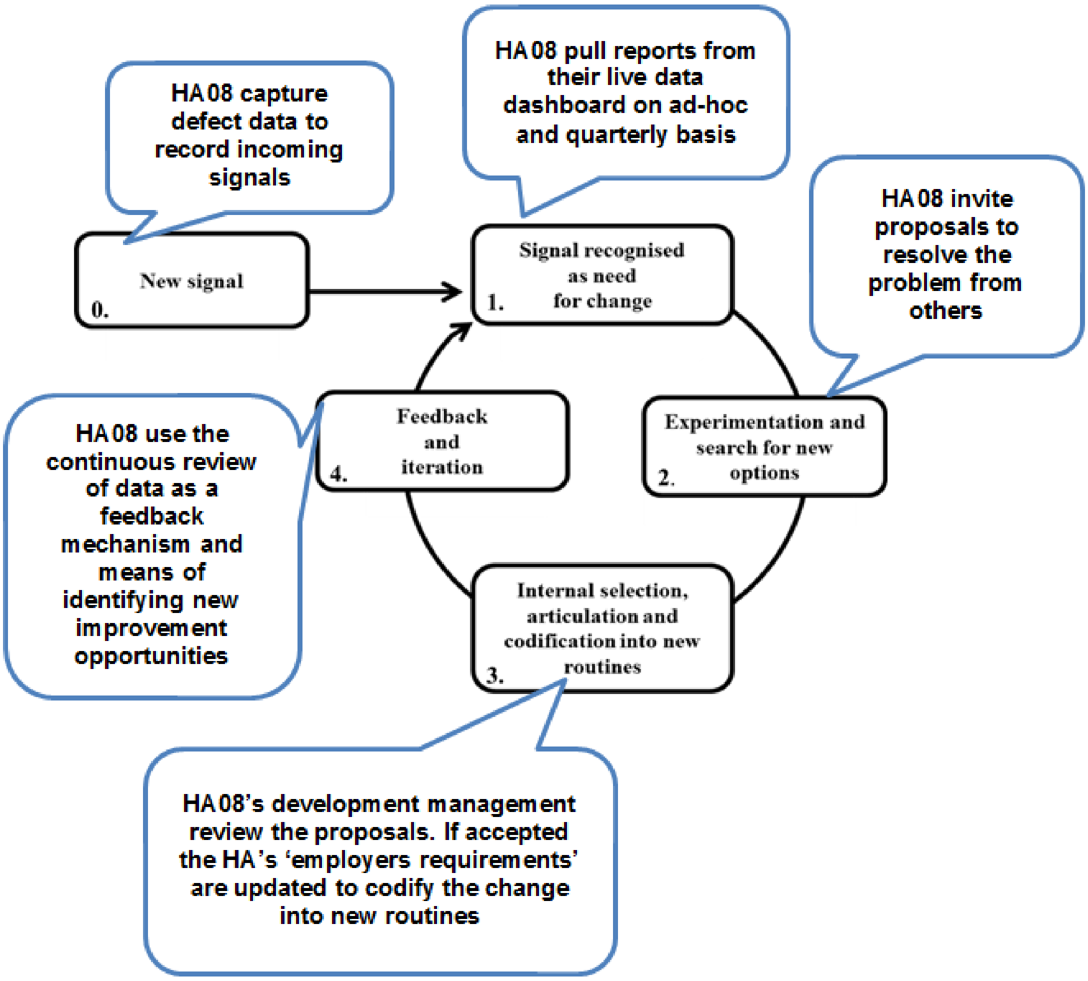

Figure 4.12: HA08 learning mapped on OL model

0. New signal: When the home occupant notices a defect in their new home, he/she contacts HA08's call centre (customer services arm). HA08's call centre operatives record the reported post-completion defect data in a bespoke defects management system. The defects management system enables the HA to record the date the defect is logged, what type of defect occurring, the property the defect has occurred in (including address, completion date, scheme ID, and the contractor responsible for build), the home occupant reporting the defect; and, a target date for any necessary repairs to be completed by. HA08 categorises defects by building area. The categorisation was built up manually from frequent areas of failure, through 'an internal brainstorming exercise'.

1. Signal recognised as need for change: HA08 has a live data reporting dashboard and review the data analysed both ad-hoc and quarterly. The Development Manager (development arm) undertakes the reviews and looks at the total number of defects occurring within the HA's build stock, the number of defects by contractor, and region. The analysis is used to monitor the HA's performance (e.g. number of defects per unit) and to inform HA08's ERs and design guides to update future properties. When specific defects are deemed a problem (a general feeling of high importance) by the Development Manager, changes are then explored. HA08's most prominent defects were in relation to internal services.

2. Experimentation and search for new options: When a change is deemed necessary, HA08's Development Manager undertakes research into specific systems and solutions to obtain further information on their ability to resolve the given problem. The Development Manager also uses anecdotal feedback from both internal and external people to identify potential solutions based upon individual and collective experience. When received, the initial potential options are exposed to a review group (consisting of individuals from both the development and customer service arms) and discussed with the HA's employer's agents to gain a cost perspective. The proposals for change are generally in relation to adaptations to the HA's ERs or design guide.

3. Internal selection, articulation and codification into new routines: In order for a change to be properly implemented in the HA, the review group puts the most suitable recommendations forward to the development arm. The development arm will review the proposals and approve those they deem suitable. When a change has been approved it is incorporated into the HA's ERs or design guides, which are updated annually. Any changes that have been implemented in relation to a contractor or manufacturer are communicated accordingly.

4. Feedback: When the change has been implemented, HA08 use anecdotal feedback to gauge the early feeling around the change and identify any major concerns. The HA also use ongoing monitoring both to identify new signals and as a feedback mechanism to determine whether the change has reduced the targeted defect. HA08 also has a review panel to review changes 12 months after implementation.

i) HA09 description

HA09 develop between 1,000 and 1,500 new affordable homes per year in the south of England and the midlands. The HA has a 'development arm' responsible for building new homes; and, an 'operations arm' responsible for managing the build stock (including defects). HA09 seek to learn from defects to reduce both the number of defects in their properties and the time it takes to get them resolved. HA09's learning from defects can be described in six stages (0-5) as shown in Figure 4.13.

0. New signal: HA09 receives notifications of defects when the home occupant calls their dedicated aftercare team (in the operations arm). The aftercare team in HA09 records the reported post-completion defects in database. In the database, the HA records the date the defect was logged, the type of defect reported, details of the contractor responsible for the build (and other associated property details i.e. address, completion date, and scheme ID), the details of the home occupant reporting the defect, a target date for a repair to be completed by, the actual start dates and end dates for the repair work, and whether the repair was completed within target. HA09 categorise their defects by building area/activity, for example windows, heating and hot water.

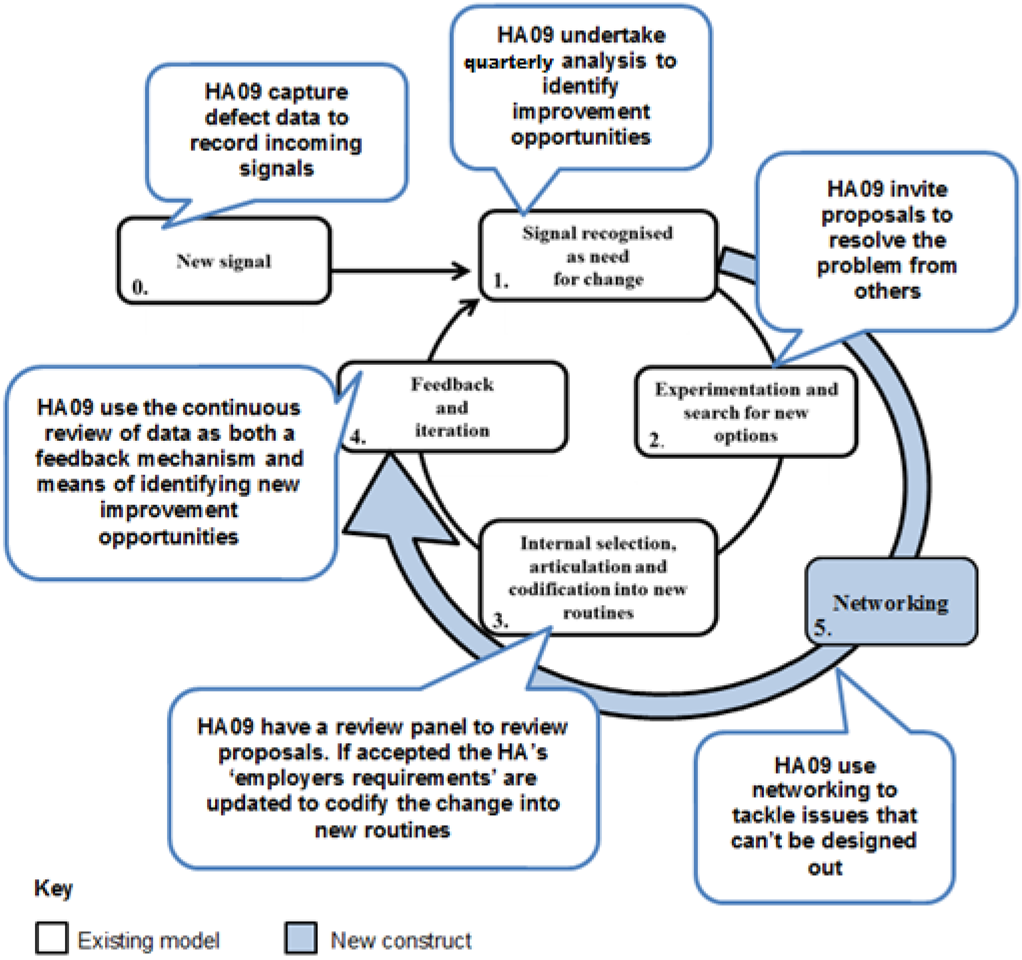

Figure 4.13: HA09 learning mapped on OL model

1. Signal recognised as need for change: The Aftercare Manager (operations arm) analyses the HA's database on a quarterly basis. The analysis looks at the frequency of defects occurring per property, the frequency of defects overall, the frequency of defects by category, the number of defects for specific contractors; and, whether a defect was resolved within the target time frame. The Aftercare Manager also undertakes more detailed analysis of all developments where the initial review identifies over one defect per property (on average) being reported for the analysed timeframe (the HA's KPIs). HA09 try to learn from defects to reduce both the number of defects in their properties and the time it takes to get them resolved. When specific defects are deemed major problems (one of the top three areas on the HA's top 10 list) the Aftercare Manager provides this information to the development managers and compliance team (development arm) for changes to be explored.

2. Experimentation and search for new options: The development managers and compliance team explore solutions to resolve the problems from internal and external sources.

3. Internal selection, articulation and codification into new routines: When a suitable option has been identified and agreed upon (by the development managers and compliance team) this is then put into the HA's ERs. The HA's ERs are updated annually. When a change has been implemented, the compliance team communicate the changes to key stakeholders within the HA (for example, design teams and the development teams) via email and training sessions. In addition to the key stakeholder messages, the HA post a list of changes on its staff intranet.

4. Feedback: When the new edition of the HA's ERs have been released, HA09 use the continuous review of data (data analysis) to determine whether the updated ERs have resolved the given issue, and also to identify new problems.

5. In addition to the OL constructs identified by the adopted model, the study of HA09's learning found that an additional OL construct was required. HA09 advocated 'networking' as an alternative to designing out defects through updates to their ERs. This was clear from the Aftercare Manager in the HA, who undertakes informal discussions with their employer's agents to raise their awareness of issues on site. The discussions are aimed at influencing the employer's agents behaviour on site to pick up more problems during construction.

j) HA10 description

HA10 develop between 1,500 and 2,000 new affordable homes per year in the south east of England and midlands. The HA has a 'development arm' responsible for building new homes; and, a 'housing management arm' responsible for managing the build stock (including defects). HA10 use their learning process to mainly monitor contractors. HA10's learning from defects can be described in six stages (0-5) as shown in Figure 4.14.

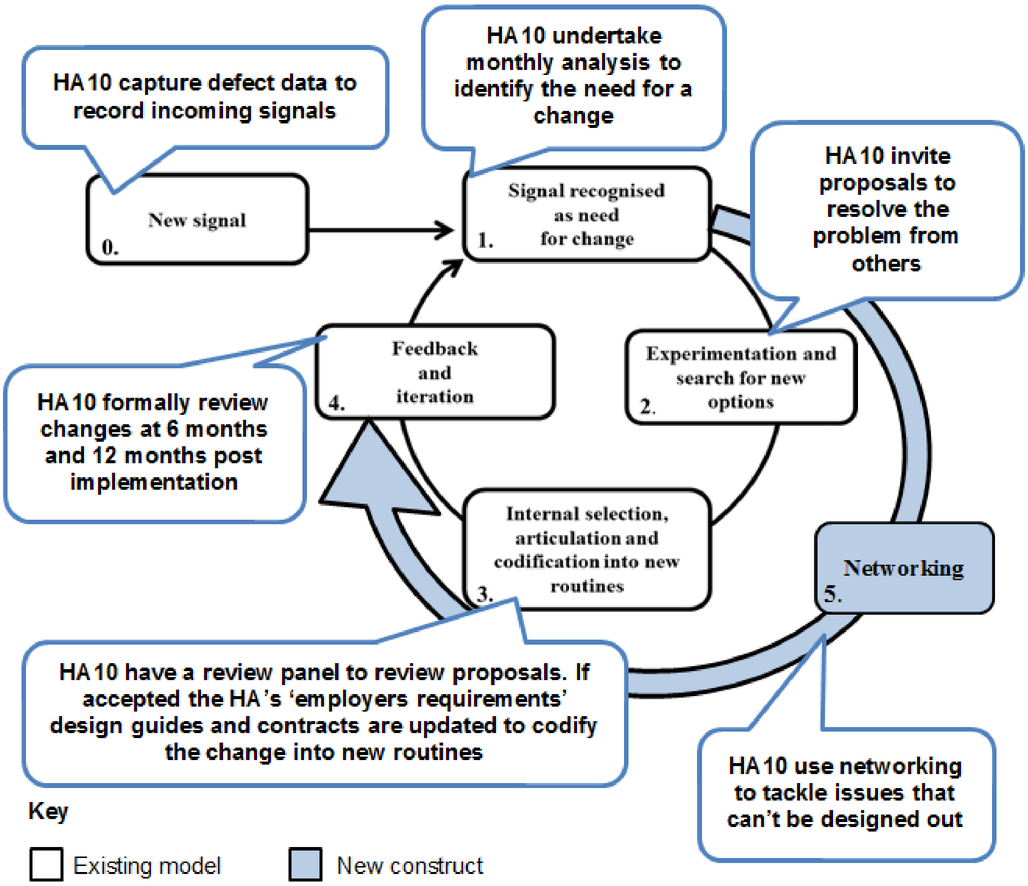

Figure 4.14: HA10 learning mapped on OL model

0. New signal: When a home occupant notices a defect within their property they can either contact HA10's aftercare team (in the home management arm) via telephone or email to report the defect. HA10 records the reported post-completion defect data in a 'bespoke' defects management system. The defects management system allows the user to look up the details of the property the defect is in (details include the address, the property completion date, and the scheme the property is in) and the contractor responsible for the build. The aftercare team member inputs the details of the home occupant reporting the defect and the details of the defect being reported (including a category). The defect is logged against a unique identification number, date and a repair arranged (if necessary). Upon completion of the repair, the resident's level of satisfaction with the service is noted. HA10 categorise their defects by the trade responsible for the defect's occurrence.

1. Signal recognised as need for change: HA10's Head of Quality (development arm) runs a report from their defects management system to analyse their defect data. The analysis is undertaken on a monthly basis, and looks at the frequency of defects overall and by individual categories, the contractors' defects performance (number of defects per contractor compared to volume of units built), and the home occupant's satisfaction with the service provided. The contractor performance is directly linked to retention (funds retained as part of the construction contract). When specific defects are deemed major problems (a comparatively high volume or failure to achieve a KPI) the Head of Quality will explore changes.

2. Experimentation and search for new options: The Head of Quality will invite proposals for alternative products and systems from internal sources.

3. Internal selection, articulation and codification into new routines: When a suitable option has been identified (by the Head of Quality) he then commits these to the HA's ERs, contracts, or design guides. The contracts, ERs and design guides are updated annually. A list of changes are then posted on the HA's intranet.

4. Feedback: When the HA's updated contracts, ERs and design guides have been implemented, HA10 review their data in relation to the specific change at six months and 12 months post implementation.

5. In addition to the OL constructs identified by the adopted model, the study of HA10's learning found that an additional OL construct was required. HA10 believe that the majority of defects are less design related and more issues of poor workmanship on site, and advocated 'networking' as a means of tackling these workmanship issues. This was clear from Head of Quality undertaking contractor quality discussions (based upon their contractor's defects analysis) with senior management in the development arm in a bid to guide the future awarding of contracts based upon past performance.

k) HA11 description

HA11 develop between zero and 500 new affordable homes per year in London and the south east of England. The HA has a 'development arm' responsible for building new homes; and, a 'customer services arm' responsible for managing the build stock (including defects). HA11 seek to learn from defects to identify improvement opportunities to address issues and trends (of defects) and increase customer satisfaction. HA11's learning from defects can be described in five stages (0-4) as shown in Figure 4.15.

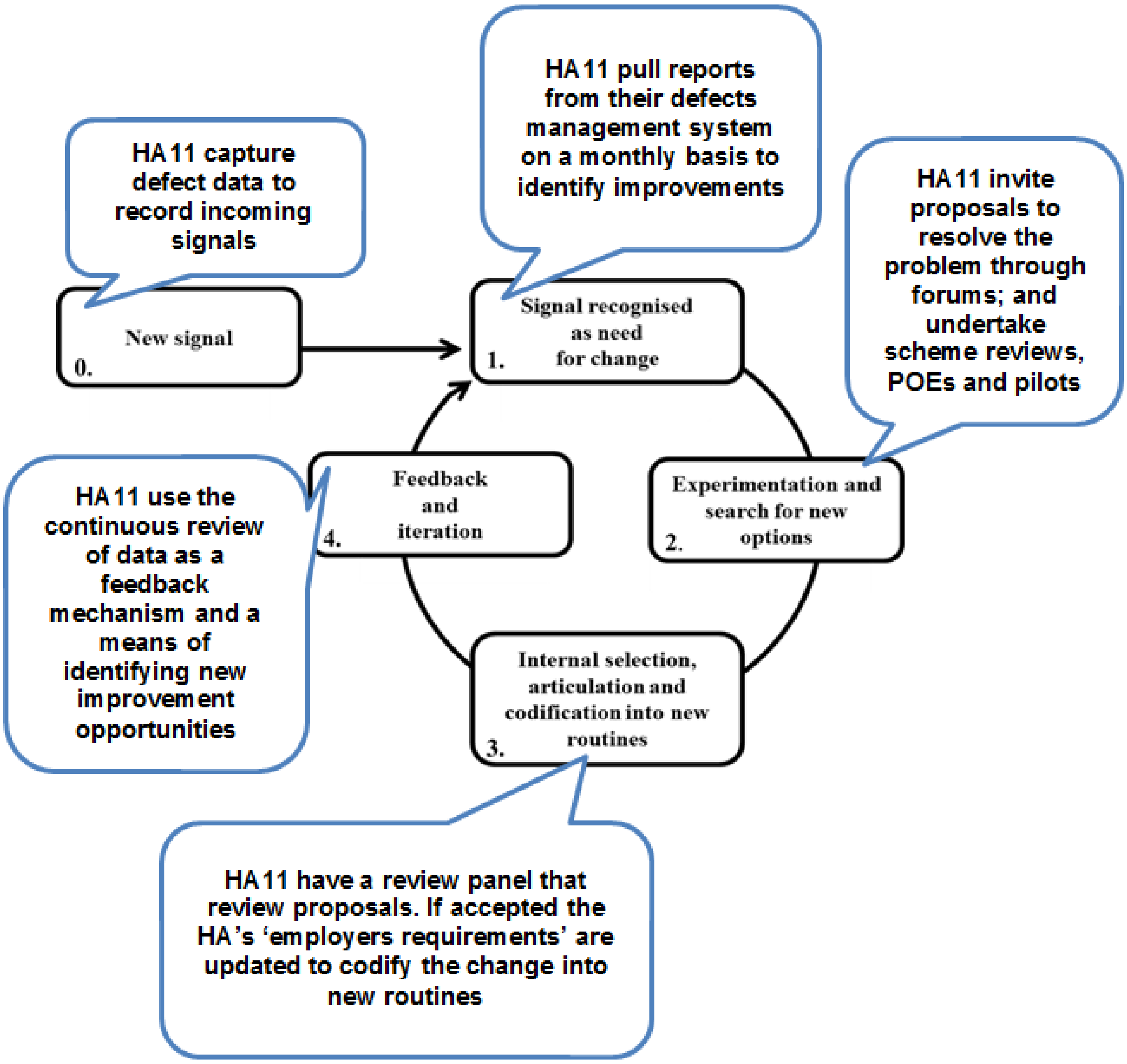

Figure 4.15: HA11 learning mapped on OL model

0. New signal: HA11 receives notifications of defects when the home occupant calls their customer care line. The customer care line contacts are sent to the HA's aftercare department (in the customer services arm) on a two hourly basis. The aftercare team records the post-completion defect data in an off the shelf defects management system. The defects management system allows the aftercare team member to look up the property details for the reported defect, including the scheme the property is in, the region (address details), the property completion date, the property type, and the contractor responsible for the build. The aftercare team member can then log a new defect (against a date) by inputting the home occupant's details, the type of defects occurring, a target completion date for the repair work, the priority of the defect repair (e.g. urgent), the actual start date and end date of the repair; and, the cost of the repair. HA11 categorise their defects by the trade responsible for its occurrence (i.e. carpentry, electrical, plumbing) as well as the building area in which the defect is occurring (e.g. windows, heating and hot water). In addition, the HA categorise defects by the repair priority. The HA is restricted to categories available on their system.

1. Signal recognised as need for change: HA11's New Homes Manager (customer care arm) runs a report from their defects management system to analyse their defect data. The analysis is undertaken on a monthly basis, and looks at the frequency of defects occurring, the cost of repairs, the scheme defect ratios, the property defect ratios, contractors' defects performance, and whether a defect was resolved within the target timeframe. HA11 try to learn from defects to both address issues and trends and update their ERs on future schemes. The New Homes Manager provides the defect data analysis to the Head of Quality and the Development Director (development arm). When specific defects are deemed an area for improvement (a problematic scheme, region, or failure to achieve a KPI, a high volume of defects in a specific area, or high repair costs) by the Head of Quality and the Development Director, the Head of Quality will initiate the exploration of potential change options. The focus of change option exploration tends to be on updating components, systems and construction methods to resolve the problem.

2. Experimentation and search for new options: The Head of Quality will invite solutions from internal and external sources (a number of pre-existing groups within the HA), as well as reviewing schemes that are performing well in the problem area. In addition, the HA will undertake post occupation evaluations (POE) at nine months after handover, where home occupants have an opportunity to contribute their feedback and make suggestions for improvement to both specifications and processes. Where no clear solution is evident, the HA will pilot changes on a small scale, and where something new (from the pilot) is reported as an improvement (during home occupant discussions) it is put forward to be reviewed for use on other projects and for incorporation into the HA's ERs.

3. Internal selection, articulation and codification into new routines: When suitable options have been received, the Head of Quality will email them to an impartial review panel consisting of senior management from the HA (including the Head of Quality and Development Director). The review panel will review the proposals and determine their viability. Costs and efficiency play a significant element in determining which change options are adopted. When a suitable option is adopted it is put into the HA's ERs and design guides to update components, systems and construction methods etc. Changes are also communicated around the organisation through stakeholder emails, meetings, and updates being posted on the staff intranet. In addition to internal communication, HA11 also use external feedback to contractors and manufacturers to communicate details of any changes that affect them.

4. Feedback: When the new edition of the HA's ERs have been implemented, HA11 use the continuous review of data (data analysis – by the New Homes Manager) to determine whether the updated ERs have resolved the given issue, and also to identify new problems. HA11 suggest that it typically takes around 18 months for future projects to benefit from the changes.

l) HA12 description

HA12 develop between 1,500 and 2,000 new homes per year nationwide. The HA has a 'development arm' responsible for building new homes; and, an 'asset management arm' responsible for managing the build stock (including defects). HA12 seek to learn from defects to identify problems and improvement opportunities to reduce defects in future homes. HA12's learning from defects can be described in five stages (0-4) as shown in Figure 4.16.

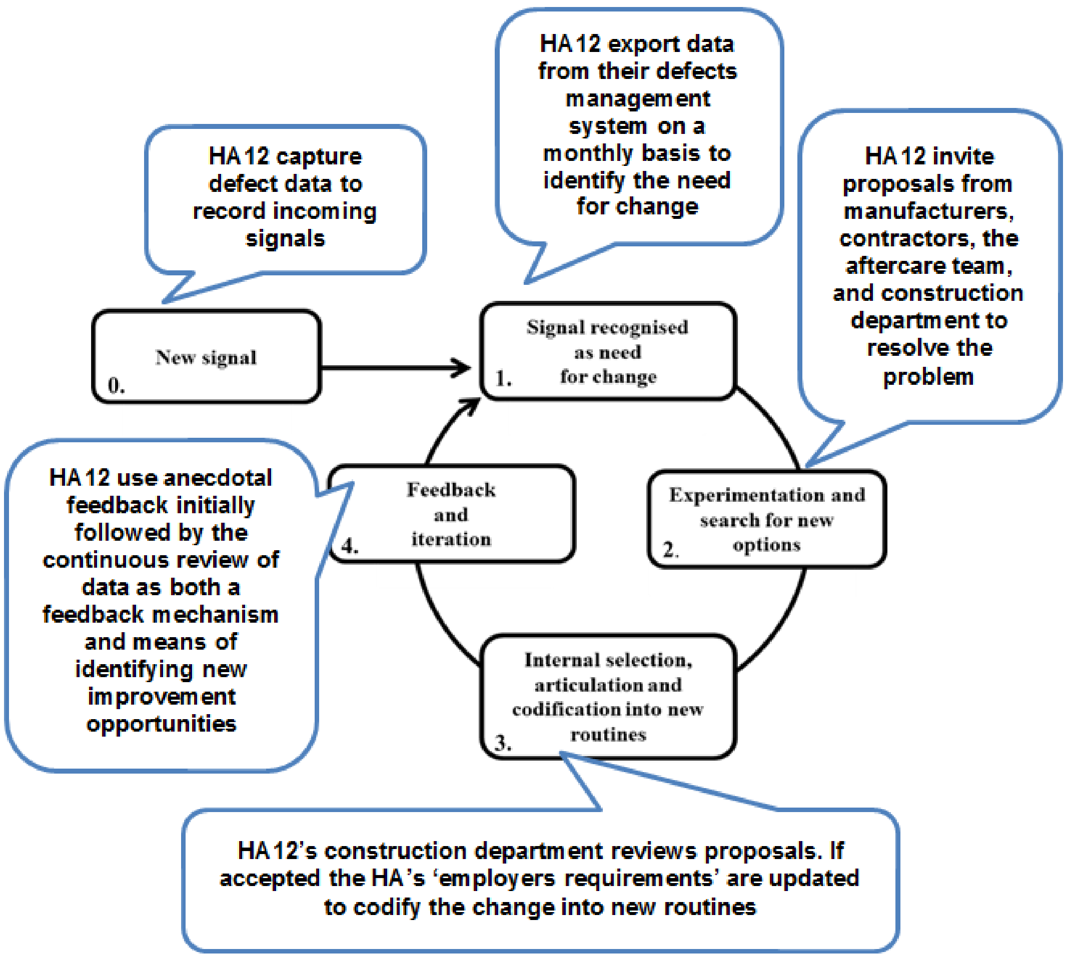

Figure 4.16: HA12 learning mapped on OL model

0. New signal: HA12 receives notifications of defects when the home occupant calls their aftercare team (in the asset management arm). HA12 records this post-completion defect data in an 'off the shelf' defects management system. The aftercare team member logs the defect (against the date reported) by recording the type of defect reported, the home occupant and property details (e.g. the property address, completion date, the development the property is in, the contractor responsible for the build, the home occupant's name and phone number), the trade responsible for the defect, the location in the property that the defect is occurring (e.g. whole house, bedroom), the specific building element at fault (e.g. plumbing, staircases), a manual text description of the problem reported, the repair priority (e.g. the defect has to be repaired within four hours, 24 hours, seven days, or 28 days), the status of the repair, and the cost of the repair. HA12 categorise their defects by building area, the trade responsible for the defect, the extent of the defect, and the repair priority.

1. Signal recognised as need for change: HA12's Aftercare Manager (asset management arm) exports data from the HA's defects management system to a spreadsheet to analyse their defect data. The analysis is undertaken on a monthly basis, and looks at the cost and frequency of defects overall as well as by category (building area). HA12 analyse their defects to look for opportunities to improve their properties, reduce defects and long-term costs. The analysis also helps the HA's Aftercare Manager to prove a problem's existence and the benefits of introducing a change (to other departments). When specific defects are deemed major problems (a comparatively high frequency or high cost of a particular building area) the Aftercare Manager discusses this information with the Asset Manager and alternative ways of working are explored. HA12's most prevalent defects relate to internal services.

2. Experimentation and search for new options: The Aftercare Manager and Asset Manager explore solutions to resolve the problems from internal and external sources, such as discussions with manufacturers and contractors involved; discussions with the HA's aftercare and construction departments. The potential solutions are positioned around changing the HA's ERs.

3. Internal selection, articulation and codification into new routines: When a suitable option has been identified it is further discussed with the HA's construction department (development arm), who have overriding authority on whether the change is implemented. If the proposed solution is accepted, then it is put into the HA's ERs. When a change has been implemented it is communicated internally through meetings and externally through feedback to relevant contractors and manufacturers.

4. Feedback: When the new updated ERs have been released, HA12 initially use anecdotal feedback to gauge the feeling around the change, and then use their continuous review of data to determine whether the implemented change has reduced the targeted defect(s) (as well as identify new improvement opportunities).

J) Examples of learning from defects in a housing association environment

In order to further understand how the HAs learnt from defects, where possible, participants were asked to describe a specific event of defect reduction. The process was mapped onto the OL framework. Figure 4.17 below shows the learning process in HA12 to reduce shower tray failures.

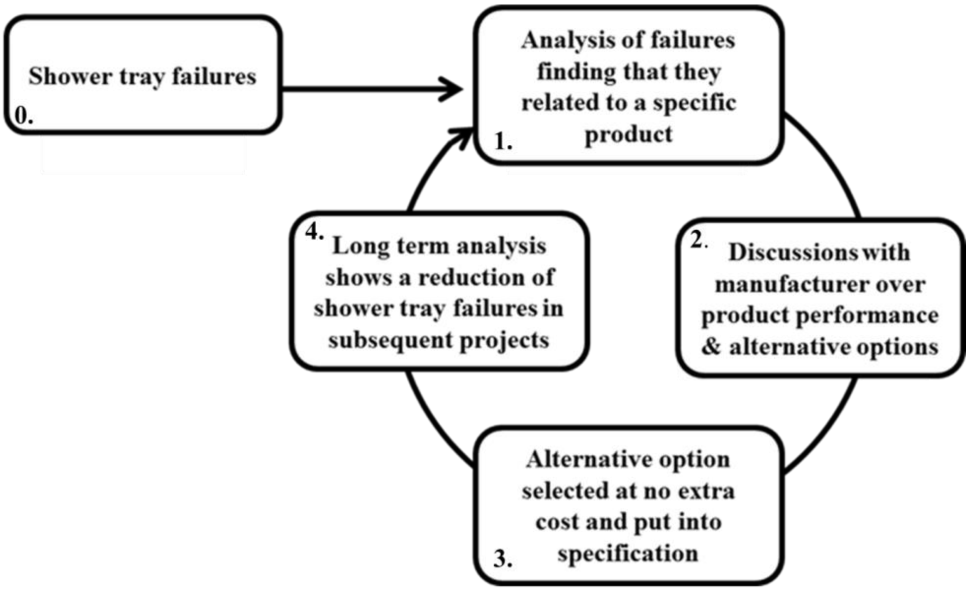

Figure 4.17: OL to reduce shower tray failures in HA12

0. New signal. New signals were entering the organisation through the HA's customer care department via reports of shower tray failures.

1. Signal recognised as need for change. A member of the aftercare team along with the Aftercare Manager analysed data for trends and found a comparatively large number of shower tray failures. Due to the high volume of shower tray failures, the Aftercare Manager brought this to the Asset Manager's attention and they believed this may be something that warrants change. More detailed analysis was undertaken by the Aftercare Manager. The analysis showed that the failures typically related to one manufacturer's shower tray.

2. Experimentation and search for new options. The Aftercare Manager had discussions with the manufacturer over the product performance and came to an agreement with the manufacturer that the manufacturer would provide a higher specification shower tray for the same price of the original.

3. Internal selection, articulation and codification into new routines. The Aftercare Manager and Asset Manager then proposed this to the senior manager within the construction department, who approved the change (as it was at no extra cost) and codified the change into organisational routines by way of updating the HA's 'employers requirements' (specification to be used on all builds) documents.

4. Feedback and iteration. After the new specification was implemented for some time, long-term analysis/continuous performance review (undertaken by the Aftercare Manager), identified that the alternative shower tray had reduced the number of shower tray failures (comparatively) since its introduction.

Figure 4.18 below shows the learning process in HA02 to reduce cracking and movement associated with timber frames in their properties.

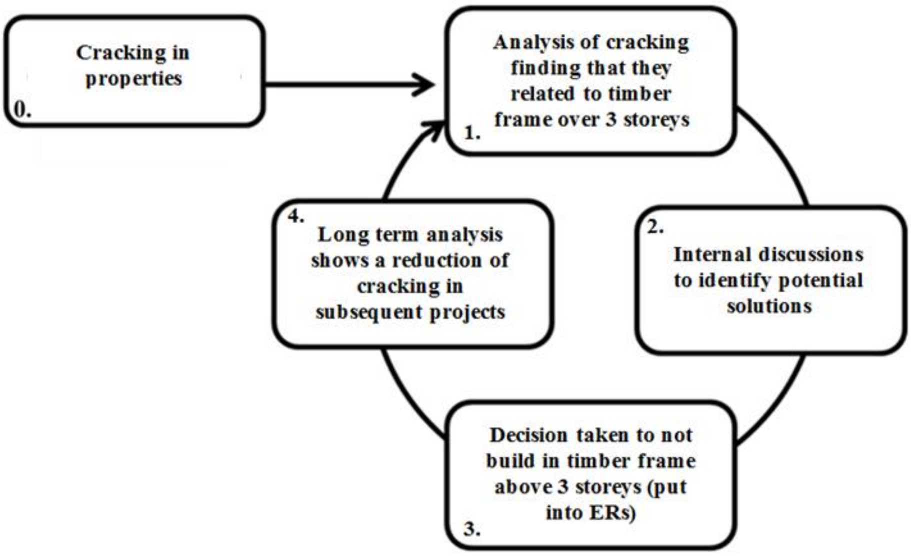

Figure 4.18: OL to reduce cracking in timber frame properties in HA02

0. New signal. New signals were entering the organisation through the HA's call center via reports of cracking and movement to properties.

1. Signal recognised as need for change. The aftercare team and Asset Manager analysed data for trends and found a comparatively large number of cracking reports. Further, more detailed investigation work by the Clerk of Works found that the cracking typically related to movement in properties above three storeys high of timber frame construction.

2. Experimentation and search for new options. The Asset Manager sat down to discuss the problem with the Quality Manager, and through the discussions they came to the simple solution of not building in timber frame above three storeys on future developments.

3. Internal selection, articulation and codification into new routines. The Quality Manager put the proposal to not build timber frame above three storeys in height to the HA's formal review panel that approved the proposal, and had the change codified into organisational routine through updates to the HA's ERs document (and specification to be used on all builds).

4. Feedback and iteration. After building with the new requirements for some time, long-term analysis and continuous performance review identified that the alternative method of constructing properties above three storeys in height had reduced the number of reports of cracking (comparatively) since its introduction. HA02's defect log only contains one report of cracking/movement in the superstructure out of 85 records.

In addition to the examples of successful learning above, the HA's, in some cases, outlined examples of where their learning and improvement attempts had failed. Figure 4.19 below shows the failed learning process in HA12 when attempting to reduce roof mortar failures.

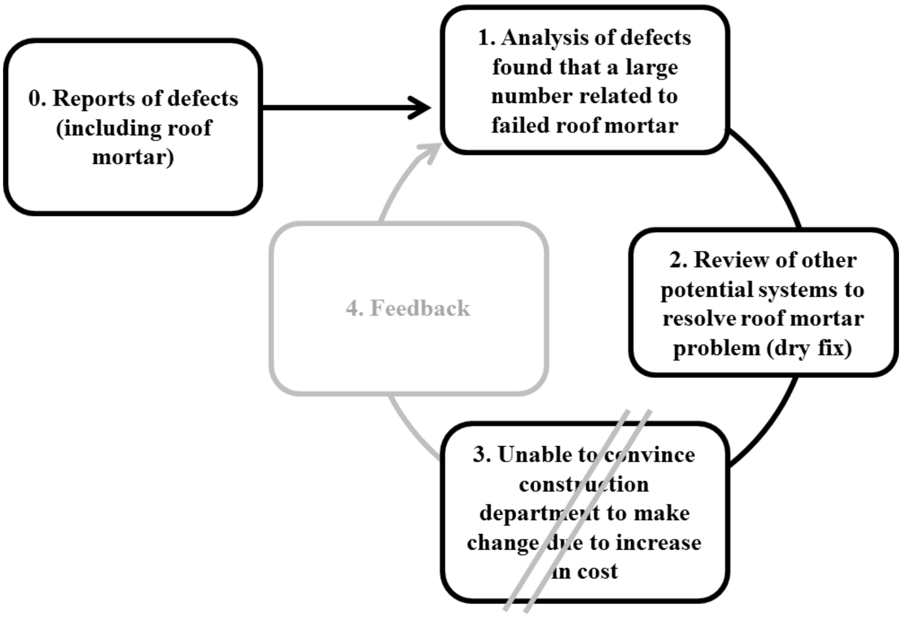

Figure 4.19: Failed OL to reduce roof mortar defects in HA12

0. New signal. New signals were entering the organisation through the HA's customer care department via reports of failed verge and ridge mortar.

1. Signal recognised as need for change. A member of the aftercare team along with the Aftercare Manager analysed data for trends and found a comparatively large number of roof mortar defects. Due to the high volume of roof mortar defects, the Aftercare Manager brought this to the Asset Manager's attention and they believed this may be something that warrants change.

2. Experimentation and search for new options. The Aftercare Manager reviewed other types of verge and ridge systems and came to the conclusion that a dry fix system could resolve the roof mortar problems.

3. Internal selection, articulation and codification into new routines. The Aftercare Manager and Asset Manager then proposed the dry fix system to the senior manager within the development/construction department, who denied the change because there was a lack of proof that the initial cost increase would reduce costs long-term.

HA06 provided a similar example of failed learning to reduce the number of lift failures. The change was rejected due to a lack of proof that alternative lifts would perform better.

Cross-case analysis

As shown in section 4.2.2 'individual case studies' the 12 HAs learning practices were evaluated using the adopted OL model as a guide to establish whether the HAs were modifying their behaviour to reflect new knowledge and insights from past defects. This section compares the 12 HAs learning practices. Table 4.1 below outlines the 12 HAs' different approaches to learning, arranged into three categories: no learning, undertaking OL as per the adopted OL model, and undertaking OL that identified the requirement of a modification to the adopted OL model. The compared learning approaches are discussed in more detail below.

Table 4.1: Overview of HAs different learning approaches

Learning approach		HAs	Constructs used
No Learning		HA05	*0. New signal construct only*
Learning	**as per adopted OL model**	HA01, HA04, HA06, HA07, HA08, HA11,HA12	*All of the five constructs of the adopted OL (0. New signal; 1. Signal recognised as need for change; 2. Experimentation and search for new options; 3. Internal selection; articulation and codification into new routines; and, 4. Feedback constructs)*
	with the need for an additional OL construct	HA02, HA03, HA09, HA10	*All of the five constructs of the adopted OL and an additional construct of 5. Networking*

No learning: Where 'no learning' had been deemed to take place (HA05) the adopted OL model did not progress beyond the new signal construct. This no learning could be seen as a simple process of repairing defects and returning the home to the state that it should be in. What is not evident is any effort to change processes in an attempt to stop or reduce the defects occurring in future homes.

Learning as per the adopted OL model: Seven HAs (HA01, HA04, HA06, HA07, HA08, HA11 and HA12) followed the stages as outlined in the adopted OL model.

Learning with the need for an additional OL construct: From the individual HA analysis the questions in relation to the internal selection construct identified a new OL construct of 'networking' to generally share knowledge informally in four HAs (HA02, HA03, HA09 and HA10). Networking tended to occur after the 'signal recognised as need for change' construct. The learning followed one of the two routes below. First, the learning started with 'signal recognised as need for change', followed by 'experimentation and search for new options', 'internal selection, articulation and codification into new routines', ending with 'feedback and iteration' before returning to the start of the OL cycle. Second, the learning started with 'signal recognised as need for change', followed by 'networking', 'feedback and iteration' and then returning to the beginning of the cycle as shown in Figure 4.20 below. Networking was typically used as an alternative route to the main process as explained below. However, this is not to say that networking and the main loop could not be used concurrently.

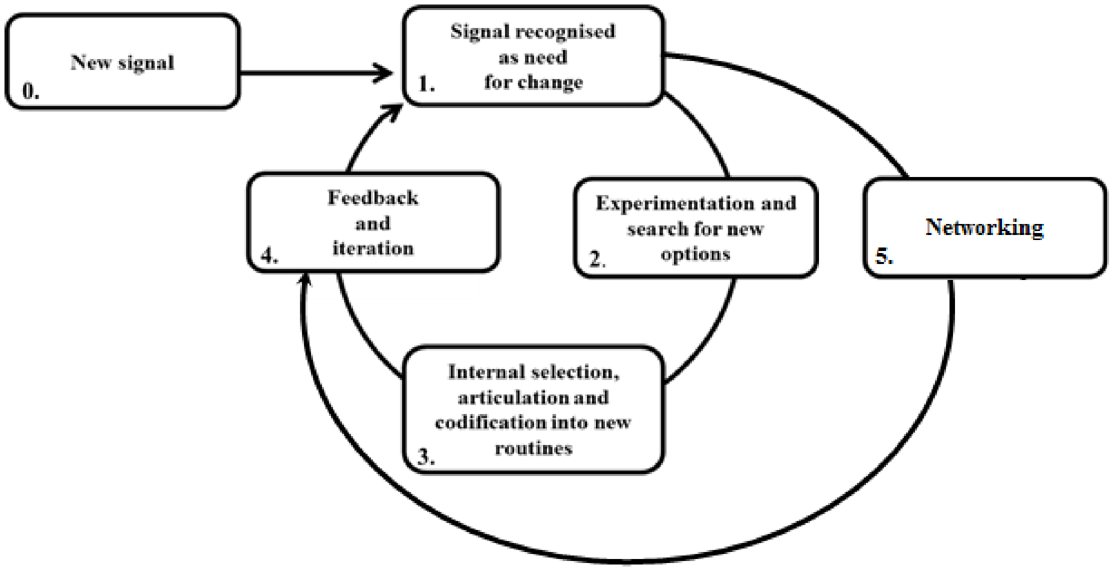

Figure 4.20: The modified OL model showing the networking construct

0. New Signal: The key findings indicate that all 12 of the HA's recorded defect data, typically through a central team which deals with the defects management process (the defects management team) (see Table 4.2). However, the defect data was captured in a variety of systems, with varying detail, extent, and classification.

In regard to systems used, three HAs (HA01, HA02, and HA05) recorded post-completion defect data in a standard spreadsheet, whereas the remaining nine HAs used defects management information systems (a combination of off the shelf packages and bespoke systems) to both capture data and manage the repair process. A defects management system allowed a HA to look-up property records for their existing build stock. After identifying the property, the HA could: create a new defect record, input home occupant details (e.g. name, telephone number); arrange an investigation (if deemed necessary); assign a repair to a contractor; and, document and track progress along the way. The volumes of defect data captured within the respective systems per year ranged from a low of 85 records held in HA02's spreadsheet to 16,000 records contained in HA12's defect management system.

Table 4.2: New signal themes

0. New signal	**General Theme**	**Specific Theme**	**HA01**	**HA02**	**HA03**	**HA04**	**HA05**	**HA06**	**HA07**	**HA08**	**HA09**	**HA10**	**HA11**	**HA12**
Do you record post completion defect data?	-	Yes	1	1	1	1	1	1	1	1	1	1	1	1
At what level of detail is the data captured?	**Property Details**	Address	1	1	1	1	1	1	1	1	1	1	1	1
		Property completion date	1	1	1	1	1	1	1	1	1	1	1	1
		Construction type		1									1	
		Scheme ID	1	1	1	1	1	1	1	1	1	1	1	1
		Contractor	1	1	1	1	1	1	1	1	1	1	1	1
		Warranty policy no.		1			1							
	-	Customer details	1	1	1	1	1	1	1	1	1	1	1	1
	Defect/ repair details	Building area	1			1			1	1	1		1	1
		Trade			1			1				1	1	1
		Extent												1
		Repair priority	1										1	1
		Free-text description	1	1	1	1	1	1	1	1	1	1	1	1
		Damage						1						
		Date logged	1	1	1	1	1	1	1	1	1	1	1	1
		Target completion date			1	1				1	1		1	
		Start date					1				1		1	
		End date					1				1		1	
		Status of repair		1							1			1
		Repair cost		1			1						1	1
		Estimated savings		1										

Table 4.2 continued…

0. New signal	General Theme	Specific Theme	HA01	HA02	HA03	HA04	HA05	HA06	HA07	HA08	HA09	HA10	HA11	HA12
Do you use any categories to classify defects?	-	Yes	1		1	1		1	1	1	1	1	1	1
	-	No		1			1							
What categories are chosen to classify defects?	-	Trade			1			1				1	1	1
	-	Building area	1			1			1	1	1		1	1
	-	Extent												1
	-	Damage						1						
	-	Repair priority	1										1	1

In respect of detail and extent of data captured, all 12 HAs captured seven core fields of information: (1) the property address, (2) the property completion date, (3) the associated scheme ID, (4) the name of the contractor responsible for the build, (5) the details of the customer reporting the defect, (6) the date the defect was reported/logged, and (7) a free-text field for a description of the defect and any damage reported. Outside of these seven core fields the data captured differed significantly between the HAs; for example, two HAs recorded construction type, two HAs recorded the warranty provider's policy number for the property, one HA recorded estimated cost savings (typically when a warranty claim had been successfully made) and three HAs kept a record of the status of a repair (e.g. closed, ongoing). Further, divergent levels of data accuracy between respective HAs were evident. HA11 suggested that inaccurate defect data was hampering their learning capabilities when they explained that:*"…we are hoping to reduce inaccurate defect recording which will provide a more in depth understanding of what needs to be changed or improved on our future projects...".* One instance of potential poor data accuracy was in HA10, who place a large emphasis on redirecting defects straight to the main contractor to rectify and record their data based upon home occupants' reported descriptions of the defects. HA10 is in stark contrast to HA02 who have clerk of works who investigates all defects and then add notes in their system to outline the cause established from those detailed investigation findings. HA02's defect log contained significantly fewer defects compared to the other HAs and they were one of the HAs who could outline specific instances of how they had achieved defect reduction through OL.

In terms of defect classification, 10 of the 12 HAs used categories to classify defects while the remaining two HAs did not attempt to categorise defects (instead, relied upon the free-text descriptions for capturing defect data). When classifying defects, the categories used in rank order were: ‘building area’ (the area of the building in which they had occurred, e.g. doors and windows, electrics, heating) (seven HAs), ‘trade’ (the trade responsible for their occurrence, e.g. plumber, joiner, electrician) (five HAs), ‘repair priority’ (the priority of the repair, e.g. emergency, urgent, or routine) (three HAs), ‘damage’ (the damage caused as a result of the defect’s occurrence) (one HA), and ‘extent’ (the level in which the defect was affecting the property, e.g. whole house) (one HA). Further, the defect classification adopted by the 10 HAs varies, from the use of the ‘trade’ category only (two HAs) to the use of four categories (building area, trade, repair priority and extent) (one HA) (Table 4.2).

1. Signal recognised as need for change: The HAs relied upon analysing defect data as the catalyst for their learning processes. The need to analyse defect data in order to identify the need for change was evident in 11 of the 12 HAs. HA02, for example, confirmed that analysing defect data enabled them to *“…identify areas of strength or weakness and potential areas that require change…”.* In contrast, the only HA who did not undertake any analysis reported that they could not identify trends and improvement opportunities to reduce defects.

With regards to why HAs analyse defect data, there were three consistent themes, monitoring, defect reduction; and, improvement. Nine of the 11 HAs analysed defect data for monitoring purposes, of these five did it for general performance monitoring, four to monitor contractors, and two to also monitor product and system performance. Seven of the HAs analysed defect data for reduction purposes. All of the seven believed that analysing defect data could reduce defects, with two also believing that it could reduce the repair duration. Finally, six HAs analysed defect data to identify improvement opportunities, four believed it could improve customer satisfaction, and one HA used the data analysis to justify proposed changes.

Where HAs undertook defect data analysis, the ‘frequency’ and ‘areas’ analysed varied considerably. In terms of frequency of analysis, 10 of the HAs analysed defect data based on one particular frequency: a ‘monthly’ basis by six HAs, a ‘weekly’ basis by two HAs, an ‘ad-hoc’ basis by one HA, and one HA on a ‘quarterly’ basis. Only one HA undertook the analysis on both an ‘ad-hoc’ and ‘quarterly’ basis.

In respect of what HAs analyse, there were two consistent features: the frequency of defects within the organisation’s build stock (10 of the 11 HAs), and the number of defects within the organisation’s build stock sorting by type/category (eight HAs). Other common aspects analysed were: the number of defects occurring sorting by the key actor responsible for the build – typically the contractor (seven HAs), the number of defects per unit built over a given time period (six HAs), the total repair cost for the analysed time period (four HAs); and, whether the repair had achieved its target completion date (four HAs).

In contrast to the common analysis approaches one HA analysed the type/category of defects occurring separating by the key actor responsible for the build (typically the contractor), two HAs analysed the customer’s levels of satisfaction with the repair and service, HA12 analysed the cost of defects occurring by type/category of defects; and, HA08 analysed the number of defects sorting by geographical regions (Table 4.3).

Table 4.3: Signal recognised as need for change themes

1. Signal recognised as need for change	**General Theme**	**Specific Theme**	**HA01**	**HA02**	**HA03**	**HA04**	**HA05**	**HA06**	**HA07**	**HA08**	**HA09**	**HA10**	**HA11**	**HA12**
Do you analyse defect data?	-	Yes	1	1	1	1		1	1	1	1	1	1	1
	-	No					1							
What do you analyse?	**Number**	Overall	1	1	1	1		1		1	1	1	1	1
		Per unit	1						1	1	1	1	1	
		Per contractor/consultant/ employee			1	1			1	1	1	1	1	
		Per region								1				
	Type/ category	Overall	1	1				1	1		1	1	1	1
		Per contractor/consultant/ employee							1					
	Cost	Overall		1		1							1	1
		Type/category												1
		Per contractor/consultant/ employee				1								
	-	Customer satisfaction							1			1		
	-	Repair target achieved			1	1					1		1	

Table 4.3 continued…

1. Signal recognised as need for change	General Theme	Specific Theme	HA01	HA02	HA03	HA04	HA05	HA06	HA07	HA08	HA09	HA10	HA11	HA12
How frequently is the analysis undertaken?	-	Ad -hoc						1		1				
	-	Weekly		1	1									
	-	Monthly	1			1			1			1	1	1
	-	Quarterly								1	1			
Why do you analyse defect data?	**Monitoring**	Monitor performance				1			1	1			1	1
		Monitor contractors	1	1	1							1		
		Monitor product/systems		1					1					
	Reduction	Reduce defects	1	1				1	1	1	1			1
		Reduce long-term costs		1				1						
		Reduce repair duration								1	1			
	Improvement	Identify improvement opportunities	1	1				1	1				1	1
		Improve customer satisfaction	1					1		1			1	
	-	Justify proposed changes						1						
How do you decide that the findings present a need for a change?	-	KPIs	1						1		1	1	1	
	-	High frequency (comparatively)	1					1	1		1	1	1	1
	-	General feeling of high importance		1	1	1		1		1				1
	-	Customer complaints				1								
	-	High repair costs											1	

2. Experimentation and search for new options: The identification of new adaptation options were found mainly through 'invitation' to relevant internal and external people, followed by the review of data relating to projects performing well, review of customer feedback, and piloting alternatives to gauge viability on a small scale. First, it was found that all of the HAs who analysed defects data exploited the knowledge and experience of co-workers by openly inviting proposals to solve a given problem through internal communication, such as formal meetings and discussions. HA04, for example, described how alternative options were generated *"…via [formal] meetings and discussions with our finance, maintenance and development teams…."*. Further, external discussion was advocated by five HAs, with HA12 promoting "…*discussions with manufacturers and contractors involved…"*. Second, three HAs were in favour of reviewing products, systems and personnel in schemes that are performing well when compared to their peers. HA06 encouraged *"…looking at the past performance of the alternative products/systems…"* as a means of determining the long-term viability of alternative options. Third, in addition to discussions with those actors involved in the construction process, HA11 considered feedback from residents via satisfaction surveys when identifying changes. Finally, HA11 piloted potential changes on a small scale prior to mass introduction and suggested that *“when something new is reported as an improvement it is rolled out on other projects and incorporated in updated future standards”* (Table 4.4).

Table 4.4: Experimentation and search themes

2. Experimentation and search for new options	**General Theme**	**Specific Theme**	**HA01**	**HA02**	**HA03**	**HA04**	**HA05**	**HA06**	**HA07**	**HA08**	**HA09**	**HA10**	**HA11**	**HA12**
If a change is needed, how do you identify adaptation options?	**Invitation**	Formal internal communication	1	1	1	1		1	1	1	1	1	1	1
		Formal external communication		1						1	1		1	1
	-	Review of well performing schemes		1				1					1	
	-	Pilots											1	
	-	Customer feedback											1	

3. Internal selection, articulation and codification into new routines: It was found that selecting and approving an adaptation option was made through review panels at an organisational level and informal communication at an individual/unit level. First, review panels were conducted by seven HAs to consider change proposals and determine whether the proposed changes were in alignment with the organisational strategy. A review panel was typically the leadership group which consisted of senior management from the organisation. Second, the remaining four HAs were reliant on the department who could make the change. This was captured by HA12 who stated that *“…the construction department has the final say in whether a change [to specification] is made…”*.

Once a change has been selected, changes were captured and codified into new routines by 11 HAs, primarily through updating their ‘employers requirements’ (specification to be used for all builds). Five of the 11 HAs further updated their ‘design guides’ in light of accepted changes.

Nine of the HAs had strategies in place to communicate the implemented changes to key stakeholders including emails to key internal stakeholders, posting updates on a staff intranet, feedback to contractors, feedback to manufacturers, internal meetings, updating of a lessons log, and providing internal training groups for stakeholders directly affected by a change (see Table 4.5 below).

Table 4.5: Internal selection themes

3. Internal selection, articulation and codification into new routines	**General Theme**	**Specific Theme**	**HA01**	**HA02**	**HA03**	**HA04**	**HA05**	**HA06**	**HA07**	**HA08**	**HA09**	**HA10**	**HA11**	**HA12**
How are adaptation options decided and selected, and by who?	-	Review panel	1	1	1			1	1	1			1	
	-	Team responsible for overseeing change				1					1	1		1
Once selected, how are the new processes communicated around the organisation?	**Formal Documents**	Employers Requirement/ specification	1	1	1	1		1	1	1	1	1	1	1
		Design Guide						1	1	1		1	1	
		Contracts										1		
	Internal feedback	Lessons log		1					1					
		Stakeholder email	1					1			1		1	
		Internal meetings		1									1	1
		Staff intranet							1		1	1	1	
		Training sessions							1		1			
	External Feedback	Contractor feedback		1						1			1	1
		Manufacturer feedback		1									1	1

The questions in relation to the internal selection construct identified a new OL construct of ‘networking’ to generally share knowledge informally. Networking is discussed in more detail later in this section (5. Networking).

4. Feedback and iteration: The feedback on the implemented changes was monitored through three mechanisms: anecdotal feedback, ongoing performance monitoring, and review panels. Two HAs relied solely upon feedback from anecdotal channels to gauge the success of a change. Two HAs conducted review panels to formally review progress since the implementation of a change. Three HAs trusted the continuous review of data and ongoing monitoring to determine the success of a change. The remaining four HAs exercised a combination of the approaches. For example, HA02 advocated an approach of using anecdotal feedback to evaluate the early feeling around the implemented change. HA02 would then take an approach of continuously monitoring and reviewing performance to observe progress (as well as identify new signals) (Table 4.6).

Table 4.6: Feedback themes

4. Feedback and iteration	**General Theme**	**Specific Theme**	**HA01**	**HA02**	**HA03**	**HA04**	**HA05**	**HA06**	**HA07**	**HA08**	**HA09**	**HA10**	**HA11**	**HA12**
When implemented, how do you monitor the new processes to make sure they are viable and remain viable?	-	Anecdotal feedback	1	1		1		1		1				1
	-	Review panel	1						1	1		1		
	-	Ongoing performance monitoring		1	1					1	1		1	1

5. Networking: In four (HA02, HA03, HA09, HA10) out of the 11 HAs where new lessons that had been identified that did not result in "adaptation" to formal routines (i.e. updates to the HAs 'employers requirements' or 'design guides'), 'networking' (a new OL construct) was found to be used by these four HAs to informally share new lessons learnt with colleagues within and cross departments. HA10, for example, remarked that *"… defects are typically [in their experience] related to workmanship rather than design…"*. With the workmanship concerns in mind four HAs had internal informal discussions (networking) with site teams to raise awareness of problem areas of construction. This was further evident in HA02 where the Head Clerk of Works (who was largely office based and focussed on defects post-completion) arranged regular team meetings with his clerk of works (who were typically site based inspecting new-builds) which required them to provide examples of typical defects they felt they were seeing frequently on site for discussion. The Head Clerk of Works would also provide an overview of particular problems identified through their defects log. Through these discussions the clerk of works were further aware of potential problem areas on site. In addition to networking with site teams to share experience and knowledge, HAs also advocated 'networking' with departments responsible for procurement and development. This was clear from HA03 who undertook quality improvement discussions with senior management in a bid to guide future decision making; and two further HAs who discussed contractors' long-term performance and general problems with their development department to influence their future awarding of contracts.

The need to both design out defects and use networking to reduce workmanship problems was captured by HA10 who argues that *"our experience is that the majority of defects are less design and more poor workmanship"* and HA11 who suggests that *“whilst we can make improvements in our designs and process the quality of workmanship available is a barrier to reducing defects”*. It is worth noting that HA10 used networking whilst HA11 did not.

4.2.3 Diagnosis phase (reflection)

This section reflects on the diagnosis phase, first providing reflection on the impact of defects, followed by a reflection on learning from defects.

The impact of defects

From the questionnaire relating to the impact of defects it would appear that reducing defects would be of benefit to the UK house building industry. There are indications that this benefit would be realised primarily by reducing the H&S implications related to defects and disruption defects cause to home occupants. The house building industry’s key stakeholders appeared to identify the potential H&S concerns defects pose, as well as the disruption defects cause home occupants (and the dissatisfaction that causes) as the main priority and potential motivation for reducing defects. Reducing defects to benefit the home occupant and improve home occupant satisfaction resonates with a number of the HAs’ learning attempts. For example, three HAs recorded and prioritised repairs based upon the repair priority, consisting of the perceived level of danger the defect reported posed to the home occupant. Four HAs set target dates for repairs to be achieved by, and two HAs sought to learn from defects to specifically reduce their repair durations (and subsequent disruption to home occupants). Finally, four HAs explicitly stated that they were looking to reduce defects to improve home occupant satisfaction. The home occupant prioritisation over cost identified from the survey suggests that the house building industry is customer focussed, however, it should be noted that cost was found to be a significant aspect when considering which changes and improvements were implemented in some HAs.

Despite the house building industry stakeholders indicated customer focus; there appears to be a stark contrast in the way the home occupants view the house building industry. Home occupants prioritised themselves (aspects that directly affected them) over any other aspects within the survey. This self-prioritisation was indicated by some home occupants to stem from the belief that the house building industry does not value them and is continually constructing sub-standard products which cause the home occupants dissatisfaction and disruption. In order to improve home occupant satisfaction, more HAs may want to reduce defects by focussing on those that pose H&S concerns and cause disruption to home occupants, over the most frequent or those perceived as important (typically frequent or costly). This home occupant approach to defect reduction may be one way for the house building industry to help improve its image and improve customer satisfaction levels.

In order to guide HAs on which defects they should focus on for the “home occupant approach to defect reduction”, as opposed to the most prominent defects from a list, the action researcher believed that the development of a weighting system for defects based upon their respective characteristics was necessary. With a weighting system, the HAs would be able to pick the top defects from their weighted list. The concept of the weighting system was developed for discussion with the HAs in the action planning phase.

Learning from defects

From the research relating to learning from defects, it would appear that the house building industry could actually reduce defects in future homes by learning from defects, as evidenced by a number of examples of successful learning provided by the HAs. With regards to how HAs learn from defects, this is discussed around the modified OL constructs below.

0. New signal. It appears that HAs record and analyse defect related data within a dedicated “defects management team”. The HAs also appear to capture this data through a combination of different actors and systems. In reference to different actors, the majority of the HAs have a call centre or dedicated aftercare team (defects management team) who the home occupant can call to report any defects. Through this channel, incoming signals were captured. However, in a few HAs, the home occupants contact the contractor responsible for the build directly to report the defects. As a consequence, there may be instances where the chance to capture incoming signals is lost. With respect to systems, four of the HAs use off-the-shelf defects management systems, five HAs have developed their own bespoke defects management systems; and three HAs are reliant on a standard spreadsheet. There were indications that a bespoke system was more beneficial for a HA and their learning (e.g. HA08's live data dashboard), whilst HAs who used an off-the-shelf package were constrained to the limitations of that system (e.g. HA12 needing to export their defects data to a spreadsheet for analysis).

1. Signal recognised as need for change. Data recording and analysis was found to be pivotal to the HA's learning as it enabled them to identify improvement opportunities and provided them with the platform for the succeeding stages of their learning process. Without this continuous review of data as a feedback mechanism, HAs would be limiting themselves to unstructured feedback and signals received through anecdotal channels alone, or in the case of HA05 would not be able to identify improvement opportunities at all.

2. Experimentation and search for new options. Sourcing and sharing knowledge was found to be important to a HA's learning from defects. In the search for potential new adaptation options to resolve identified problems, the HAs were typically reliant on sourcing knowledge from internal staff. This was further evident with only five HAs seeking to invite solutions from external sources compared to all inviting solutions from internal sources. This searching for new knowledge was typically in relation to identifying product or system improvements that would result in widespread changes in the HA (as discussed below). Before introducing these organisational-wide changes (discussed below), there was minimal evidence that the HAs experimented or piloted the changes on a small scale to determine their suitability in resolving the given problem.

3. Internal selection, articulation and codification into new routines. There appears to be a consistent logic within the HAs of reducing defects by making product and system improvements through broad changes throughout the organisation. The 'designing out defects approach' is the HAs primary approach to defect reduction. The broad organisation-wide changes to integrate new or modified products and systems were evident in the majority of the HAs who codified and introduced changes into new organisational routines through updates to their ERs (the specification to be used on all builds). There was also found to be a need for review panels to translate the identification of a problem situation to a change in organisational routine. Review panels would impartially assess a change's suitability and concordance with existing organisational objectives and strategies. It was further found that where no review panel was in place, reliance fell upon one individual for selecting changes; and as such, learning processes took place at different rates dependent on the individuals and their communication network. However, there is potential for 'networking' to be used to overcome this potential barrier.

4. Feedback and iteration. In addition to the recording and continuous review of data acting as a process of identifying new signals it also appears to act as a feedback mechanism to review implemented changes.

5. Networking. In addition to searching for new potential adaptation options from internal sources to design out defects, four HAs identified the need for a new learning construct (an adaptation to the existing model) called 'networking' to generally share knowledge. Networking tended to be a secondary task which did not result in a 'formal routine' change, with HAs continuing to work within standard procedures and guidelines; and, was informal in nature. Despite its informal nature, it is worth noting that networking was suggested by the HAs to result in the modification of an individual's working practices in light of new knowledge gained and was typically used to tackle site workmanship issues. The identification of networking as a new construct for HAs to improve their learning from defects to tackle site workmanship is important for two reasons. First, as previously outlined, the majority of HAs had a primary approach of designing out defects without fully acknowledging site workmanship issues as a major contributor to defects. Using networking in addition to their primary approach appeared to enable the four HAs to resolve issues that the other HAs could not "design out". Second, this use of networking outlined that the four HAs were using a dual approach to learning consisting of two differing styles: a codification approach of designing out defects as their primary approach, followed by a personalisation approach as a support.

This section has discussed the diagnosis phase and potential problems for HAs. The next section discusses the action planned with one HA to improve their learning from defects.

4.3 Action planning phase

This section reports the action planning phase of the research. From the diagnosis phase two HAs (HA02 and HA05) showed interest in bringing changes into their respective organisations. As the action planning phase progressed HA02 followed the phase through to completion.

4.3.1 Action planning phase (practice)

12 HAs were researched during the diagnosis phase of the AR. Four key activities were carried out between September 2015 and February 2016 during the action planning phase: a) securing access to HAs from the diagnosis phase for introducing action interventions, b) developing the outline proposal for a defects weighting system based upon cost, H&S, and disruption; c) conducting a follow-up focus group with HA02; and, d) follow-up email and telephone communication containing recommendations.

a) Securing access to housing associations

The action planning phase of this research started with the researcher trying to secure access to HAs who were interested in bringing changes into their organisations. Two HAs were identified: HA05 (who had a clear improvement opportunity); and, HA02 (who had a strong desire to improve their defects management and learning practices). Both HAs were of a similar size and structure and facing the same pressures of funding reductions and increased defects. This section first discusses securing access to HA05 followed by a brief discussion on HA02.

➢ *HA05*

From the diagnosis phase HA05 was identified as a HA who could benefit from an action intervention. HA05 had a clearly defined problem of not analysing defect data. The absence of defect data analysis (despite capturing detailed data) made HA05 unable to identify improvement opportunities and opportunities to reduce defects in future properties. During the initial interview, HA05 expressed an interest in improving their practice. Due to the identified problem and initial interest, the researcher contacted the interview participant at HA05 in September 2015 to arrange a follow-up meeting to discuss the potential for the HA to analyse defect data. After a number of repeat attempts (in November and December 2015) the meeting request was, however, declined on 12th February 2016 by HA05's Customer Care Manager:

> *"Thank you for the offer, but I will have to put this on hold for now. I will let you know if I change my mind."*

HA05 later cited 'current workload pressures' as a reason for not being able to go further with the research.

- *HA02*

HA02 were looking to reduce defects in their new homes and the associated repair costs to maximise profit to increase their production of new homes, in response to their current challenges. HA02's desire to improve was driven by their Asset Manager. HA02's Asset Manager was a senior figure in the HA and was responsible for managing the defects management team's manager (the Head Clerk of Works), managing all assets post-completion, agreeing and assigning repair budgets etc. and had a close relationship with the HA's development arm (responsible for developing new homes) and was an important figure in the HA's learning from defects. During the diagnosis phase HA02's strong desire to improve their learning and defects management practices were outlined, but they were unable to identify a clear problem. There was only a collective perception amongst the stakeholders that something needed to be done and improvement made, and the HA asked the researcher to intervene, thus being self-selected to partake in the action planning phase. A follow-up focus group therefore was arranged with three key participants (Asset Manager, Head Clerk of Works, Aftercare Administrator).

b) The outline development of a new defects impact assessment to give a weighting to different defect types based upon cost, health and safety, and disruption

Prior to the focus group with HA02, the action researcher developed an outline for a defects impact assessment/defects weighting system in September 2015 which may help the HA to analyse their defect data. The assessment covered the aspects identified by the impact of defects questionnaire with the mode response (with a code of ‘1’ for ‘not a priority’, to ‘5’ for ‘essential’) to the relevant questions forming a level of weight for the aspect. The weighting system used the National house Building Council’s (NHBC) claims figures for the average cost of repairs, the average cost of investigations, whether the repair was deemed as presenting a danger to home occupants, whether the work was considered high risk to those undertaking the repair (e.g. working at height); when the defects typically occurred; and, the duration of repairs and whether the home occupant is likely to require alternative accommodation. The average repair cost data was then split into three categories, low, medium and high. A low repair cost was anything below £1,000, a medium repair cost was between £1,001 and £10,000; and, a high repair cost was over £10,000. The average investigation cost data was also split into low, medium and high categories, with a low investigation cost being anything below £100, a medium investigation cost being between £101 and £1000; and, a high investigation cost being over £1,000.

When the claim occurred in conjunction to the time taken to undertake the repair was used to determine disruption to the builder and home occupants. For example, a low disruption defect occurred during construction, when the house builder was still on site and lasted no longer than a few days. A medium disruption defect was seen as occurring during the first two years post-completion, when the builder was potentially still on site or was still in contact with the trades who undertook the work and lasted no longer than 10 days. Finally, a high disruption defect was one that occurred during years 3-10 of the warranty where the builder would not be on site and was likely to need to make arrangements for new operatives to attend to the defect or lasted in excess of 10 days. For home occupants, the repair durations, whether alternative accommodation and whether access would be required to the home were used to identify low, medium, and high disruption defects. For instance, a defect that required alternative accommodation or required a repair lasting longer than 10 days (with access to the home) was considered high. A defect where a repair lasted up to 10 days and required access to the home was considered medium; and, a defect that required no access to the home was considered low impact. The proposed weighting system recommended to HA02 is outlined in Table 4.7 below.

Table 4.7: Example defects weighting system

Category	Description	Rating	Weight
Health & Safety	Q1. Does the defect pose a danger to workers on site?	No = 0 Yes = 1	5
	Q2. Does the defect pose a danger to home occupants?	No = 0 Yes = 1	5
H&S combined =(Q1+Q2)/2			
Cost incurred	Q1. Investigation cost to house builder or warranty provider	Low = 0 Medium = 0.5 High = 1	3
	Q2. Repair cost to the house builder or warranty provider	1 Low = 0 Medium = 0.5 High = 1	4
	Q3. Warranty provider incurred any costs for Building Regulation contraventions	Low = 0 Medium = 0.5 High = 1	4
	Q4. Complaint costs to the house builder or warranty provider	1 Low = 0 Medium = 0.5 High = 1	4
	Q5. Warranty provider’s cost recovered from builder	Low = 0 Medium = 0.5 High = 1	3
Cost combined =(Q1+Q2+Q3+Q4+Q5)/5			
Disruption caused	Q1. Level of disruption to the builder’s construction programme	Low = 0 Medium = 0.5 High = 1	3
	Q2. Level of disruption to the builder in arranging trade return	Low = 0 Medium = 0.5 High = 1	2
	Q3. Level of disruption to home occupants having trades return	Low = 0 Medium = 0.5 High = 1	4
Disruption combined =(Q1+Q2+Q3)/3			
Overall weight = H&S+Cost+Disruption/3			

The defects impact weighting system was then used to show the “impact” of three typical defects experienced in practice to highlight their importance and illustrate how the impact weighting would work. The examples chosen were three largely different types of defect: a foundation failure, a boiler flue failure; and, a paint run.

By way of explanation, using the weighting system above a typical foundation failure resulting from a claim would have a weight of **2.2**. Foundation failures typically occur post-completion during years 3-10 of the warranty, therefore causing the builder high disruption in arranging trades due to the complex nature of the defect and a repair duration of over 10 days. A typical foundation failure requires the home occupant to be rehoused for over 10 days causing them significant disruption, which tends to cause the home occupant to make a complaint. A typical foundation failure has a high repair cost (circa £60,000) and a high investigation cost of over £1,000 (specialist investigations are typically required); and, poses danger to site workers due to deep excavations and structural works.

In contrast, using the weighting system a boiler flue failure would provide a weight of **1.6**. Boiler flue defects typically occur during years 0-2 post-completion, which causes the builder medium disruption in arranging trades to return. Boiler flue defects cause danger to the home occupant as carbon monoxide is leaking out of the flue and require the home occupant to take time off of work to allow trades to access their house for one day, thus causing medium disruption. In addition, home occupants tend to make complaints due to the health and safety concerns posed. Boiler flue defects typically have a medium repair cost (circa £4,000); and, a low investigation cost (£50).

Finally, using the weighting system a paint run would have a weight of **0.3**. Paint runs tend to be noticed in years 0-2 post-completion, therefore causing the builder medium disruption in arranging trades to return. Paint runs cause no danger to either home occupants or site workers, but cause medium disruption to the home occupant in requiring them to take time off of work to allow trades to access their house for a day. Paint runs have a low repair cost (circa £100) and no investigation cost. Table 4.8 outlines how these figures were derived.

Table 4.8: Comparison of defect types

Category	Description	Foundation Rating	Flue Rating	Paint Rating	Weight
Health & Safety	Q1. Does the defect pose a danger to workers on site?	Yes = 1	No = 0	No = 0	5
	Q2. Does the defect pose a danger to home occupants?	No = 0	Yes = 5	No = 0	5
H&S combined score (Q1+Q2)/2		(1*5+0*5)/2 = **2.5**	**2.5**	**0**	**Max = 5**
Cost incurred	Q1. Investigation cost to house builder or warranty provider	High = 1	Low = 0	Low = 0	3
	Q2. Repair cost to the house builder or warranty provider	High = 1	Medium = 0.5	Low = 0	4
	Q3. Warranty provider incurred any costs for Building Regulation contraventions	Low = 0	Low = 0	Low = 0	4
	Q4. Complaint costs to the house builder or warranty provider	High = 1	High = 1	Low = 0	4
	Q5. Warranty provider's cost recovered from builder	Low = 0	Low = 0	Low = 0	3

Table 4.8 continued…

Cost combined score (Q1+Q2+Q3+Q4+Q5)/5		(1*3+1*4+0*4 +1*4+0*3)/5 = **2.2**	**1.2**	**0**	**Max = 3.6**
Disruption caused	Q1. Level of disruption to the builder's construction programme	Low = 0	Low = 0	Low = 0	3
	Q2. Level of disruption to the builder in arranging trade return	High = 1	Medium = 0.5	Medium = 0.5	2
	Q3. Level of disruption to home occupants having trades return	High = 1	Medium = 0.5	Medium = 0.5	4
Disruption combined score (Q1+Q2+Q3)/3		(0*3+1*2+1*4)/3 = **2**	**1**	**1**	**Max = 3**
Overall weight = (H&S+Cost+ Disruption)/3		(2.5+2.2+2)/ 3 = **2.2**	**1.6**	**0.3**	**Max = 3.9**

The concept was that these weights (which would be validated by and further developed with the HA based upon their experience of the respective defect types) would then be used as multipliers for the frequency of defects. For example, if there were 20 foundation failures, 100 paint runs; and, 40 flue defects the highest priority (for targeted defect reduction) would be flue defects (64).

c) Follow-up focus group

The focus group took place in October 2015 at the HA's headquarters and the principles of soft systems methodology (SSM) were drawn upon to guide the action planning (Section 3.6.5). At the start of the focus group the researcher outlined his understanding of the HA02's current situation based upon the diagnosis phase, and the HA confirmed this to be accurate (Section 3.6.5).

➢ *Formulating a relevant purposeful activity model*

After the discussion relating to HA02's current situation, the three participants were asked to (individually) outline what their current system (the system they perceived to be of concern) was supposed to enable them to do.

The Aftercare Team Administrator had a short-term view of what the system should do pertaining solely to the repair process and suggested that the system is in place to provide the home occupants with a good repair service when she stated that *"the current spreadsheet in place was started from a blank canvas and developed based upon the experience of the job role. The system exists to help us to manage the* *defects process and record detailed defect data to enable us in providing the customers with a good repair service, that they can be satisfied with".*

In contrast to the Administrator's short-term repair view, the Head Clerk of Works and Asset Manager had a long-term view of defect and repair cost reduction when they advised that *"the system should provide us with an informed view of what is going wrong in homes, so I can feed this back to my site teams to make them aware of problematic areas of work, which should help us to reduce defects moving forward"* and *"the system in place should provide real time information and knowledge of specific defects in homes to develop solutions to help us achieve long-term cost savings and defect reduction through identified improvement opportunities"* respectively.

Normally, SSM would seek to develop a purposeful activity model for each of the key stakeholder's worldviews for discussion. However, after outlining their individual worldviews in the focus group a discussion among the three key stakeholders ensued and the different interests were negotiated and a level of consensus was reached in regards to what the system of concern is and what it should (ideally) do.

From this consensus the following clear definition of the purposeful activity was developed: *"The defects management system is owned by the Asset Manager, who together with the Aftercare Team Administrator and Head Clerk of Works, captures post-completion defect data from the home occupants in order to manage the defects remediation process to a satisfactory completion, and provides real time information as the basis of the learning process to help identify improvement opportunities for future projects, to satisfy customers, reduce targeted defects and reduce long-term repair costs associated with new homes".*

Drawing upon the above definition and further discussion about the tasks involved, a consensus model was built to depict the ideal system state (Figure 4.21).

The consensus model of the HA's defects management system consists of the following activities: First, a report of a defect is received by the aftercare team and logged within the HA's defects management system. Second, the site environment is entered and the defect is investigated and detailed defect data captured. Third, based upon those detailed investigations the scope of work is established and the repair scheduled. Fourth, from the repair schedule the necessary materials, contractors and equipment are procured. Fifth, the repair is undertaken. Seventh, whilst activities 2, 3 & 5 are being undertaken in the site environment, back in the aftercare team (business environment) these three activities are monitored against predefined acceptable measures of performance (activity 6) such as estimated repair durations and agreed costs. Eighth, if the acceptable measures are exceeded then action is taken by the aftercare team to get the site work back on track. Finally, upon completion of the repair, the aftercare team have discussions with the home occupant and identify their level of satisfaction with both the repair and service.

During the learning process/system, the Asset Manager will be monitoring performance and identifying potential improvement opportunities by extracting live data reports from the defects management information system. This data extraction is then used as the catalyst for corrective and preventative action (taken forward with other actors in the organisation - see 4.2.2b) to reduce the volume of defects in future homes, decrease the long-term cost of repairing defects; and, increase the home occupants satisfaction with the repair service.

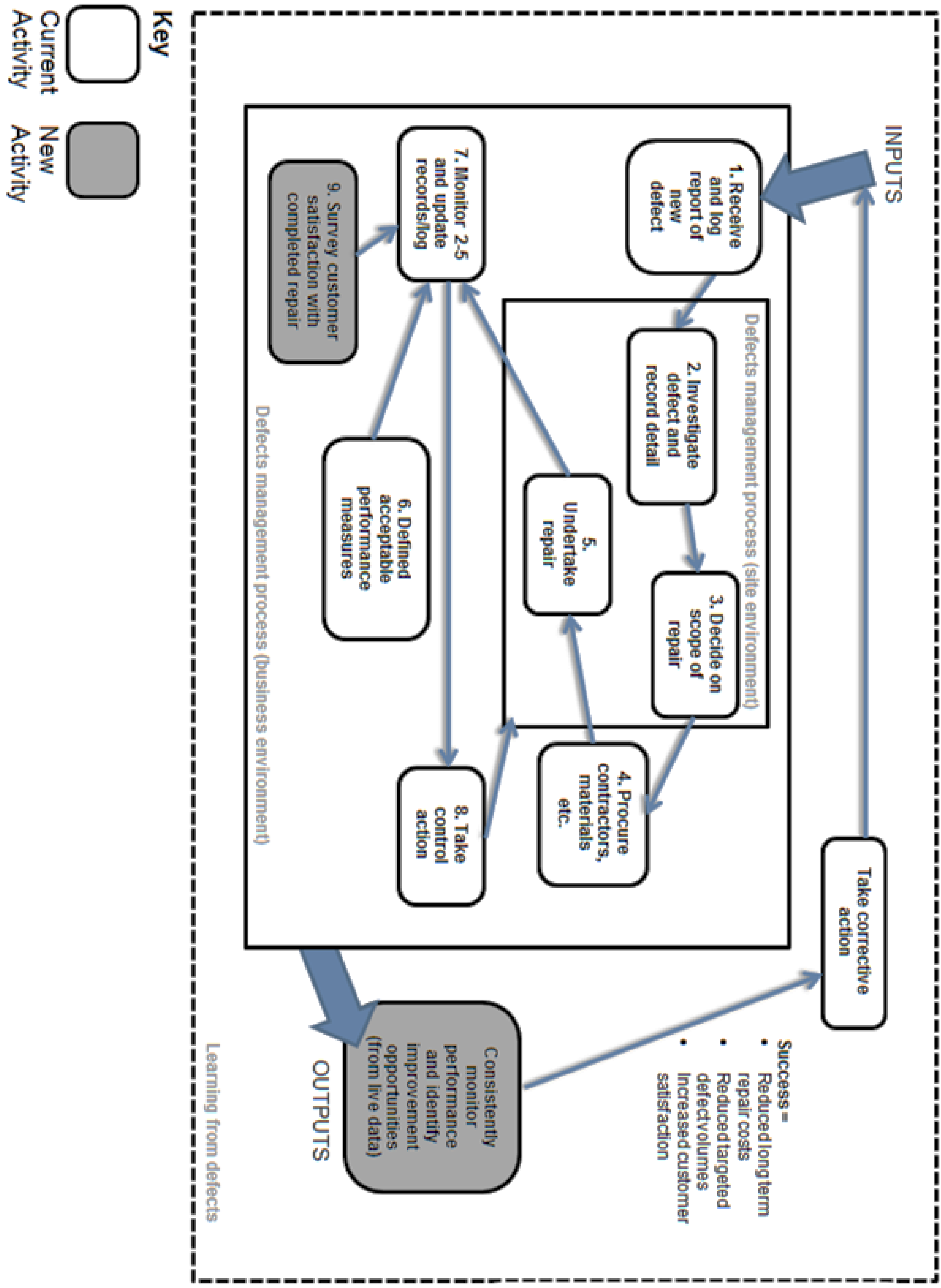

Figure 4.21: Consensus model of HA02's defects management system – the ideal system state

- *Debating the situation*

The model (Figure 4.21) was used to explore possible improvements to the current/real-world situation by comparing the ideal system state with the current situation. It was found that there is a clear mismatch between what the current system should be doing to enable the HA to manage and learn from defects, and reality. HA02's current defects management system is centred around a standard spreadsheet which is reliant on manual text input for recording all details of the defects reported and the subsequent repair processes (including property details). At present the HA's sole way of capturing details of defects reported is through the use of a free-text field within that spreadsheet (called nature of the defect). The nature of the defect field typically contains a long string of text outlining various details pertaining to the defect, with no simplified description or category (such as building area or similar) to aid trend identification. Further, the HA do not currently record the home occupant's level of satisfaction with repairs. As a consequence, the HA cannot analyse customer satisfaction. The HA's current defect analysis approach to identify improvement opportunities is a manual process of reviewing text descriptions, which is in stark contrast to the live data analysis capabilities outlined for the ideal system state.

During the debate surrounding the ideal system state and the current/real-world situation, the deficiencies of the HA's current system became apparent to them. The HA's Asset Manager suggested that they can no longer go on using a standard spreadsheet due to the current system's disadvantages, and confirmed that he will take action. The primary disadvantages of the current system are the laborious data analysis procedures associated with manually reviewing free-text descriptions contained within long strings of text, and the inability for the HA to track the home occupant's satisfaction with the repair service. The HA identified a strong desire to develop a bespoke defects management information system that allows the HA to look-up property records for their existing build stock. After identifying the property, the HA would like to be able to: create a new defect record (including a category by building area), input customer details (e.g. name, telephone number, whether they were satisfied with the repair at the end of the process); arrange an investigation (if deemed necessary); assign a repair to a contractor; and, document and track progress along the way. Based upon the data held within the system, the HA also desire to have the capability to undertake live data analysis and reporting to track cost and trends of specific defects, displayed via a reporting dashboard. In addition to the aforementioned changes the HA wish to bring in a new process of surveying the home occupant's satisfaction with the repair.

Building upon the desired changes, a number of potential options were discussed with the HA. The options were identified from other HA's working practices (Section 4.2.2) and the impact of defects (Section 4.2.1). The impact of defects findings provided the HA with an insight into what other key stakeholders involved in defect detection and remediation found important and provided the HA with a yard stick to measure their own priorities against. The HA were in agreement that (in addition to their costs), the H&S of home occupants and site workers was an important consideration, as well as disruption to the home occupants during the repair process.

The recommendations were outlined, including:

(1) changes to the way HA02 captured defect data (see Appendix 4 for the recommended structure for the HA's defect data),

(2) changes to the way HA02 analysed their defect data,

(3) the introduction of a customer satisfaction survey,

(4) the development of a new weighting system so that the HA can analyse defects by their individual impacts; and,

(5) the development of a new defects management system with a live data reporting dashboard.

Among these options, the development of a new weighting system for defects (option 4): based upon that outlined in part b) was the only option rejected-outright by the HA, as the solution was not feasible or desirable to meet their needs.

The remaining recommendations were further converted by the HA into two actions. The first action was to implement an immediate short-term solution of updating their spreadsheet and processes to change their data capture and analysis techniques. The second action was to introduce a long-term solution of introducing a customer satisfaction survey, and developing a bespoke defects management system with live data dashboard. The defects management system with live data dashboard was to be developed by the HA's IT department.

The full list of recommendations are shown in Table 4.9. The reason HA02 rejected the development of a new weighting system for defects was because they could not see the benefit and would prefer to have the different aspects (H&S, cost, and disruption) displayed separately.

d) Follow-up email and telephone communication containing recommendations

After the focus group, follow-up email and telephone communication was continued with the participants. During those communications the potential modifications that the HA02 may find useful as a means of assisting the HA in achieving their aims were reiterated and documented. Table 4.9 below shows recommended areas of change for HA02's system and reporting dashboard.

The recommendations in Table 4.9 were not imposed on HA02. It was the HA who ultimately decided on which modifications were desirable and feasible to them and what changes they will make to their current system. The main focus of the action planning was to assist the HA in seeing what potential improvements could be made, and being the catalyst for this change and empowering the HA to make future change.

Table 4.9: Recommended areas of change for HA02's system and reporting dashboard

Recommendations		Actor responsible	Target date
Change to data capture	Categorising defects by building area, building element, building sub element, and damage.	Aftercare Administrator	ASAP
	Recording the type of property (e.g. flats, semi-detached house, detached house etc.) in a new field.	As above	ASAP
	Recording the type of construction (e.g. brick and block, timber frame etc.) in a new field.	As above	ASAP
	Recording the priority of repair (e.g. urgent, routine etc.) in a new field.	As above	ASAP
	Recording whether a complaint has been made in a new field.	As above	ASAP
	Recording of the scheme ID in a new field and recording the number of plots within that scheme.	As above	ASAP
	Recording of the scheme region in a new field.	As above	ASAP
	Recording of the developer/contractor responsible for the original build in a new field and recording the number of plots produced by them.	As above	ASAP
	Recording the clerk of works who was in place during the construction.	As above	ASAP
	Record potential financial liability.	As above	ASAP
Change to data analysis	Analyse frequency by category to identify general trends and problem areas.	Head Clerk of Works/Asset Manager/Admin	ASAP
	Analyse cost by category to identify general trends and high cost areas. For cost the HA may wish to produce a bar chart showing defect types with cost incurred, cost saved, and potential liability.	As above	ASAP
	Analyse frequency and cost (per unit) and/or type by developer to develop an overview of developer/contractor performance, and also provide site teams with knowledge of a particular developer's problem areas of construction.	As above	ASAP
	Analyse frequency and cost (per unit) and/or type by scheme to develop an overview of scheme performance.	As above	ASAP
	Analyse frequency and cost by construction type to monitor system performance	As above	ASAP
	Analyse frequency and cost by property type to monitor dwelling type performance	As above	ASAP
	Analyse type by clerk of works (on site during construction) to identify potential areas of technical weakness and training requirements	As above	ASAP
	Analyse the number of complaints by category to gauge what defect types cause home occupants most distress	As above	ASAP
	Analyse repair priority by category to outline which defect types may cause danger to home occupants	As above	ASAP
Developing a new defects impact assessment to give a weighting to different defect types based upon cost, health and safety and disruption		N/A – proposal rejected outright	N/A
Adding a customer satisfaction survey for the repair service		Asset Manager	April 2016
Develop a new bespoke defects management system with live data reporting dashboard		Asset Manager	October 2016

4.3.2 Action planning phase (reflection)

This section reflects on the action planning phase, first providing general reflection on the action planning phase, followed by a reflection on SSM; and, the role of the researcher.

General reflection on the action planning phase

The action planning phase started by trying to gain access to HAs who desired to introduce change. At the start of the action planning phase two HAs (HA02 and HA05) were interested in improving their practice, however one HA (HA02) completed the action planning phase.

The first three constructs of OL in house building model offer some explanation for how events in the action planning phase unfolded in the two HAs. These are discussed below.

0. New signal: Both HA02 and HA05 were under increasing pressures of reduced funding from government, the need to reduce their social housing rents; and increasing volumes of defects within their properties. HA05 in particularly was identified in the diagnosis phase as a HA who could benefit most from an action intervention. HA05 collected vast amounts of defect data, but were unable to translate this into any action to improve – predominantly due to their lack of data analysis (and the capability that generates to identify problems or areas of improvement).

1. Signal recognised as need for change: Due to the increasing pressure of income reductions and increasing volumes of defects within their properties, HA02 were seeking to cut costs. The Asset Manager in HA02 saw their repair costs increasing (a significant cost increase for 2014-15 compared to 2013-14) due to the increasing volumes of defects in new homes and was seeking to improve how they learn from defects so that the HA could reduce their long-term repair costs, however he was unable to identify a clear improvement opportunity. Through the introduction of a researcher who was looking at how HA's manage and learn from defects (and had an understanding of numerous HAs working practices), HA02 saw an opportunity to improve and outlined their desire and need to change to the researcher. Moving on to HA05, the Customer Care Manager acknowledged that the HA could improve their learning from defects and was initially interested in introducing data analysis to identify improvement opportunities, after openly admitting to sitting in quality improvement meetings and not being able to contribute.

2. Experimentation and search for new options: The review of HA02's defects management and learning processes (from the diagnosis phase) found that they used data captured by their defects management system and analysis of that data as the basis of their learning and improvement. HA02's defects management and learning systems were explored through the use of SSM. HA02's current system was not doing what the participants believed it was doing. Each participant had an individual view of what the system should enable them to achieve, however through discussion a level of consensus was agreed. A number of new activities were found to be required in order to bring the system in line with the HA's expectations which were: changing the HA's current data capture and analysis techniques, the development of a bespoke defects management system with live data reporting; and, the introduction of a satisfaction survey (for repairs). In contrast, in HA05 as time passed after the initial interview the willingness in searching for new options appeared to fade. One possibility for the willingness fading was that the level of effort involved with developing new systems and ways of working became apparent. HA05 cited 'workload pressures' and other facets of the job as the reason for not continuing with the action planning phase, which suggests that OL is a secondary task.

Soft Systems Methodology

The adoption of SSM in the action planning phase made it possible for HA02 to explore the situation the stakeholders identified as problematical (facilitated by the researcher) to understand their issues. More importantly, the flexibility of the SSM (the ability for the study to commence at any point) allowed the principles to be adapted to suit the specific situation (the action planning phase alone). SSM primarily through the structured discussion in the focus group surrounding what the system should be doing and the reality of the situation made the deficiencies of the HA's current system apparent to them and enabled them to recognise desirable and feasible changes. This also helped the HA identify that a new weighting system for defects was not suitable for their purposes and meant that HA02 did not blindly accept recommendations proposed by the researcher.

The role of the researcher

The action planning phase started with the action researcher as an outsider who was aiming to better understand HAs' learning processes. From the initial interaction to the findings presented in the action planning phase, the action researcher's role moved from an outsider to an active part in HA02's change. When becoming actively involved in the research, it is vital to acknowledge that involvement and the effect it may have.

The action researcher, based upon the findings from the impact of defects survey during the diagnosis phase believed that a defects weighting system was necessary to help HAs target the most important defects for reduction purposes. On reflection the weighting system proposed may not have been statistically robust and was using the questionnaire data (ordinal in its nature) in ways it should not have been used. The weighting system treated codes assigned as if they had metric properties. Further, a pre-determined solution was not sympathetic or suitable for the HA and their needs. By discussing the weighting system with the HA the action researcher may have influenced the HA's view on what was required and what action they should take.

The principles of SSM showed real power in enabling the action researcher to maintain a level of neutrality despite his predisposition to the weighting system. The SSM got to the heart of what HA02 needed and wanted and enabled the HA to identify desirable and feasible changes. After discussing potential options that may satisfy HA02's needs, the use of SSM allowed the HA to understand that they desired a dashboard displaying aspects that were actually important them as opposed to the weighting system that amalgamated those key aspects into a single multiplier. Despite the benefit of SSM it should be noted that by discussing other HAs practices with HA02 and making recommendations generally, the action researcher is likely to have influenced the HA's view of what action they should take as well as the array of options available to them.

This section has discussed the planned actions. The next section discusses the actions that have been taken.

4.4 Action taking phase

This section reports the action taking phase of the research which took place over an 11 month period (October 2015 – September 2016). From the action planning phase one HA (HA02) was taking planned action to bring changes into their organisation.

4.4.1 Action taking phase (practice)

From the action planning phase HA02 converted their desired changes into four activities (changes to data capture, changes to data analysis, introduction of a repair satisfaction survey; and, the development of a bespoke defects management system with live data analysis dashboard) (see Table 4.9). Changes to data capture and changes to data analysis were short-term changes that the HA desired to implements as soon as possible. The introduction of a repair satisfaction survey and the development of a bespoke defects management system with live data analysis dashboard were long-term changes with no firm implementation date decided by the HA (the dates in Table 4.9 were indicative). During this phase regular contact was maintained with the HA via telephone calls, email communication, and follow-up interviews. The changes being made are discussed below.

Changes to the way HA02 captured defect data

During the telephone calls and emails with the Aftercare Administrator, she indicated that a number of the data capture changes had been implemented. A follow-up interview took place on 7th June 2016, with the Aftercare Administrator, the Head Clerk of Works and the Asset Manager. The interview started by exploring which changes the HA02 had made to their data capture.

During the interview, the Aftercare Administrator confirmed that data capture changes had been made to their current system in light of the recommendations, expressing that *"… we [the housing association] have updated our spreadsheet to record defect types under categories. This is done by categorising the defect by the area of the building in which it occurs and a brief uniform record of what is going* *wrong ... we have added a field to calculate our potential exposure on repairing defects should the developer or warranty provider be unable to rectify them … we also record the priority of the repair, and the property and construction types where possible…".*

On 15th September 2016, HA02 provided the researcher with a copy of their current spreadsheet (see Figure 4.22) to confirm what changes had been made to the HA's data capture. All the changes made to the spreadsheet following the action planning phase are highlighted in yellow.

HA02 changed their spreadsheet to record 27 fields of data: 16 contained within the original spreadsheet, eight recommended during the action planning phase, four introduced by the HA themselves, and one removed by the HA. The changes to data capture are outlined in Table 4.10 below.

Table 4.10: Changes made to data capture

Original used	Recommended	HA introduced	Removed
1. Date logged 2. Reference number 3. Site address 4. Region 5. Referred by 6. Build date 7. Warranty period expiration 8. Warranty number 9. Local/national builder 10. Key contact 11. Status 12. Case status 13. Estimated savings 14. Agreed actions 15. Cost of making good 16. Potentially valid warranty claim?	1. Site reference (unique property reference number - UPRN) 2. Property type 3. Construction type 4. Nature of the defect/damage 5. Category 6. Repair priority 7. Potential liability 8. Complaint made?	1. Target completion date 2. Completed in time? 3. Open/closed 4. Year logged	1. Date warranty claim made

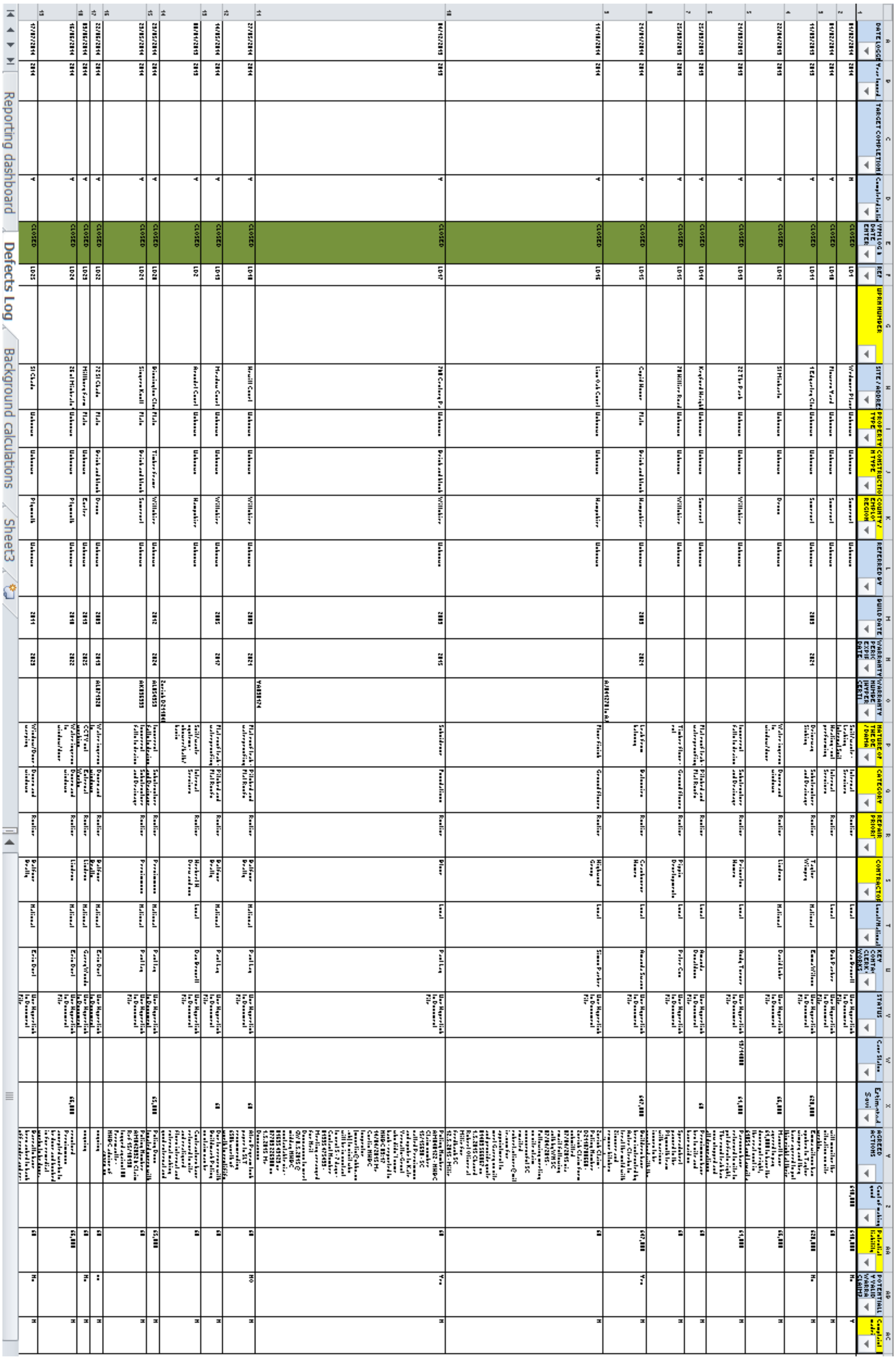

Figure 4.22: HA02's current spreadsheet

A more detailed version of this figure can be found in Appendix 3 under the heading of ‘extract from HA02’s updated defects log’.

One of the recommended changes was to modify the nature of the defect field within the HA's original spreadsheet. Table 4.11 shows examples of how the defect data recorded under the "nature of the defect" has been updated to aid simple trend identification and defect analysis.

Table 4.11: Re-categorising of HA02's defects

Original	New
Drainage problem, there has been 6 blockages in the same line at this address in the last 18 months, poorly laid pipework where the pipe leaves the property to the inspection pot, too many bends and very little fall.	Category: substructure and drainage Nature of defect: incorrect falls to drains
Heating running costs, panel heaters, no NSH (Night Storage Heating).	Category: internal services Nature of defect: heating – not performing
Didn't follow 'Robust details' when floor installed in timber frame property and the floor is bouncing – batton's in the middle of the joists – Head Clerk of Works to progress to the NHBC claim don't bother with the builder just to NHBC.	Category: upper floors Nature of defect: timber floor - movement
Fire in shared owners block, lack of intumescent treatment at new build and closers, similar general needs block on development.	Category: doors and windows Nature of defect: window/door – intumescent strips and closers

(Note: the HA still keep the detailed record of the defect – the new simplified categories are for consistent data capture and simple data analysis purposes)

Changes to the way HA02 analysed their defect data

After exploring the changes HA02 had made to their data capture, the interview then explored what changes the HA had made to their data analysis techniques. This question identified that the need for quick and easy data analysis was a priority for the HA, especially to continue learning with an increase in their workload. The Head Clerk of Works suggested that 'workload pressures' made data analysis in their current format too difficult and time consuming when he revealed that *"… with a recent increase in our workload we are getting limited opportunity to analyse data…"*. The HA's Asset Manager reiterated the need for quick data analysis by stating that *"… data analysis in a spreadsheet is laborious, and doesn't provide us with the up-to-date real time (hassle free) information we require…"*.

HA02, however, still showed a strong desire to undertake data analysis in the following areas: cost, frequency, and customer focus. In respect of ‘cost’, HA02 expressed an interest in being able to analyse cost incurred by defect category, cost incurred for particular developers, cost incurred for properties completed in different years, cost incurred on specific types of construction, cost incurred for the year it was spent, the cost incurred for particular case statuses, cost incurred on specific property types; and, cost incurred on each scheme.

With regards to ‘frequency’, HA02 had a desire to be able to analyse the number of defects by category and by defect description, the frequency of defects occurring by the year the defect was logged, the volume of defects by construction type, the frequency of defects occurring for specific developers, the number of defects occurring in different property types, and the volume of defects on individual schemes.

Finally, in respect of ‘customer focus’, HA02 expressed an interest in being able to analyse the number of closed and ongoing repairs each year, the designated repair priority for current and closed repairs, the key contact’s (Clerk of Works) current workload, whether the HA’s target completion date has been achieved, the volume of complaints made to the HA and the types of repair (priority) they were being made on, the repair priority for particular defect categories; and, the number of complaints made for the respective categories.

The introduction of a customer satisfaction survey (for HA02’s repair service)

During the interview the HA were also asked on the progress of their customer satisfaction survey. The Asset Manager confirmed that the customer satisfaction survey was an action the HA were planning on taking in the near future by stating that *“… we will shortly be introducing our customer satisfaction survey for our repair service…”*. However, as of the end of September 2016 the HA02 had not implemented their customer satisfaction survey.

The development of a defects management system with a live data reporting dashboard

During the interview and follow-up email communication the HA were asked on the progress of their bespoke defects managements system. The HA's Asset Manager was disappointed by a lack of progress of the bespoke defects management system when he explained that *"Unfortunately due to limited IT capacity, we have to bid for IT resource (along with other areas of the HA). Whilst this project is important to the HA, there are, at the moment, other more important IT projects that have taken priority over the defects management system. So, we are currently looking at another couple of years until this system will be developed and implemented".* Therefore this intervention will not take place during the life of this AR project.

Due to the lack of progress with the bespoke defects management system with a live data dashboard and the stress increased workload was putting on the HA's learning, the action researcher suggested a fifth intervention (interim solution). The researcher explained that there was a potential solution to provide the HA with the "live" dashboard they required. The possibility of setting up tables and graphs in the HA's existing spreadsheet that drew off of the HA's defects log were discussed. This solution meant that when additional data was added to the HA's defects log and the data refreshed (a refresh all button was pressed in Microsoft Excel), the tables and graphs refreshed to provide the HA with a 'live' reporting dashboard. The HA agreed to allow the researcher to modify their spreadsheet further so that the HA's desired areas of data analysis described in "changes to the way HA02 analysed their defect data" above were undertaken. So, for the interim solution the researcher and HA02 co-developed a live data analysis dashboard.

Figure 4.23 below shows the 'live' defects analysis dashboard added to HA02's current spreadsheet. Detailed views of the HA's new dashboard can be found in Figure 4.24, Figure 4.25 and Figure 4.26 below.

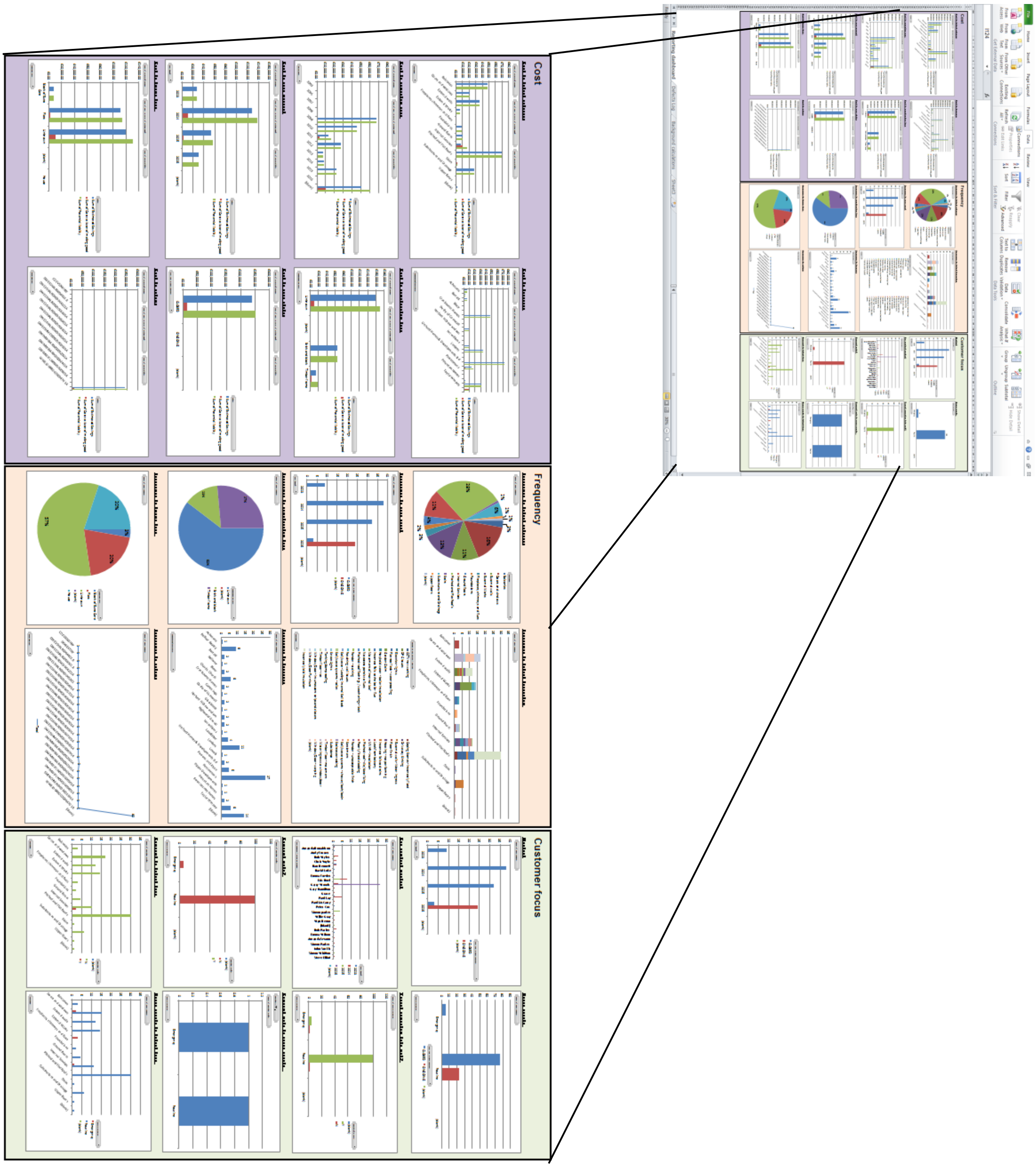

Figure 4.23: HA02's new defects dashboard

HA02's defects analysis dashboard can be split in to three separate panels: cost (see Figure 4.24), frequency (see Figure 4.25); and, customer focus (see Figure 4.26).

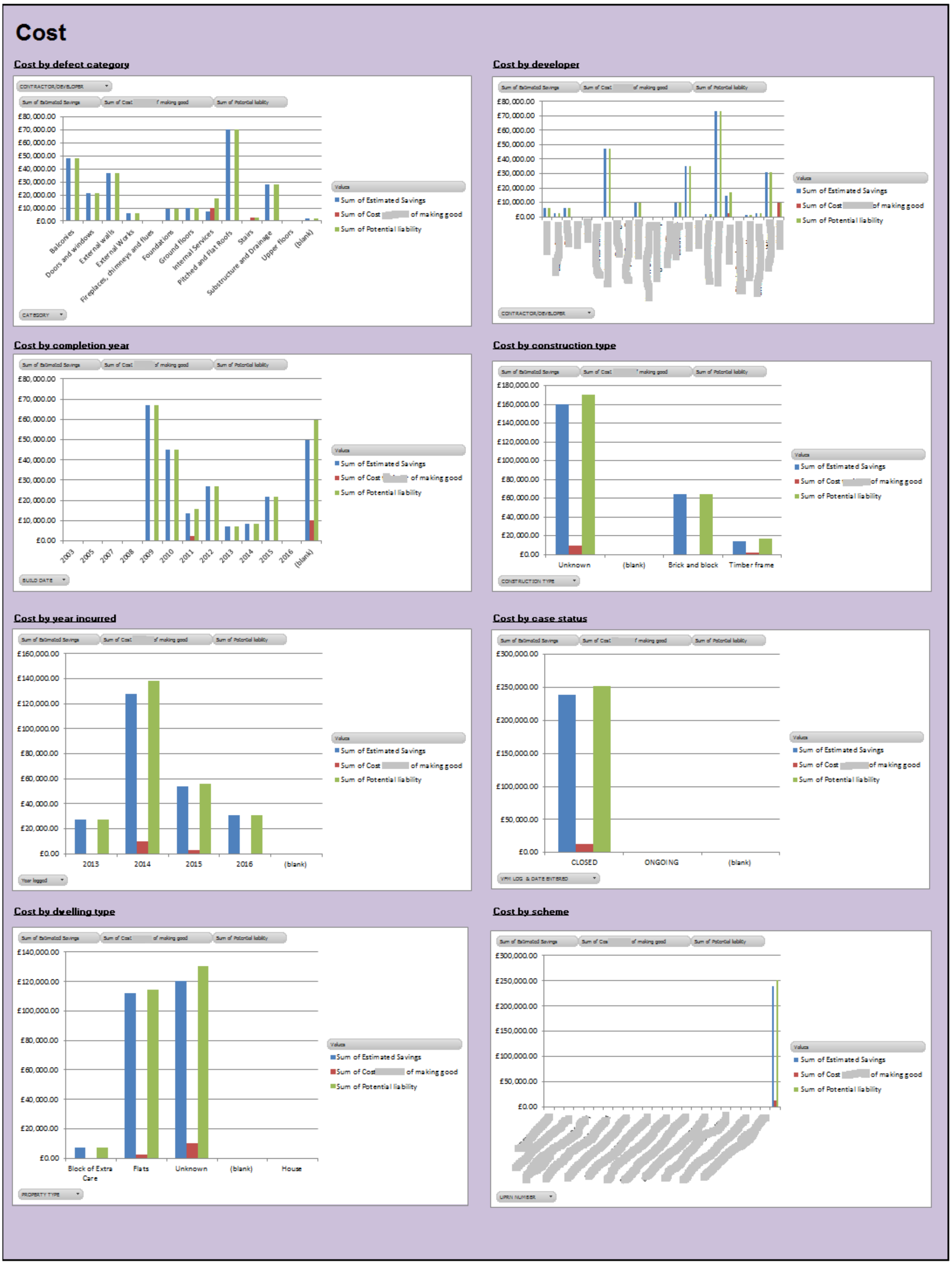

Figure 4.24: Close up of cost dashboard panel

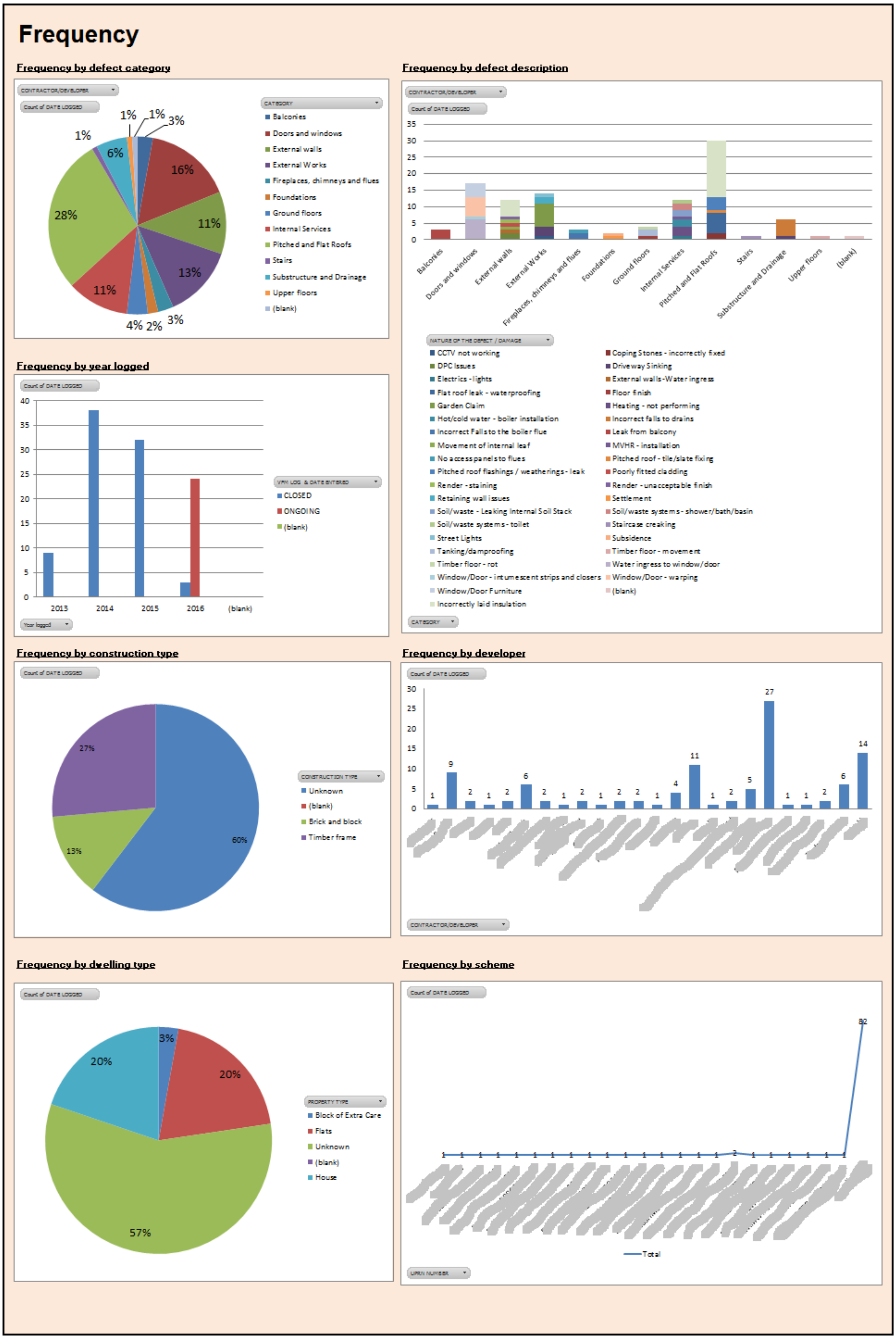

Figure 4.25: Close up of frequency dashboard panel

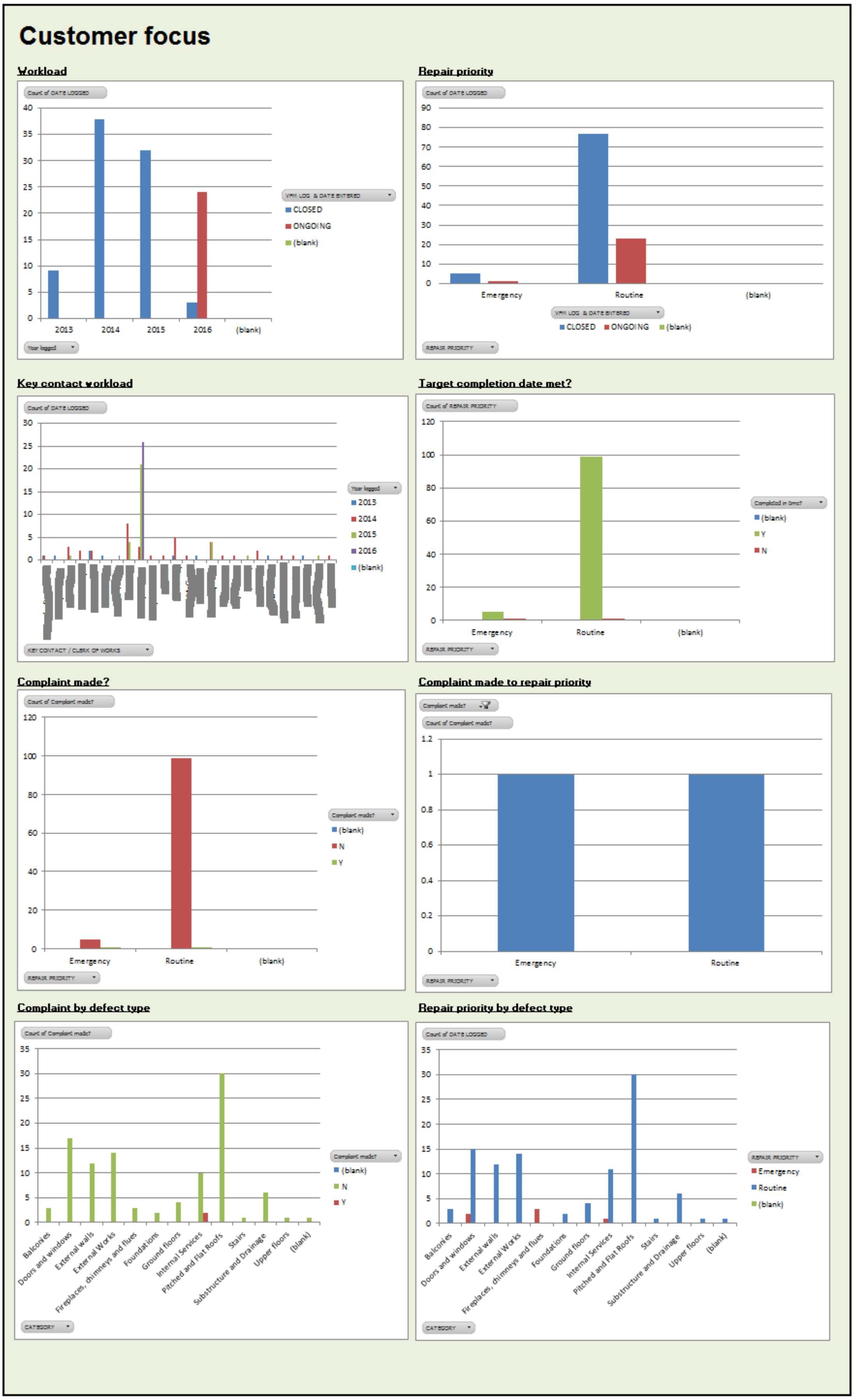

Figure 4.26: Close up of customer focus dashboard panel

The ‘cost’ panel (Figure 4.24) contains eight areas of cost analysis. The first graph displays ‘the cost by defect category’ to identify general trends and high cost areas; and is displayed in a bar chart showing defect types with cost incurred, cost saved, and potential liability (this chart is filterable by developer). The second graph shows ‘the cost by developer’ to develop an overview of developer/contractor performance (however not per unit as recommended – this may not give the HA a true representation of developer cost performance as one developer may have developed significantly more homes than others). The third graph presents ‘the cost incurred by completion year’ to establish whether there are any problematic years of construction for the HA to see if their defect costs are reducing over the years (however as this cost is not per unit it may not give the HA a true representation of cost performance as the HA may have built different volumes of homes over the respective periods). The fourth graph displays ‘the cost incurred by construction type’ to monitor system performance. The fifth graph shows ‘the HA’s expenditure (and potential exposure) by the year the cost was incurred’. The fifth graph was requested by the HA so that they could monitor their overall expenditure and plan future repair budgets. The sixth graph displays ‘the cost incurred by case status’ (i.e. ongoing/closed) so that the HA can monitor their current expenditure in relation to the year’s budget. The seventh graph presents ‘the cost by property type’, so that the HA can monitor typical dwelling type performance. The final graph shows the cost incurred on each scheme. The final graph will enable the HA to develop an overview of scheme performance (albeit the graph will not take into account the number of properties within each scheme).

Under the ‘frequency’ panel (Figure 4.25) seven areas of frequency are analysed. The first and second graphs display the number of defects by category and by defect description (a sub category with more detailed information). The first two graphs will enable the HA to identify general trends and problem areas (filterable by developer). The third graph shows the frequency of defects occurring by the year the defect was logged, so that the HA can monitor current case loads and general defect volumes. The fourth graph presents the frequency of defects by construction type to assist the HA in monitoring system performance. The fifth graph displays the frequency of defects occurring by developer to provide the HA with an overview of developer/contractor performance (however not per unit as recommended – this may not give the HA a true representation of developer performance as one developer may have developed significantly more homes than others). The sixth graph shows the frequency of defects occurring in different property types, so that the HA can monitor dwelling type performance. The final graph presents the frequency by scheme to develop an overview of scheme performance, however as this is not unit based it does not take into account the volume of properties within individual schemes.

Finally, the ‘customer focus’ panel (Figure 4.26) contains eight areas of analysis. The first graph shows the number of closed and ongoing repairs each year; the second graph displays the repair priority for current and closed repairs; the third graph presents the key contact’s (Clerk of Works) current workload; the fourth graph shows the whether the HA’s target completion date has been achieved; the fifth graph presents the number of complaints made to the HA; and, the sixth graph shows the number of complaints made sorting by repair priority. The first six graphs were requested by the HA to help them monitor their previous and current workload, so that they can manage their workload and priorities. The seventh graph displays the repair priority by defect type so that the HA can outline which defect types may cause danger to home occupants. Finally, the eighth graph shows the number of complaints by defect type, so HA02 can gauge what defect types cause home occupants most distress.

The updated spreadsheet with the reporting dashboard was provided to the HA on 20th September 2016 for them to use from that point forward.

Summary of changes made during action taking phase

This section provides an overview of the changes made during that action taking phase of the AR project. Table 4.12 provides an overview of the changes made during the action taking phase of the AR in comparison to recommendations made during the action planning phase. The ‘action taken’ can be split into three categories: recommended changes fully implemented, recommended changes partially implemented; and, recommendations not implemented.

Table 4.12: Summary of recommendations and changes

Recommendations		Implemented?
Change to data capture	Categorising defects by building area, building element, building sub element, and damage.	Fully (ASAP)
	Recording the type of property (e.g. flats, semi-detached house, detached house etc.) in a new field.	Fully (ASAP)
	Recording the type of construction (e.g. brick and block, timber frame etc.) in a new field.	Fully (ASAP)
	Recording the priority of repair (e.g. urgent, routine etc.) in a new field.	Fully (ASAP)
	Recording whether a complaint has been made in a new field.	Fully (ASAP)
	Recording of the scheme ID in a new field and recording the number of plots within that scheme.	Partially (ASAP)
	Recording of the scheme region in a new field.	Fully (ASAP)
	Recording of the developer/contractor responsible for the original build in a new field and recording the number of plots produced by them.	Partially (ASAP)
	Recording the clerk of works who was in place during the construction.	No (ASAP)
	Record potential financial liability.	Fully (ASAP)
Change to data analysis	Analyse frequency by category to identify general trends and problem areas.	Fully (ASAP)
	Analyse cost by category to identify general trends and high cost areas. For cost the HA may wish to produce a bar chart showing defect types with cost incurred, cost saved, and potential liability.	Fully (ASAP)
	Analyse frequency and cost (per unit) and/or type by developer to develop an overview of developer/contractor performance, and also provide site teams with knowledge of a particular developer's problem areas of construction.	Partially (ASAP)
	Analyse frequency and cost (per unit) and/or type by scheme to develop an overview of scheme performance.	Partially (ASAP)
	Analyse frequency and cost by construction type to monitor system performance	Fully (ASAP)
	Analyse frequency and cost by property type to monitor dwelling type performance	Fully (ASAP)
	Analyse type by clerk of works (on site during construction) to identify potential areas of technical weakness and training requirements	No (ASAP)
	Analyse the number of complaints by category to gauge what defect types cause home occupants most distress	Fully (ASAP)
	Analyse repair priority by category to outline which defect types may cause danger to home occupants	Fully (ASAP)
Developing a new defects impact assessment to give a weighting to different defect types based upon cost, health and safety and disruption		No (rejected at planning phase)
Adding a customer satisfaction survey for the repair service		No (April 2016)
Develop a new bespoke defects management system with live data reporting dashboard		No (October 2016)
NEW: Implementation of interim data dashboard in the HA's spreadsheet environment.		Yes (September 2016)

The recommended changes fully implemented, recommended changes partially implemented; and, recommendations not implemented are discussed in more detail below.

a) Recommended changes fully implemented

The following 14 recommendations have been fully implemented by HA02 (changes to data capture and analysis, and interim dashboard):

1. Categorising defects by building area, and the provision of a standardised description of the more detailed defect/damage,

2. Recording the property type (e.g. house, flats) for the property experiencing the defect,
3. Noting the construction type (e.g. brick and block, timber frame) for the property experiencing the defect,
4. Logging the repair priority (e.g. emergency, routine) for the individual defects reported,
5. Noting whether a complaint has been made during individual repairs,
6. Recording the potential exposure of the defects reported/repaired to the HA (their savings when the developer or warranty provider repair them on their behalf added to the cost the HA has spent on repairing defects),
7. Logging the scheme region for the property experiencing the defect,
8. Analysing the frequency of defects occurring by defect category,
9. Evaluating the cost of defects occurring by defect category,
10. Examining the cost and frequency of defects by construction method,
11. Analysing the cost and frequency of defects by property type,
12. Evaluating the number of complaints by defect category,
13. Examining the repair priority by defect category,
14. Implementing an interim dashboard to develop live data analysis in the HA's spreadsheet environment.

b) Recommended changes partially implemented

The following four recommendations have been partially implemented by HA02 (data capture and analysis:

1. Analysing the frequency and cost of defects by developer. The original recommendation suggested analysing these factors per unit. The analysis per unit (house produced) aspect of the recommendation was not implemented. By not analysing the developer's defect performance in comparison to the number of homes produced (per unit), it is unlikely that HA02 will develop a true representation of developer performance because if a developer builds more homes for the HA they will likely incur more defects,
2. Recording the developer responsible for the original build. The original recommendation suggested analysing these factors per unit. The per unit aspect of the recommendation was not implemented,

3. Evaluating the frequency, cost, and types of defects by developer. The original recommendation suggested analysing these factors per unit. The per unit part of the recommendation was not implemented,
4. Analysing the frequency and cost of defects by scheme. The original recommendation suggested analysing these factors per unit. The per unit aspect of the recommendation was not implemented, nor the type of defects occurring on the different schemes.

c) Recommendations not implemented

The following five recommendations were not implemented by HA02 (changes to data capture, analysis, the development of a new defects management system with live data reporting dashboard, and the introduction of a customer satisfaction survey for repairs):

1. Recording the Clerk of Works who was in place during the construction,
2. Analysing the type of defects occurring by the Clerk of Works on site during construction,
3. Implementing a new defects impact assessment to give a weighting to different defect types based upon average cost, H&S and disruption,
4. Developing a new bespoke defects management system with live data reporting dashboard.
5. Developing and introducing a satisfaction survey to be issued to home occupant at the end of repairs.

In addition to the recommended changes, the following 13 additional changes were identified as desirable by the HA02 and incorporated during the action taking phase, but were not discussed nor identified during the action planning phase (further changes to data capture and analysis):

1. Logging the year the defect was reported,
2. Recording the target completion date for the repair,
3. Noting whether a repair was completed by the target completion date,
4. Recording whether a repair is closed or ongoing,
5. Evaluating the cost incurred by the property completion year,
6. Examining the cost incurred by the year the cost was incurred,
7. Analysing the cost expenditure on ongoing and closed cases,

8. Evaluating current workload (the volume of repairs),
9. Examining the key contact's (clerk of works) current workload,
10. Analysing general repair priority,
11. Evaluating whether a completion date had been achieved within the target,
12. Analysing whether a complaint had been made,
13. Examining the complaints made in comparison to various repair priorities.

These additional changes were proposed by the HA as a means of managing their workload and aiming to give the home occupant a repair service that they could be satisfied with.

4.4.2 Action taking phase (reflection)

The action taking phase observed 18 recommendations/planned actions implemented (14 fully and four partially), five planned actions/recommendations not implemented; and, 13 further changes identified by the HA02 implemented. The large number of recommendations/changes implemented by the HA during the action taking phase suggests that the action planning phase was a success in that it was the catalyst for the HA making change. The 13 additional changes identified by the HA (to their data capture and analysis) further shows that the action planning phase also empowered the HA to make their own changes independent of the researcher and recommendations/planned actions.

With regards to the recommendations/planned actions implemented, the failure for the HA to introduce the number of units produced on schemes and by developers may hamper their analysis and learning; and, may not provide the HA with a true understanding of their defects performance. The reason this may hamper their learning is that the different number of units produced in different schemes and by different developers is likely to correspond with the number of defects experienced i.e. more units, more defects. However, the limitation of not incorporating the number of units built may become apparent to the HA. The frequency of defects by scheme chart presented on the live data dashboard shows that the HA's largest scheme (with the largest number of units) has the highest volume of defects due to the volume of units on that scheme. This realisation may mean that the HA implement further change.

The majority of the changes implemented successfully were the changes that were within the direct span of control of the individuals introducing the change; and, if they were deemed desirable they were easily implemented. The remaining desirable change that was not implemented was the solution of developing a bespoke defects management system and live data reporting dashboard, which involved external IT engagement. The fourth construct (internal selection, articulation and codification into new routines) of the OL in house building model offers an insight as to where and why this intervention failed.

As discussed in Section 4.3.2, due to reduced funding, social housing rents and increasing volumes of defects HA02 were seeking to cut costs by improving how they learnt from defects. When a researcher was introduced to the HA, they saw an opportunity to improve. A number of desirable and feasible changes were identified after exploring the HA’s defects management and learning systems.

The Asset Manager (with agreement from the other key stakeholders) selected the new bespoke defects management system as the most suitable option and articulated his desire to develop and implement this change to the HA’s IT department. However, due to limited IT capacity, various departments and members of the HA had to bid for IT resource, and whilst the defects management system was important to the HA, there were other IT projects that were a higher priority. Therefore the change failed to be codified into organisational routine, and another option (AI5: the development of a live data dashboard in the HA’s spreadsheet environment) was introduced instead.

This failed intervention is similar to the failed learning in a number of the HAs discussed during the diagnosis phase, for example, the failed OL to reduce roof mortar defects in HA12 (see Section 4.2.2). These failures tend to occur due to the ‘lack of control’ by the individual(s) wishing to introduce the change and a reliance on an individual person, or department to complete the process. In the defects management system introduction, the HA’s Asset Manager desired to introduce the change, however, was reliant on the HA's IT department to implement the change and complete the process.

This section has discussed the action taken, both successfully and unsuccessfully. The next section evaluates the action that was taken.

4.5 Action evaluation phase

This section reports the action evaluation phase of the research. From the action taking phase a number of changes had taken place in HA02. This section set out to evaluate the action taken.

4.5.1 Action evaluation phase (practice)

After the action had been taken the researcher left the HA (HA02) for six months to allow the changes to be experienced further and fully evaluated at a later date. From the action taking phase it was evident that the HA had implemented the recommendations to update their data capture and analysis within the action taking phase. In addition, the action researcher and the HA co-developed a fifth action intervention "the interim dashboard solution" to provide the HA with a live view of their defects performance within their standard spreadsheet environment. The action was evaluated at two points: anecdotally evaluated in October 2016 through three follow-up telephone calls; and, formally evaluated via an interview in February 2017.

1st action evaluation point: October 2016

To evaluate how the action taken was helping the HA in the early stages (first month post-implementation), three follow-up telephone calls were made to the Asset Manager, Head Clerk of Works, and Aftercare Team Administrator in HA02. The participants were asked what their experience of the new dashboard was like, and whether it was helping them to identify any new learning opportunities. During the follow-up telephone conversations with the HA's Asset Manager and Head Clerk of Works separately in early October 2016, there were early indications that the dashboard in the HA's spreadsheet environment was helping the HA to identify improvement opportunities. Both the HA's Asset Manager and Head Clerk of Works remarked that having an up-to-date view of their defects performance (based upon statistical analysis) allowed them to show their development department and clerk of works teams where their areas of future focus should be. Evidence of the benefit of the interim dashboard in helping the HA to identify improvement opportunities that they were unaware of previously came in relation to the belief from the HA's Head Clerk of Works that balconies (single ply membranes) were the HA's biggest area of defects and should have been the HA's largest area of focus during construction (the issue identified during the diagnosis phase - see Section 4.2.2b for further detail).

However, the more rigorous analysis showed that balconies were only responsible for 3% of the HA's defects by frequency and were the second highest of potential exposure by cost at circa £48,000. HA02 had not actually incurred any cost on balconies due to making claims against their new home warranty or allowing the original builder to rectify the issues at their own cost.

The analysis provided by the live data dashboard had helped the HA identify that the largest areas of exposure (as above, the warranty provider or builder had covered the costs) were in relation to roofs (circa £70,000), balconies (circa £48,000), and then external walls (circa £37,000). In respect of 'cost' incurred, HA02 had spent the largest amount of money repairing internal services issues at £17,500 followed by stairs at £2,500. In respect of 'frequency' of defects, the live data dashboard showed the HA that their most prevalent defects related to roofs (28%), followed by doors and windows (16%), external works (13%), and external walls and internal services each with 11% respectively.

During the roof investigations it was found that circa 60% of the roof issues were in relation to the incorrect installation of soffit ventilation which meant that the roof was not being effectively ventilated (see Figure 4.27) and was exhibiting itself as mould on the walls and ceiling (see Figures 4.28 to 4.30).

Figure 4.27: Ventilation gap closed. Batten has trapped felt and rafter tray has been compressed against the felt by the insulation, thus blocking off the air path

Figure 4.28: Mould growth to wall/ceiling junction 1

Figure 4.29: Mould growth at wall/ceiling junction 2

Figure 4.30: Mould growth at wall junction

From a telephone conversation with the Aftercare Team Administrator in late October 2016 it emerged that HA02 were learning from these issues and acting to reduce them in their future properties due to the high cost exposure and high frequency identified through the analysis; and, the H&S concerns posed (mould growth) by the specific problem (a measure of importance introduced in Section 4.2.1). The Aftercare Administrator explained that *"… we now know that we have an issue of incorrect installation of soffit ventilation on a [developer's name] standard house type. [Head Clerk of Work's name] is working with his clerk of works to make them aware of this issue, so that they can look out for the problem when inspecting plots of this house type that are currently progressing in order to reduce the issue. We have also made [developer's name] aware of this problem…"*.

2nd action evaluation point: February 2017

A follow-up interview took place on 6th February 2017 at HA02's premises which aimed to formally evaluate the effectiveness of the changes made and their ability to improve the HA's defects management and learning; and, further to see whether the HA had implemented their satisfaction survey for repairs and progressed their bespoke defects management system with live data dashboard. Having not spoken to the HA since late October 2016, the action researcher believed that the interview would be with the same participants as the action planning and action taking phases of the research. At the start of the interview, the researcher was introduced to the HA's new Head Clerk of Works (as the previous one had left the organisation) and was informed that the HA's Asset Manager would not be attending as he had been promoted to a Director role within the organisation and a new Asset Manager was in place who did not want to attend.

The two participants (the Aftercare Team Administrator and Head Clerk of Works) were first asked for an update on how their bespoke defects management system development was progressing. The Aftercare Team Administrator confirmed that the HA had aborted plans to develop the bespoke defects management system with live reporting dashboard when she said *"that's not going ahead anymore, we purchased a new system (off-the-shelf package) that our Asset Manager used at his previous company"*. The Administrator further explained that this new system allowed the HA to look-up property details from their database, record home occupant details (name, contact number, etc.); and, record the defect as free-text. The researcher then asked the participants whether they still categorised defects. The Aftercare Team Administrator explained that it was not possible to categorise defects within their new system.

The participants were then asked whether they would still be implementing the satisfaction survey for their repair service. In response, the Aftercare Team Administrator confirmed that this change was not going to be progressed further, citing that she *"would like an extra 20 hours in the week to be able to survey satisfaction, but that's not likely to happen"*.

Moving on to the changes that had been made during the action taking phase, the HA was asked the following question: *"I can see that you have made changes to your defect data collection and analysis procedures but not introduced a satisfaction survey for repairs, why did you adopt those recommendations (and not others)?"*

The Head Clerk of Works answered this question and explained that the changes made during the action taking phase were no longer in effect. The Head Clerk of Works explained that he had changed the way the department was working when he explained that he had *"...looked at what we were doing as a department and decided that we don't want to be doing it like that...".* The Head Clerk of Works went on to explain that his focus was on improving the HA's inspection procedures instead of looking at past defects when he outlined that "*my time is better spent training my clerk of works and getting out on site to inspect [instead of looking at past problems]. We have tightened up our inspection procedures to stop defects being as much of a problem, you know, less get through to completion".*

The interview then digressed from the interview schedule (see Section 3.6.3). In response to the Head Clerk of Work's comments of not focussing on past problems, and to gauge the HA's current understanding of what was going wrong in their properties, the researcher asked the Head Clerk of Works whether there were any frequent defects that the HA were experiencing post-completion (following the introduction of HA02's more rigorous inspection processes). In response to the question of issues post-completion, the Head Clerk of Works suggested an issue the house building industry may face in the future (in general) when he suggested that *"in future, the industry will have big problems because of part M (access to and use of buildings) and level thresholds".*

The Head Clerk of Works was then asked what specific issues the HA were experiencing themselves. The Head Clerk of Works was unable to answer the question and asked the Aftercare Team Administrator *"what repairs are we doing at the moment?"*. The Aftercare Administrator then suggested that she did not know without analysing the defect data, when she who responded with *"we've got one for roof tiles falling off, and another for condensation in the roof space, but I wouldn't know without looking through the repairs".*

Aware that the action interventions had been aborted and that the interview was not going to offer any possibility of evaluation, the researcher thanked the participants for their time and left the HA.

Whilst in some AR projects' findings like the one from the action evaluation phase could have signalled the return to the beginning of the AR cycle whereby there was a new problem to be diagnosed. For the purposes of this research it signalled the end of the AR. There were two reasons that the action evaluation phase signalled the end of the AR: (1) there was no longer sufficient time to return to the start of the AR cycle; and, (2) due to the change in key personnel at the HA, there is little evidence showing that the HA had the desire to continue with the AR project.

4.5.2 Action evaluation (reflection)

The feedback construct of the adopted OL model showed that when learning from defects HA02 used anecdotal feedback to identify any significant early concerns in respect of changes made. HA02, however, were more reliant on the continuous review of data (data analysis) to determine whether a change had been effective. During the action evaluation phase, the anecdotal feedback at 1st evaluation point (October 2016) showed that the change was having a positive effect on the HA's learning, and the action researcher did not find any examples of negative feedback. In addition, the change was not implemented for a long enough period of time for HA02 to verify whether the change was successful through the continuous use of data (their long-term feedback mechanism). It would appear that the changes in HA02 were discontinued within the HA despite good anecdotal feedback and a lack of opportunity to verify their effectiveness due to a change in personnel. The findings from the action evaluation phase highlighted four important lessons: a) the importance of key individuals within an organisation to instil a learning culture; b) the importance of analysing defect data to understand what is going wrong in new homes, as the basis of OL from defects (reinforcing the finding from the diagnosis phase); c) that change is difficult to implement; and, d) that academia and industrial co-production, and action research by its very nature is challenging. These four lessons are discussed in more detail below.

a) For the majority of this AR project the HA's (old) Asset manager and (old) Head Clerk of Works were two of the key stakeholders involved in the HA's quest for defect improvement. The HA's Asset Manager was keen for his area of the business – the asset management arm of the HA (and the HA in general) to learn and improve and liaised with the development arm to design out prevalent defects, and the HA's Head Clerk of Works had a strong desire for his clerk of works team (inspecting new-build sites) to learn from past defects. As these two key individuals left or changed roles in the HA, the HA's attitude towards learning from past defects appeared to change from one who wanted to improve to one who felt that they did not need to look at the past to improve. It would have been interesting to see whether the HA's attitude had been different should only one of these individuals have left. For example, would the HA have continued to design out defects should the old Asset Manager have remained, or would the HA have continued to use networking to tackle site workmanship issues if the HA's old Head Clerk of Works not left?

b) After removing the process of analysing defect data following the change in personnel, the HA reinforced the need to analyse defect data to highlight learning opportunities through their inability to identify current problems (and therefore improvement opportunities) and through their admission that they would not know which defects were a cause for concern without analysing their defects log.

c) The action evaluation phase highlighted that implementing change is difficult. The changes were co-developed between the action researcher and the HA after the HA had identified that they needed to change. More importantly, the HA also identified what changes were needed in order to improve their defects management and learning practices, and bring their system in line with their expectations. In addition, a number of changes had been implemented and new ways of working were in place, which further shows that even when change appears to have been implemented and proving successful, unexpected events, such as the introduction of new staff can derail that change.

d) The difficulty of introducing change also highlights the challenges of academia and industrial co-production, and action research as a research approach. In the case of this action research, organisational change was initially promoted (1st evaluation point in October 2016), however, at the end of the research project (2nd

evaluation point in February 2017) the research had been abandoned. This finding reinforces the difficulty in carrying out an AR project and brining changes into an organisational setting.

This section has discussed the action evaluation phase of the AR. The next section discusses the learning of both the HA and researcher from the entire AR project.

4.6 Specifying learning

4.6.1 Specifying learning (practice)

The 1st action evaluation point (October 2016) suggested that HA02 were learning from this AR project. This learning was evident from making a number of additional changes to how they wanted to analyse their data during the action taking phase (when compared to the first interaction during the diagnosis phase), and working with the researcher to co-develop a live defects data analysis dashboard.

However, at the end of the AR project (second action evaluation point in February 2017); it could be argued that specifying learning did not happen in HA02 due to significant changes to key personnel. In essence, HA02 are now in a worse place than at the start of this project. HA02's new OL cycle (Figure 4.31) is reminiscent of HA05's OL cycle in the diagnosis phase, whereby the HA records defect data, but does not analyse it and therefore does not know what is going wrong in their properties and are unable to implement change to improve. It would appear that HA02 are undertaking the most basic form of OL whereby they are detecting and correcting errors. To elaborate on this point, a post-completion defect is reported to the HA (i.e. an error is detected). The HA then arrange for a repair to be undertaken to resolve the issue (i.e. the error is corrected).

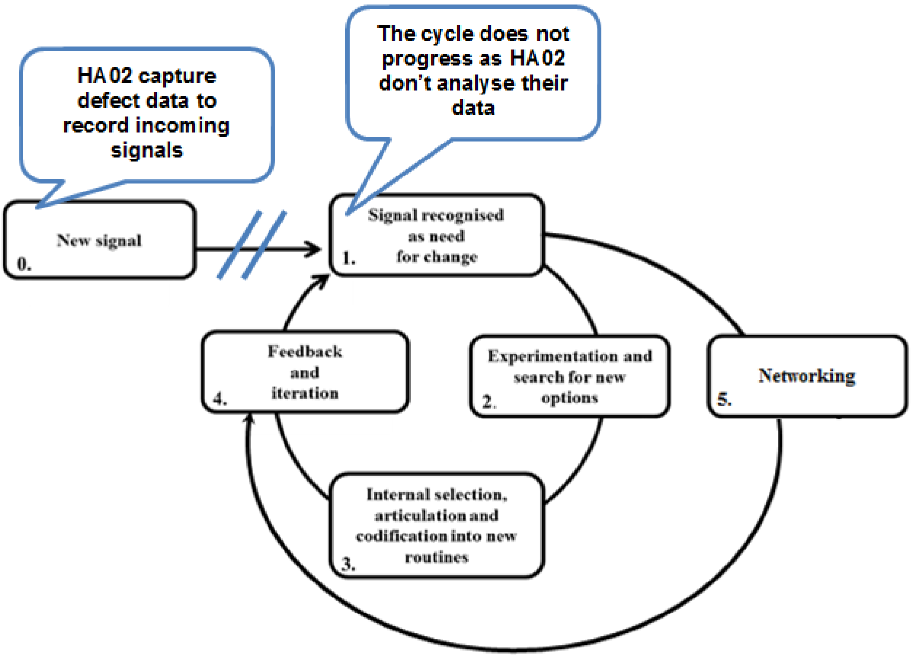

Figure 4.31: HA02's new OL from defects cycle

4.6.2 Specifying learning (reflection)

The following summarises the key reflections from the action research process, positioned around the OL constructs of the adopted model.

0. New signal

There were two consistent features in relation to new signals and the way in which new signals were captured by HAs. First, all signals that HAs received were external to the HA. The external nature of the signals was evident from the diagnosis phase of this AR project (see Section 4.2.2) where all signals of defects were reported by the home occupants post-completion; and, during the action planning phase (see Section 4.3.2), HA02 were experiencing incoming signals by way of reduced government funding and a forthcoming requirement for the HA to reduce their social housing rents. Second, in respect of learning from defects all of the HAs had mechanisms in place to capture post-completion defect data, in order to record incoming signals, thus highlighting the importance of data capture as the starting point to OL from defects (see Section 4.2.2).

There were, however, a number of variables in relation to how data was captured, what data was captured (including volume of defects); and, how defects were classified that emerged during this research (see Sections 4.2.2 and 4.2.3). These are discussed in more detail below.

First, the HAs were found to use three different system types to record their defect data. Three HAs (HA01, HA02, and HA05) recorded post-completion defect data in a standard spreadsheet, five HAs had bespoke defects management systems (HA03, HA07, HA08, HA09, HA10); and four HAs used an off the shelf package (HA04, HA06, HA11, HA12). It is also worth noting that HA02 moved to using an off-the-shelf package at the end of this research. There were no indications that a particular type of system was more or less effective in helping HAs to learn from defects.

Second, all of the HAs captured seven core fields of information: (1) the property address, (2) the property completion date, (3) the associated scheme ID, (4) the name of the contractor responsible for the build, (5) the details of the customer reporting the defect, (6) the date the defect was reported/logged, and (7) a free-text field for a description of the defect and any damage reported. Outside of these core fields there was a range of data captured by the HAs, including: construction type, warranty provider's details, estimated cost savings; and repair status. The additional details appeared to be used to help the HA achieve their respective learning aims. For example, HA03 recorded start and end dates of repairs, and sought to learn from defects to reduce their repair durations.

Finally, 10 of the 12 HAs used categories to classify their defects (HA02 and HA05 being the exceptions). The most popular category was 'building area' (the area of the building in which the defect had occurred, e.g. doors and windows, electrics, heating) (seven HAs), followed by 'trade' (the trade responsible for their occurrence, e.g. plumber, joiner, electrician) (five HAs). Other categories recorded by the HAs included 'repair priority' (the priority of the repair, e.g. emergency, urgent, or routine), 'damage' (the damage caused as a result of the defect's occurrence), and 'extent' (the level in which the defect was affecting the property, e.g. whole house) (one HA). During the action taking phase, HA02 also introduced 'building area' and 'repair priority' categories which helped the HA identify trends; however, at the end of this research, HA02 reverted back to using no categories, and were unable to identify trends. Therefore, there were indications that HAs who assigned categories to defects were more capable of easily identifying trends in performance and improvement opportunities. HAs who did not assign categories either did not analyse the data, or manually attempted to pick out trends from long strings of free text, which has the potential to lead to a belief that aspects that were perceived as most problematic were not (e.g. HA02 and balconies).

1. Signal recognised as need for change

There were three consistent features of how signals were recognised as a need for change in HAs. First, for most HAs (sans HA05) there was a reliance on ‘a defects management team’ – a team of individuals who manage the repair process (for example, an aftercare team) analysing defect related data to translate past issues into identified improvement opportunities (i.e. recognising the incoming signals as a need for change). Without these individuals/human activity systems it would appear that HAs would not learn from defects (typically driven by key individuals). This reliance on humans indicates that learning from defects in HAs seem to be driven by individuals at a departmental level to translate defects identified within these departments (and their daily activities) into organisational action to improve. The action evaluation phase also shows the importance of key individuals in how HAs learn. In HA02, an unexpected chain of events and organisational change impacted on the outcome of the AR project. Despite the early engagement and suggestions that the action taken was beneficial, when the action researcher returned to HA02 he found that all of the changes made had been aborted due to a change in personnel and the introduction of beliefs that analysing defect data was not an important task. Ironically, the failure of the interview participants in HA02 to be able to outline what is wrong in their properties reinforced the earlier finding of this research that capturing and analysing defect data was a critical part of a HA’s learning from defects. The action evaluation phase showed the importance of key individuals in an organisation to instil or promote a learning culture at that departmental level (see Section 4.5.2).

Second, the HAs appeared to rely on a statistical approach to demonstrate the need to change their existing routines (see Section 4.2.2). This statistical approach was further evidenced by HA02 identifying the need to update their defect data analysis processes and develop a live data reporting dashboard to enhance their learning potential (see Section 4.3.2). However, there appears to be merit for this reliance on a statistical approach as evidenced by HA02 during the action evaluation phase: a) where HA02 used a less rigorous approach to analysing their data (i.e. a manual review of free text) the HA perceived certain defects to be important, when the HA used statistical approach after taking action the HA realised that other defects were actually more prevalent and costly; and, b) where HA02 deviated from this statistical approach to not analysing defect data at all, they were unable to identify improvement opportunities (see Section 4.5.2).

Finally, recognising signals as a need for change appeared to be a ‘reactive’ process in HAs. Where HAs were looking to learn from defects they would look at past performance to determine their future areas of focus, there appeared to be no attempt to improve until a problem was identified (see Section 4.2.2). This reactive nature was also evident in HA02 during the action planning phase: the HA’s Asset Manager noticed that their repair bill was increasing and the HAs funding/finance was decreasing, so costs needed to be cut (see Section 4.2.2). Further, during the action planning phase, through the use of SSM it was found that HA02’s defects management and learning system was not doing what the participants believed it was, which made the deficiencies of the HA's current system apparent to them. As a result of the system not doing what it was meant to HA02 reacted to the situation and (with the researcher) recognised desirable and feasible changes to bring their system in line with the HA’s expectation (see Section 4.3.1).

There were also a number of variables in relation to how signals were recognised as a need for change. These variables were typically in relation to how HAs interpreted past issues as a need for change, and how frequently they look (see Sections 4.2.2 and 4.2.3). These are discussed in more detail below.

First, the HAs typically undertook their data analysis (look to identify the need for change) at different frequencies. Six HAs analysed their data on a ‘monthly’ basis (HA01, HA04, HA07, HA10, HA11,and HA12), two HAs on a ‘weekly’ basis (HA02, HA03), one HA on an ‘ad-hoc’ basis only (HA06), one HA on a ‘quarterly’ basis only (HA09), and one HA undertook the analysis on both an ‘ad-hoc’ and ‘quarterly’ basis (HA08). There was, however, no indication that more or less frequent analysis made the HA more or less capable of recognising the signals as need for change (see Section 4.2.2).

Second, the way HAs identified signals as a need for change (i.e. which specific defects to target) differed significantly (see Section 4.2.2). Five HAs (HA01, HA07, HA9, HA10, and HA11) had KPIs for acceptable levels of performance. When these KPIs were exceeded the HA would take action. Seven HAs would use the volume of a specific type of defect (compared to other defects experienced) to determine which defects to target for reduction purposes. Six HAs would use their experience to determine which defects were “significant”. One HA would use customer complaints (to a specific issue), and one HA would look at defects with high repair costs. There were indications of inadequacies in each of these approaches if adopted alone. For example, if a HA only looked into the most prevalent defects they may miss other defects that caused an impact to the home occupants. For instance, where HAs had KPIs this would limit the HA’s learning in as much as the HA would not act to improve unless the KPI was not achieved.

Finally, the impact of defects survey (see Sections 4.2.1 and 4.2.3) identified the need to target defects that pose H&S concerns and cause home occupants dissatisfaction over the most frequent. During the action taking phase HA02 introduced repair priority, complaints, estimated repair duration; and, whether a repair was completed on time. It was suggested during the action evaluation phase that this was beneficial in helping HA02 to understand which issues they should target to help satisfy their customers (see Section 4.5.1). In addition, this finding suggests that the really important aspect of the impact of defects questionnaire was in its ability to provide the HA with an insight into what was important to home occupants.

2. Experimentation and search for new options

One consistent feature of how HAs experiment and search for new options emerged is that all of the HAs were reliant on sourcing knowledge from relevant internal people who were invited to provide solutions to the problem based upon their levels of knowledge and experience in the given area (see Section 4.2.2). This was also similar with HA02 during the action evaluation phase (Section 4.5.1) where the HA introduced a number of new systems and processes due to the (perceived) knowledge and experience of the two new people they brought into the organisation.

There were however four observed differences between how HAs experiment and search for new options. First, three HAs (HA02, HA06, and HA11) reviewed schemes that were performing better in the given problem area, to determine whether something could be adopted and applied to the poorly performing projects. Second, only one HA (HA11) experimented before implementing organisational wide changes, through pilots. Third, only one HA (HA11) used customer feedback to directly influence the options applied to future projects. Finally, five HAs (HA02, HA08, HA09, HA11, and HA12) invited proposals from relevant external people to provide solutions to the given problem (see Section 4.2.2). Identifying aspects of schemes performing better in a given problem area, experimenting; and, using customer feedback may offer a potential solution to overcome barriers experienced in other HAs of not being able to convince departments that a change would be beneficial (e.g. HA12). The action interventions in HA02 also resonate with this finding and suggest that the way HAs use the same process to source knowledge and solutions to problems outside of their learning from defects. HA02 seized the opportunity to improve how they manage and learn from defects and sought to use the researcher's relevant experience and knowledge to help them to identify new options (see Section 4.3.2). In addition, HA02 also made use of the researcher's knowledge and skills of Microsoft Excel whilst co-developing the live data analysis dashboard in their existing spreadsheet environment (see Section 4.4.1).

3. Internal selection, articulation and codification into new routines

Three consistent features arose in relation to internal selection, articulation and codification into new routines. First, after identifying improvement opportunities the HAs tended to remove the problem by taking 'a codification approach' to learning. This codification approach was through designing out defects using organisation wide changes to the HAs employers requirements, specifications, and design guides (see Section 4.2.2). This finding was also similar to HA02's approach during the action planning and taking phase. HA02 concentrated on changing their formal systems of capturing and analysing defect data as well as the technology that they were using to do this. Also, HA02 were looking to introduce a satisfaction survey for repairs to formalise their collection of home occupant data (see Section 4.3.2). This codification approach may have been used by HA's to ensure that learning from defects was documented to ensure it took place.

Second, the importance of impartial review panels to translate 'individual/group learning' to OL was identified. Without this review panel, a HA's learning potential was limited to whether an individual or a department would accept a change, for it to be implemented (see Section 4.2.2). In addition, the involvement of senior individuals within the review panel overcame any potential resource issues as the change became a 'top-down' initiative whereby departments were required to allocate necessary resources to implement the change. The lack of a review panel and a top-down approach to change manifested itself in HA02's inability to successfully develop their bespoke defects management system with a live data reporting dashboard due to a reliance on individuals and departments to approve changes without direction from higher up in the organisation (see Section 4.4.2). The bespoke system was not developed due to limited IT capacity, whereby the IT department prioritises changes, and did not see the bespoke defects management system as a "priority", therefore blocking the change from being implemented. The action taking phase also showed that in this case of a department blocking a change, the HA implemented a change that was in the span of control of those who wanted to implement it. HA02 implemented a fifth intervention, which was to develop a live defect data dashboard in the HA's spreadsheet environment.

Finally, the majority of the HAs provided feedback of changes that had been implemented to key internal stakeholders to keep them informed of any new changes. However, a number of different methods were used to communicate the change to others in the organisation: emails, lessons logs, meetings, training sessions, and posting of updates on a staff intranet (see Section 4.2.2).The aim of this feedback was to make key individuals aware of changes, however, there was no evidence that any one, or combination of these approaches was more capable of raising awareness than others. It should be noted, that where specific individuals were directly affected by a change (as part of their daily activity) the training session approach tended to be adopted.

One variable was also highlighted by this research. Only four HAs provided external feedback of any changes made. For example, feedback to contractors on their performance, or feedback to manufacturers on how their products were performing. Where this feedback was not provided, there were instances of HAs discontinuing the use of products and not making the manufacturer aware of the product's poor performance and not offering the manufacturer feedback to aid their product improvement.

4. *Feedback and iteration*

In relation to feedback and iteration, one consistent feature was identified during this research (see Section 4.2.2). HAs would typically use a combination of feedback mechanisms to evaluate the effectiveness of a change. Most HAs would use anecdotal feedback to gauge the success of a change in the early stages. This anecdotal evidence style was also used by HA02 during the action taking phase to determine the initial success of their changes to data capture and analysis. The anecdotal feedback from HA02's Asset Manager and Head Clerk of Works reported that the changes to their data capture and analysis; and, the introduction of the data dashboard were beneficial to the HA's learning (see Section 4.5.2). Some HAs used a review panel to review changes that had been implemented a number of months post-implementation. Most importantly the majority of HAs would use the continuous review of data (data analysis) to determine whether a change had been successful in reducing the targeted defects (see Section 4.2.2). This continuous review of data would provide evidence to the HA to justify continuing with a new way of working, or to abort that change. There were, however, no indications that poor anecdotal feedback would result in the HA aborting a change in the early stages. Whilst the anecdotal feedback for HA02 was positive in that the changes made (see Section 4.5.2) had provided them with a more rigorous way of identifying improvement opportunities, unfortunately due to the changes in HA02 the research was unable to statistically verify whether the changes made had helped HA02 reduce their defects (see Section 4.5.2), which is in stark contrast to the general consensus.

5. *Networking*

Finally, four HAs undertook a dual approach to learning, where they combined the 'codification' approach of designing out defects as the main approach which was then supported by a 'personalisation' approach to learning of informal internal communication (referred to as 'networking' in this research). This networking was aimed at raising an individual's knowledge therefore adding to the knowledge base of the organisation. There was evidence that workmanship was one of the largest areas of concern (and cause of defects) within HAs and some HAs who solely relied upon the codification approach to learning believed that they could only reduce defects to a certain extent (i.e. improve their processes and designs to a point). This dual approach may be a better way to learning from defects to reduce both design issues and on-site workmanship issues.

4.7 Summary and link

This section presented the key findings from the entire AR project. The next section discusses those findings.

5 Discussion and Conclusions

5.1 Introduction

This chapter discusses the findings in relation to the research aim and objectives set out in Section 1.4 as well as presenting the conclusions drawn from this research. The chapter is structured as follows:

(1) The chapter begins by reflecting on the research aim and three objectives (Section 5.2).

(2) The contribution of this research to organisational learning theory is discussed (Section 5.3).

(3) The contribution this research has made to methodology is presented (Section 5.4).

(4) The contributions to practice as a result of this research are outlined (Section 5.5).

(5) The implications for policy arising from this research are discussed (Section 5.6).

(6) Finally, the limitations of the research and areas for further research are presented (Section 5.7).

5.2 Reflection of research aim and objectives

The aim of this research was to better understand how UK housing associations (HAs), in practice, learn from past defects in an effort to reduce the prevalence of defects in future new homes. In order to achieve this aim three objectives needed to be addressed.

In achieving the research aim it was found that HAs typically sought to learn from defects as a means of adapting to survive in their current business environment by reducing defects and improving home occupant satisfaction. This learning was typically a secondary function in HAs driven by the defects management team capturing and analysing post-completion defect data to identify improvement opportunities and determine the success of implemented changes, which appeared to fluctuate with workload. There were indications that HAs learning could be enhanced by using live data to reduce the burden on the defects management team. For analysis purposes, HAs tended to focus on the most prominent defects when it may have been more beneficial to focus on defects that posed health and safety (H&S) concerns and caused home occupant disruption to address the suggested concerns from home occupants that the house building industry does not value them.

After identifying improvement opportunities the HA's had a primary approach to learning of designing out defects (codification approach) which was reliant on senior management taking forward actions as innovation champions and implementing changes in their 'employers requirements' (ERs). This designing out defects approach was shown to be successful in some situations but failed to acknowledge that defects often occur due to workmanship. Therefore, the need for networking (personalisation approach) to tackle site workmanship issues in combination with the codification approach – dual approach – was identified. An in-depth discussion of the findings positioned around the three objectives is presented below.

5.2.1 Objective 1: The impact of defects

The diagnosis phase of the action research (AR) cycle was designed to address objective 1 *"Gain insight into which impacts of defects are actually important to the key stakeholders involved in their detection and remediation from construction on site until the end of the warranty period"*.

It was found that the key stakeholder involved in the defect detection and remediation from construction on site until the end of the warranty period within new-build houses are: house builders, warranty providers, building inspectors, and home occupants (see Section 2.6). 20 potential impacts of defects were identified from both the literature and open questions within the survey which were identified through the literature and survey were positioned around the H&S, cost, and disruption aspects of defects (see Table 5.1). The impacts contained within the extant literature include: H&S impacts such as danger to home occupants and danger to site workers; cost impacts including investigation, repair, and complaint costs for house builders and warranty providers, fines for regulatory non-compliance for house builders, and approved inspector fines for breach of contract; and, house builder and home occupant disruption. The survey further identified new home occupant specific cost impacts (such as their cost of repairs and the effect defects may have on a home's resale value) and extended our understanding of what causes home occupant disruption (such as rehousing, needing to take time off of work, and not being able to use their new home as intended). Furthermore, two H&S impacts emerged from the survey that fall outside of the four key stakeholders: danger to site visitors, and the general public.

Table 5.1: The impact of defects

Impacts of defects	**Health and Safety**	**Cost**	**Disruption**
Literature review identified	• Danger to home occupants • Danger to workers on site	• House builder's investigation costs • Warranty provider's investigation cost • House builder's repair cost • Warranty provider's repair cost • House builder's complaint costs • Warranty provider's complaints cost • The effect of warranty repair costs on the house builder • House builder fines for regulatory non-compliance • Approved inspector fines for breach of contract • The cost of warranty provider repairing Building Regulation contraventions	• Disruption to the home occupants having trades return • Disruption to the house builder in arranging trades to return • Disruption to the house builder's construction programme
New impacts emerged	• Danger to the general public • Danger to visitors to site	• Home occupant's repair cost • The effect on the home's resale value	• Need for the home occupant to be rehoused during remedial work, repair duration; need for the home occupant to take time off of work to allow builder access to undertake the repair • Disruption to home occupants not being able to use their home as intended

The key findings further extend our understanding of the impact of defects phenomenon in several ways. These are first discussed in relation to individual stakeholders, and then in relation to the general findings.

Individual stakeholders

This section presents the individual priorities of the four key stakeholders in relation to the impact of defects. Each of the four key stakeholders' views are discussed in detail below.

- *House builders*

Whilst the questionnaire data was not conclusive, there were suggestions that house builders prioritised the danger defects pose to home occupants first, the danger defects cause site workers second; and, the disruption defects cause home occupants and the cost of fines for regulatory non-compliance to the builder as their joint third highest priority. One possible explanation for the house builders' high prioritisation of H&S related aspects and regulatory contravention may be due to the consequences and penalties of breaching legislation. For example, in respect of H&S legislation, organisations can be found guilty of corporate manslaughter (a criminal offence) if they breach their duty of care (HSE, 2017). For instance, if a builder breaches the Building Regulations they can receive an unlimited fine from the local authority (PortalPlanQuest, 2017). One interesting finding came in relation to house builders prioritising home occupant disruption over the majority of the cost related impacts (fines for regulatory non-compliance aside), which is in contrast to the general perception that house builders are predominantly financially motivated and cost focussed (Sommerville *et al.*, 2004).

The key results further indicate that house builders appear to be more focused on reducing defects to limit danger to home occupants and workers on site, as well as reducing post-completion disruption than saving money on remediation. One potential explanation for the house builders under prioritising the cost of repairing defects could be that they do not fully appreciate their economic impact. Some support for this potentiality is Love (2002) who argues that only when construction organisations begin to measure (and understand) their cost of repairing defects, will they fully appreciate the economic benefits of reducing defects.

➢ *Warranty providers*

Based upon the questionnaire responses, warranty providers were found to prioritise the danger defects pose to home occupants first, followed by the cost of warranty repairs on Building Regulation contraventions, with the cost of approved inspector fines for breach of contract and the disruption defects cause home occupants' as the joint third priority. Similarly to house builders the warranty providers' high priority of home occupant H&S could be due to their duty of care. One explanation for the warranty providers' focus on the cost of warranty repairs for defects that are Building Regulation contraventions and the cost of approved inspector fines for breach of contract is possibly due to the association between warranty providers and approved inspectors. Historically, under the warranty link rule an approved inspector was required to have an association with a warranty provider when they were undertaking building control (CIC, 2017). Despite the warranty link rule being abolished in 2013, a number of approved inspectors still have links with a warranty provider (e.g. NHBC, Checkmate). In the warranty provider surveyed, the warranty offers specific cover for defects that contravene the Building Regulations (when the associated approved inspector undertook building control). Where a claim is successfully made under the section of the warranty that provides cover for Building Regulation contraventions where the warranty provider's associated approved inspector undertook building control, the warranty provider will undertake the repair but will not look to recover any costs from the house builder. The Building Regulation contravention claims will not affect the house builder's premium rating. In addition, where there is a fine for the approved inspector, the warranty provider will typically cover the cost as they have the necessary funds.

➢ *Building inspectors*

For building inspectors, danger to home occupants was indicated to be the highest priority, followed by the cost of warranty repairs for Building Regulation contraventions, and home occupant disruption and approved inspector fines for regulatory non-compliance as the third joint priority. One possible explanation for the building inspectors' prioritisation could be as a result of guilt relating to their failings. For example, the high prioritisation of the cost of warranty repairs associated with Building Regulation contraventions and the high prioritisation of approved inspectors' fines for breach of contract are likely to be due the guilt that the repairs have resulted from the building inspector’s failure to identify the non-compliance during his/her inspections. Similarly, the home occupant focus is also likely to be associated with the feeling that the defects have occurred because the building inspector failed to identify the problems during construction.

- *Home occupants*

The questionnaire responses would suggest that home occupants are unconcerned with the effect defects have on the house building industry in general. Home occupants appeared to prioritise their disruption first, followed by any potential danger defects posed to them second, and danger to site workers third. There may be one simple explanation for the home occupants’ self-prioritisation, the impacts identified as important were the only impacts that are directly relevant to home occupants. Whilst the home occupants self-view is not unsurprising (as many home occupants would have just made one of the biggest purchase of their lives) their lack of appreciation for the cost and disruption effects of defects suggests a lack of awareness for the indirect effects defects have on them, in as much as the budgeted cost of defects and the purchase of any warranties for covering defects (by the builder) will typically be passed onto them in an increase to their purchase price. Further, any defect related delays to the house builder’s construction programme could delay the home’s completion date, and the home occupant’s move-in date, which is an aspect only 72% of home occupants were satisfied with when buying a new home (HBF, 2016). The reasons why the home occupants are egoistic in their views appears to be the belief that the wider house building industry shows little consideration for them and is more concerned about making money.

General findings

Whist the survey response rate was not as high as anticipated and the sample may not be truly representative of the population of interest, when considering the findings collectively there are three key messages emerging from objective 1:

- The house building industry appears to have a primary focus on H&S;
- There are indications that the house building industry are home occupant focussed, identifying home occupant impacts as important; and,
- There is a suggestion of a significant contrast between how the house builders reported home occupant focus and the home occupant’s perspective.

- *Health and safety as a primary focus*

From the responses of the three house building industry stakeholders (i.e. house builders, building inspectors and warranty providers) discussed above, H&S was found to be the main priority, in general. In addition, the responses to the open question from the survey maintained the house building industry stakeholders focus on H&S where they identified the ‘danger defects pose to visitors to site’ and ‘danger to the general public’ as important - previously unconsidered impact of defects.

The finding that the potential H&S implications of defects are the main priority to the house building industry both supports the UK perspective (e.g. Baiche *et al.*, 2006) and suggests some international transferability in the findings. The high H&S prioritisation supports the argument of Ilozor *et al.* (2004) in the international defects literature that there should be focus on defects that may be detrimental to H&S. However, this argument is in contrast to Oliveira Pedro *et al.*’s (2008) assertion that H&S issues should be considered minor issues. The high H&S prioritisation in house building is important given that Love and Teo (2017) have found that there is a high correlation between the occurrence of defects and the occurrence of injuries.

- *Home occupant focussed house building industry*

The results indicate a level of consensus from the house building industry stakeholders (i.e. house builders, warranty providers, and building inspectors) when they placed significant importance on, and showed sympathy for, the aspects that affected the home occupants. For example, ‘danger to home occupants’ and ‘disruption to home occupants’ appear in each of the stakeholders’ highest three priorities. The additional potential impacts defects (see Table 5.1) may cause identified by the open questions sustained the house building industry stakeholders’ home occupant focus. The house building industry stakeholders outlined a range of additional impacts, such as potential costs to home occupants, or the need to rehouse a home occupant during a repair.

This high prioritisation of home occupants implies that the house building industry (or at least the survey respondents) is customer focused and indicates a shift in attitude over the 13 years since Sommerville *et al.* (2004) argued that the construction industry needed to become more customer focused. There may be two reasons for this ‘shift’ in attitude: a) Sommerville *et al.*’s (2004) argument was based on the researchers’ perceptions of the house building industry as opposed to empirical data; and, b) the House Builders Federation (HBF) customer satisfaction survey results only became a public figure after 2006 (despite being in place since 2001), which may have made the house building industry place more emphasis on the home occupant.

➢ *House building industry not home occupant focussed?*

Despite the indications that the house building industry stakeholders prioritised the impacts that affect home occupants highly, there appeared to be a perception from home occupants that the house building industry was not home occupant oriented. Due to the potential contrast in the house building industry’s reported home occupant focus and the perception of the home occupants, the survey results also suggest that the UK house building industry could benefit from defect reduction, possibly through a reduction in defects associated with H&S problems along with likely disruption to home occupants and the dissatisfaction that causes. New Home Customer Satisfaction Surveys (HBF, 2016 & 2013) show that home occupants are becoming less satisfied with their new home (84% of home occupants in 2017 would recommend their builder to a friend compared to 91% in 2013). Over the same period the number of defects reported by the home occupant to the house builder has also risen (98% in 2017 compared to 91% in 2013). Home occupants are unlikely to welcome disruption that occurs due to work being carried out incorrectly (BEC, 1991). Therefore the increase in the volume of defects and the additional disruption caused may be a contributing factor to the decline in satisfaction. Reducing defects may also help to change home occupants’ perception of the house building industry. Reducing defects may remove the negative image that house builders are not customer focused, are only interested in making money, and will take short-cuts wherever possible. Some support for this idea is Somerville and McCosh’s (2006) finding that defects are damaging to the image of house builders and detract from customer satisfaction.

5.2.2 Objective 2: Learning from defects

The diagnosis phase of the AR cycle also explored how HAs collected and learnt from defects. The HAs' localised learning process exploration contributed to objective 2 *"Understand HAs' localised defects analysis procedures, and their current knowledge feedback loops to inform future practice".*

In order to explore HA's localised defects analysis procedures in detail, Berkhout *et al.*'s (2006) organisational learning (OL) model of: new signal; signal recognised as need for change; experimentation and search for new options; internal selection, articulation and codification into new routines; and, feedback and iteration was adopted (see Section 2.9). The key findings extend our understanding of the localised learning from defects phenomenon in the following two areas: the modification of the existing OL model to make it a specific learning from defects in housing model; and, the general findings.

Modified organisational learning model for housing defects

The key results enabled the development of a specific OL from defects model in house building (Figure 5.1), which consists of two approaches to learning: codification (the primary approach to reduce defects - inner circle) and personalisation (the secondary approach to reduce defects - external circle). The modified model is made up of seven constructs:

0. Capturing defect data to record incoming signals,
1. Undertaking periodic analysis to identify the need for a change,
2. Searching for new product and process changes with experimentation where necessary,
3. Internal selection, articulation and codification into new routines,
4. Feedback and periodic data analysis as concurrent processes,
5. Networking to share experience and knowledge of latest defects identified,
6. Modification of individual behaviour due to new knowledge and insight.

Although these seven constructs of OL from defects are listed in progressive order, learning is perceived as a cyclical, dynamic process. The codification approach to learning typically follows constructs/stages 0, 1, 2, 3, and 4 (the primary approach) and the personalisation approach follows constructs/stages 0, 1, 5, 6, and 4 (the secondary approach). These constructs are discussed below.

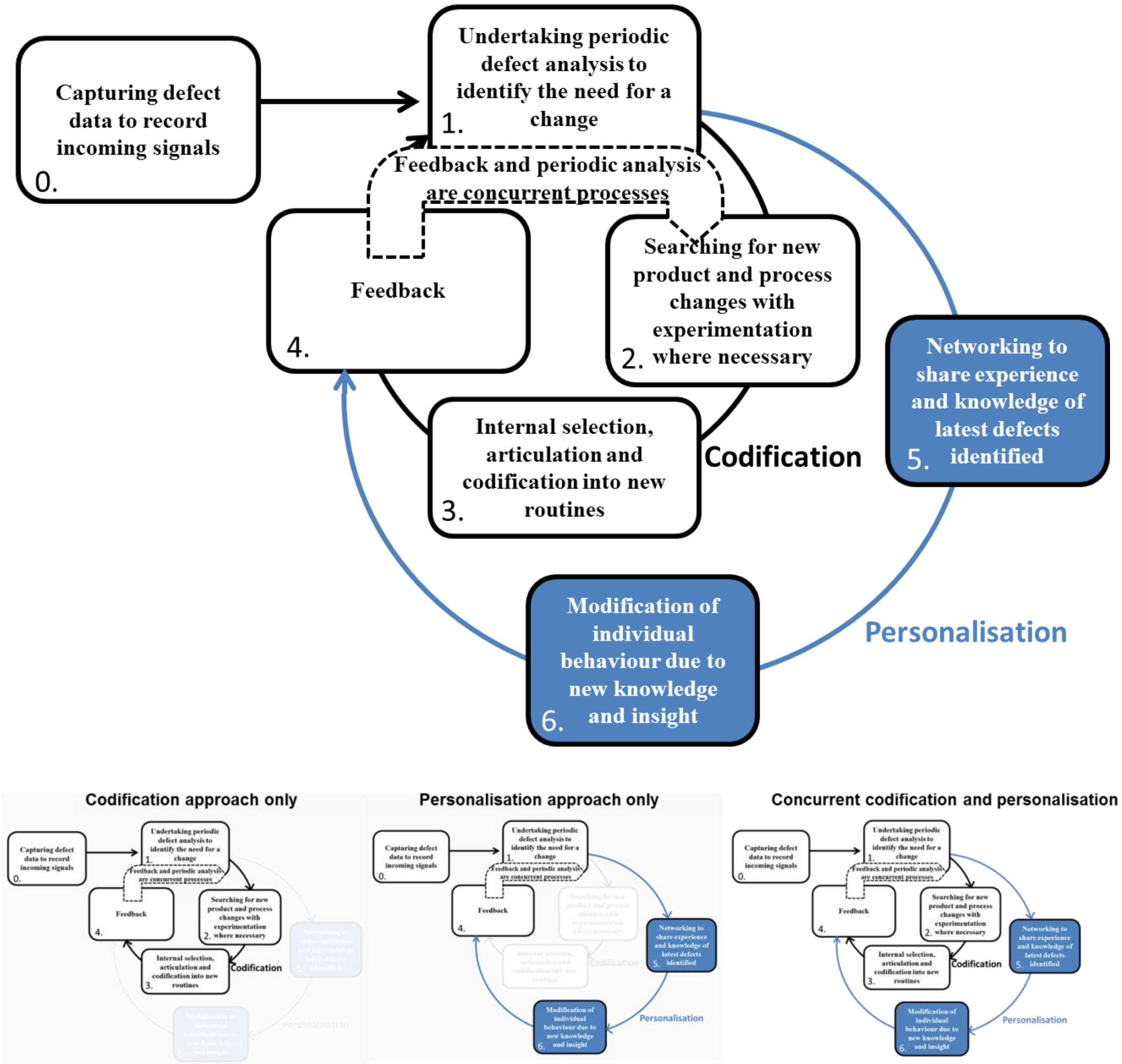

Figure 5.1: Specific organisation learning from defects model in house building

0. Capturing defect data to record incoming signals

HAs record significant volumes of post-completion defect related data (received externally from home occupants) within a centralised unit, captured through a combination of different actors and systems. Some HAs had a process of redirecting defects reported by the home occupant directly to the contractor responsible for the repair. This forwarding of the repair details typically occurred without seeking to understand or record the true nature and cause of the defects at any point. This redirecting of defects raises empirical questions regarding the defect data accuracy within HAs who redirect defects, because there is potential for a number of defects to exhibit themselves in the same way. Without understanding the true cause of defects and keeping accurate records, HAs may be unknowingly focusing on an unproblematic aspect. For example, the home occupant may report that their water storage tank is leaking. This may lead HAs to focus their defect reduction efforts on reducing water storage tank defects; instead of resolving the true defect in the central heating system - the hot water cylinder. Data accuracy is especially important when considering a need for change (see stage 1 below).

As the learning process for a HA starts with defect data recording the incoming signals concept within the existing model has been adapted to explicitly outline the need to capture defect data, thus promoting the recording of all new signals (defects) entering the organisation.

1. Undertaking periodic analysis to identify the need for a change

Following on from incoming signals defect data analysis was found to be the primary enabler to recognising a need for a change to organisational routines and the catalyst to that subsequent change taking place within HAs. The analysis of defect data tends to act as both 'a process of identifying new signals' and 'a feedback mechanism' for implemented changes.

This analysis of defect data appears to be a valid approach and conforms to the guidance provided by industry bodies, such as the National House Building Council (NHBC) Foundation (2011) and the National Audit Office (NAO, 2007); and, is similar to the learning prescriptions in the international construction and new housing defects literature (e.g. Lundkvist *et al.,* 2010; Maracrulla *et al.*, 2013). Support for the idea of capturing and analysing past defect data for learning and improvement can be found in the Information Technology (IT) literature where it is common practice to analyse defect data to support software process improvement (e.g. Raninen *et al*., 2012; Rigat, 2009) as well as in high hazard industries where accident data is analysed to reduce the occurrence of accidents in future (e.g. Carroll *et al.*, 2002).

When recognising signals as need for a change the HAs tend to focus either the prominence of defects overall (e.g. number per unit), the most frequent defect types, or on occasion defects that are perceived as important by the analyser. The focus on prominent defects or frequent types of defects is consistent with the approach taken in the UK new-build housing defect research by Sommerville and McCosh (2006) (numerical occurrences of defects) and Baiche *et al*. (2006) and Craig (2007) (prominent types of defects). The focus on defects that are deemed important by the analyser is important given the disagreement by researchers over which defects the house building industry should focus on (other than the most frequent) (e.g. Ilozor *et al.*, 2004; Georgiou *et al.*, 1999) (see Section 5.2.1).

In respect of the most prominent types of defects experienced by HAs the results show that HAs tend to experience 'internal services issues' most frequently (see Section 4.2.2). The prominence of internal services defects is inconsistent with Craig's (2007) finding that aesthetic issues are the most prominent snags in UK new homes. One explanation for such difference could be the source of data collection and the definition of defects. In this research the defects were recorded by the HAs which were contraventions of the warranty provider's standards (see Section 2.5). Craig (2007) utilised data from a snagging company 'Inspector Home' (now New Home Advisor). New Home Advisor acknowledge that a number of the 'defects' they report as defects may indeed comply with the warranty providers standards (New Home Advisor, 2017). This acknowledgement of compliance with warranty providers' standards suggests that the defects records for aesthetic issues are not judged against the standards the home was meant to be built to and were therefore over reported in Craig's (2007) work.

The finding that HAs have a centralised team (defects management team) where individuals analyse defect related data to recognise signals which indicate a need for a change to current practice as well as to monitor the effectiveness of implemented changes corroborates Berkhout *et al.*'s (2006) assertion that novel situations are usually identified through continuous monitoring of signals. In addition, the reliance of HAs on individuals within the defects management team is supported by Argyris and Schon (1996) who explain that learning typically occurs when individuals within an organisation experience a problematic situation and inquire into it on the organisation's behalf.

The structured approach to defect data capture and analysis as a feedback mechanism is in contrast to Barlow and Jashapara's (1998) and Scott and Harris's (1998) suggestions that feedback systems in place within the construction industry are unstructured and informal. One reason for such a contrasting view is the unique nature of the house building industry when compared to the wider construction sector. HAs typically have a centralised team (defects management team) within the organisation that are responsible for the defects management process and provide the link between project-level and organisational-level activities. This centralised team ensures that feedback provided from previous projects is structured and formalised. Without this centralised team the house building industry may be susceptible to the pitfalls of other construction organisations.

Due to the key role defect data analysis plays in recognising signals as a need for change, the signal recognised as need for a change construct within the existing model has been modified to ensure that the direct link between structured periodic analysis and the capability that analysis generates to identify problem areas and key signals of a need for change is recognised.

After the periodic analysis process HAs tend to have two potential streams of action resulting from the identified need for change. These two streams are in the form of procedural changes (codification - the primary approach to reducing defects: stages 2 and 3), or knowledge sharing (personalisation - the secondary approach: stage 5 and 6).

2. Searching for new product and process changes with experimentation where necessary

HAs utilised a codification approach as their primary learning approach through their harmonised logic of reducing defects by focussing on product and system focused improvements. The finding that HAs have a primary focus of a codification approach supports Knauseder *et al.*'s (2007) argument that housing organisations mainly apply one learning approach. HAs typically rely on sourcing knowledge from internal staff when searching for new adaptation options, via invitation. This process of openly inviting proposals for adaptation options from internal staff is similar to Berkhout *et al.* (2006) who found that the knowledge and know-how to solve problems was held by the specialised communities at work in organisations. The process of openly inviting proposals, however, is the opposite of Lee and Egbu's (2007) argument that people working in construction are reluctant to talk with their own managers or someone from their own company because they are not empowered to try new ideas and learn due to the rigid management processes.

There was also an indication that HAs are reluctant to invite contributions from people outside the organisation. More importantly only one HA (out of 12) seeks feedback from customers (home occupants). This lack of seeking home occupant feedback is surprising given that the HAs (if they are receiving government grants) are required to demonstrate that they have made changes to improve home occupant satisfaction, and one way of achieving this would likely be to ask the home occupants how their property could be improved (see Section 2.3).

Prior to proposing solutions to problems to be selected and introduced through broad organisational changes (see stage 3) there was little evidence of experimentation of changes on a small scale (it was only evident in one HA). This lack of experimentation aligns with Berkhout *et al.*'s (2006) suggestion that there is very little evidence of experimentation with organisations tending to draw upon the trusted options already open to them.

To acknowledge the limited evidence of experimentation of changes on a small scale within HAs; and, the HA's primary focus on designing out defects through product and system adaptations the OL model has been adjusted.

3. Internal selection, articulation and codification

Stage 3 follows on from stage 2 and continues the HAs' codification approach to learning via broad organisational changes to integrate product and system modifications. Because of the codification focus, there is no change to the existing model of the process of exposing potential adaption options to an evaluation process in order to select the option most suitable to the organisation. Product and system modification were evident in the majority of the HAs who consistently codified and introduced changes into new organisational routines through updates to their 'employers' requirements' (ERs) (the specification to be used on all builds in HAs).

The product and system improvement focus further manifests itself with five HAs updating their 'design guides'. In addition, the HAs primary focus of reducing defects via the introduction of broad product and system changes (with limited experimentation on a small scale) further emphasises that learning in house building is characterised by its focus on, and introduction of new policies, processes and routines (e.g. Berkhout *et al*., 2006; Knauseder *et al.*, 2007).

One interesting observation in relation to HAs having a primary approach of designing out defects is that existing research has found that defects typically occur due to either design errors or issues of workmanship on site (e.g. Love and Edwards, 2004; Andi and Minato, 2004; Josephson and Hammarlund, 1999; Love and Li, 2000). In respect of cost, design defects were only found to relate to 12.1% of the tender value (Abdul-Rahman, 1995). There may be four explanations for the difference to the prevailing literature: a) the literature review is drawn from the international perspective; the UK perspective may be different; b) HAs are funded by the UK Government and the government looks to fund good quality housing in "well-designed" schemes, meaning that HAs may have a placed more emphasis on design than workmanship in order to receive funding; c) HAs are following the prescriptive guidance of industry bodies such as the NHBC Foundation (2011) who suggest improving the design of a home based upon what has been learnt; or, d) HAs are predisposed to designing out issues in general, for example designing out crime by making their homes 'secured by design' (ACPO, 2014).

In order for changes to be codified into organisational routines the HAs typically advocate the use of review panels to impartially assess a change's suitability and concordance with existing organisational objectives and strategies. Where no review panel was in place, reliance fell upon one individual or department for selecting changes. In some cases, a particular department or individual could block a change when it did not serve their own interests. The use of impartial review panels in HAs contradicts the perception of workers within HAs that they are unlikely to have an influence on decisions within their organisations because managers are less encouraging and open to ideas for change from the workforce as presented in Knauseder *et al.* (2007). One reason for the use of impartial review panels may be that it forms part of the HA's consensus building strategy to secure employees' and managers' commitment to ensure that the change is successful (Cornelissen, 2008).

4. Feedback and periodic data analysis as concurrent processes

HAs use data analysis as a feedback mechanism to determine whether an implemented change has been successful in the long-term. Without this continuous review of data, HAs would be limited to unstructured feedback and signals received through anecdotal channels alone (as with HA05 in the diagnosis phase – see Section 4.2.2, and HA02 in the action evaluation phase – see Section 4.5.2). The existing model has been updated to acknowledge the concurrent processes of 'feedback' and 'continuous review of performance/data analysis' to both determine the success of a change and identify new improvement opportunities.

5. Networking to share experience and knowledge of latest defects identified

The existing model has been modified to accommodate the recognised process of sharing knowledge and experience in order to improve the tacit knowledge base of the workforce through the addition of a construct of 'networking'. Networking is a personalisation approach to learning which was used by some HAs and followed on from stage 1. Networking can be defined as "an informal task which does not result in a 'routine' change, with HAs continuing to work within standard procedures and guidelines, but results in the modification of an individual's working practices in light of new knowledge". Networking is typically aimed at raising key individuals' knowledge of specific defects and challenges. Some support for the importance of networking is Hong (1999) who argues that if individual insights gained from the learning process are not be made known to others in the group, the chances of having another learning opportunity are lessened.

6. Modification of individual behaviour due to new knowledge and insight

In order for networking to be successful the individual needs to modify their working practice based upon the understanding gained from stage 5, therefore the model has been modified to acknowledge this. Typically the individual would use the knowledge to: a) make decisions on future awarding of contracts and selection of trades; and, b) tailor their on site inspections to pick up known issues. Where HAs use 'networking' (a personalisation approach) to share knowledge person-to-person (or people-to-people) it is as a secondary approach to learning. After stage 6 the HA will seek feedback (see stage 4 discussed above)

This use of a personalisation (secondary) approach (stages 5 and 6) supports Hansen *et al.*'s (1999) recommendation that organisations should adopt one primary learning approach (in the case of the HAs a codification approach) and then use another approach in a supporting role (in the case of the HAs a personalisation approach). The use of networking is in contrast to Lee and Egbu's (2007) view that generally sharing experience and knowledge is not taken seriously. One explanation for the use of networking maybe that it evolved as a reaction to the UK house building industry's reliance on sub-contractors, whereby the HA (and house builder) have little control over the trades levels of skill and knowledge, and little incentive to train the trades (see Section 2.2). The use of networking suggests that the house building industry is not as process oriented as perceived (e.g. Egan, 1998).

General findings

When considering the findings together there are three central ideas that evolved from objective 2:

- Effective OL has the potential to reduce defects in new homes,
- The importance of capturing defect data and the value of analysing defect data periodically,
- The significance of using a primary (codification) learning approach to design out defects (see the inner circle of Figure 5.1), with a secondary (personalisation) approach of networking to reduce defects (see the external circle of Figure 5.1).

➢ *OL to reduce defects*

It was found that effective OL is capable of reducing defects in new homes. Therefore OL should be an ongoing priority for any HA or house builder that wishes to reduce defects. The main reasons HAs learn from defects are to either identify improvement opportunities, reduce defects, improve customer satisfaction; or, reduce long-term repair costs. One reason for the explicit focus on improving customer satisfaction and reducing repair costs by some HAs may be due to the HA's funding situation. Grant funded HAs (including all of the 12 HAs in this research) are required to demonstrate ‘value for money’ in order to receive government funding for future developments, including demonstrating high levels of customer satisfaction, and reduced cost expenditure (see Section 2.3.2).

- *Importance of defect data capture and analysis*

The key findings stress the pivotal role of capturing defect data and analysing defect data periodically within HAs. HAs record significant volumes of post-completion defect related data (from home occupants) through a defects management team to record signals entering the organisation. HAs would generally analyse that data periodically to identify improvement areas and therefore evidence the need for change.

Indeed, the defect data analysis is the catalyst for change and provides the basis for the subsequent stages of the learning process. The importance of data analysis was further exhibited in relation to one of the HAs (HA05) whose learning process simply stopped at recording defects data.

It appears that when HAs simply record defect data but do not continue the learning process they resort to a very basic form of ‘single loop learning’ (Argyris, 1977) whereby they detect the error (i.e. the defect occurs and is reported: the new signal comes in) and then they correct the error (i.e. they repair the defect and return the home to the condition that it was in before the defect occurred). What does not appear to happen is the HA seeking to avoid similar defects recurring in future homes by questioning the underlying organisational policies and objectives, i.e. double loop learning (Argyris, 1977).

- *The need for a dual approach*

The need of a dual learning approach is emphasised: codification and personalisation. The HAs were found to have a primary learning approach of ‘designing out defects’ through product and system adaptations (codification). The primary approach of designing out defects has been shown to be effective in reducing defects where the issue relates to products, for example, HA12’s shower tray failures; and, HA02’s cracking in timber frame properties over three storeys in height (see Section 4.2.2 for further details). However, this codification approach alone is not suitable to reducing all defects, for instance, where a home is procured through a Section 106 agreement where HAs have limited input into the design of the home or where a defect is solely as a result of poor workmanship on site. There were also indications that where HAs used a codification approach alone they were susceptible to failing in their learning efforts, for example, HA12's failure to design out their roof mortar issues by moving to dry systems.

In order to overcome the limitations of designing out defects alone and tackle the issues of site workmanship a number of HAs have developed networking which is a 'personalisation' approach and is typically used as a secondary approach. Networking was demonstrated to be beneficial in raising site teams awareness of problem areas of construction so that they can tailor their inspections based upon past experience and identify and resolve defects on site before they make it through to completion (e.g. HA02). Should HA12 have utilised networking as a support to its primary approach it could have tailored their site inspections to incorporate a roof mortar inspection to ensure the mortar was the correct mix and being applied correctly.

As both designing out defects and networking have been shown to be effective in reducing defects, this suggests the need for a dual approach to learning to enable the most appropriate learning approach to be utilised to reduce the particular defects (and causes) identified.

The findings from objectives 1 and 2 were drawn upon for the action interventions (objective 3) discussed below.

5.2.3 Objective 3: Action interventions

The action planning, action taking, action evaluation and specifying learning phases of the AR cycle designed and implemented action interventions in one HA (HA02). The action interventions contributed to objective 3 *"Design and test AR interventions to develop new defects assessment tools and learning systems to reduce targeted defects".*

The key findings demonstrate that the modified OL model is useful and valid in that it enables HAs to identify improvement opportunities via data analysis, design out defects where feasible; and, use networking to resolve defects in situations where they cannot be designed out. Namely, the key findings reinforced two key messages from objective 2:

- the importance of data analysis; and,
- the need for networking (a personalisation approach) to tackle site workmanship issues.

In addition to reinforcing objective 2, the key findings extend our understanding of advancing action interventions through action research and learning from defects, specifically highlighting three new important aspects:

- the key role of senior management as innovation champions;
- the need for HAs to adapt to survive in their current business environment; and,
- OL being a secondary function in HAs.

It is worth bearing in mind that these three new aspects came from the study of one HA and can only be applied to that case with complete confidence and may not be applicable to the wider body of HAs. However, the study and discussion of a single HA is common in interpretative research such as AR. These five aspects are discussed below.

The importance of data analysis for learning

The pivotal role structured analysis of defect data plays in identifying the need for change in HA learning is consistent with the key findings from objective 2. The changes to HA02's data capture and analysis (the categorisation of defects to provide a simple up-to-date view of the HA's defect performance) was demonstrated to have helped the HA to improve their learning by identifying new improvement opportunities. When HA02 stopped analysing defect data their ability to identify improvement opportunities was limited and based on speculation. HA02's OL appeared to resort to single loop learning – similarly to HA05 as discussed in section 4.6.1.

The finding that when HA02 categorise defects their identification of improvement opportunities increase confirms the belief within the construction defect literature and international new housing defect literature that the classification of defects (based upon the area in the building they occur) reduces instances of poorly structured data (e.g. Straub, 2009; Che-Ani *et al.*, 2011) and can aid HAs in their analysis (e.g. Georgiou, 2010; Macarulla *et al.*, 2013). The categorisation finding is consistent with Taggart *et al.* (2013) who assert that unstructured and informal recording of defects makes it difficult to avoid defects (in future homes). This finding links directly to stage 1 of the new OL from defects model (Figure 5.1) in that rigourous structured data analysis can help HAs to identify opportunities to reduce defects.

The importance of a personalisation approach to tackle workmanship issues

The importance of using a personalisation approach to learning to respond to workmanship defects is consistent with the key findings from objective 2. In respect of HA02's personalisation approach to learning, evidence of the benefit came in relation to the occurrence of widespread roof ventilation defects on one private developer's house type where HA02 were receiving these homes through a Section 106 agreement. As HA02 had limited input into the design of the homes, in response to the widespread issue the Head Clerk of Works fed the information back to his clerk of works team to informally adapt their inspection procedures for this particular house type from the individual developer as well as feeding back the problem to the developer. This further outlines that a personalisation approach to learning may be a more relevant learning approach for homes obtained through Section 106 agreements. This example also suggests that the two approaches to learning could be used simultaneously to aid the HAs in their learning efforts in that networking (and the resultant change in action) could help HAs to reduce the occurrence of defects on properties during construction whilst the design changes are being implemented.

In addition, the personalisation approach to learning may have further benefit for the wider house building industry to overcome the issues of skills shortage and the reliance on and lack of control over sub-contractors as identified in Section 2.2. For example, house builders could identify the particular types of defects cause by the specific sub-contractors, which will allow the Site Manager to tailor his or her inspections and discussions with the trades to stop the defects occurring during construction (similarly to HA02).

The key role as senior management as innovation champions

The key role of senior management within organisations acting as an innovation champion (Sergeeva, 2016) is identified in respect of advancing interventions. Two HAs (HA02 and HA05) were initially interested in progressing interventions. Intervention in HA05 however did not take place despite HA05 being identified during the diagnosis phase as the HA who could have benefitted most from an intervention. The two differences between the two HAs are: a) the level of seniority of the key contact within the respective organisations, and b) the mind-set of the contact in introducing change in their organisation.

a) The level of seniority of the contact: HA05's contact was the Customer Care Manager who is simply responsible for managing the repair process. HA02's contact was a senior manager who had a keen desire to improve how the HA managed and learnt from defects in order to continue building new homes under pressures of rental revenue reductions and the future requirement to reduce their rental revenue. The importance of leadership finding supports Knauseder *et al.*'s (2007) argument that lack of leadership in the house building sector can be a barrier to OL.

b) The mind-set of the contact: HA05's contact, the Customer Care Manager does not look to identify what is wrong in their properties nor advance any action within the HA to bring about change. In contrast, HA02's Asset Manager was a key figure in HA02's learning and frequently advanced interventions in a bid to improve performance. This previous involvement in change suggests that the Asset Manager was generally more open to change, which endorses Elving's (2005) argument that a predictor of change is readiness for change, such as a low level of resistance and support for change.

The need for housing associations to adapt to survive in their current business environment

The significance of introducing change and maximising profits to build homes in the face of financial pressure is highlighted. The finding that HA02's improvement was aimed at reducing their long-term expenditure supports HouseMark's (2013) argument that HA's need to maximise surplus revenue from service charges by reducing expenditure on responsive repairs (repairing defects). This finding further supports Chevin's (2013) suggestion that HAs are reviewing their processes to maximise profit in order to build with reduced funding from the government. In addition, the finding that HA02 wanted to introduce a satisfaction survey for repairs, introduce new categories to record repair priority (based upon the potential danger the defect poses to the home occupant), and calculate repair durations to improve customer (home occupant) satisfaction (after seeing the findings reported in objective 1) outlined the HA's desire to satisfy customers (home occupants). This desire to satisfy customers may stem from the HA's desire to receive government grants (see Section 2.3).

Organisational learning as a secondary function for housing associations

The significance of OL being a secondary function for HAs is identified. During the action taking phase a fifth intervention was introduced (Action intervention 5: AI5) "the development of a live data dashboard in the HA's excel environment". AI5 emerged because 'workload pressures' made data analysis in the HA's spreadsheet environment too difficult and time consuming and the HA had not analysed defect data as often as they would have liked. The reason for this reduced analysis was that the defects management team's main priority is to manage the repair process. Therefore, the HA needed quick data analysis to continue their learning in a stretched working environment. The finding that OL is affected when workload pressures increase suggests that OL is a secondary function in HAs and that 'day-to-day activities' take priority. This finding may explain why OL in the more project-based environment of the wider construction sector is more difficult to implement (e.g. Winch, 1998) because when the project is completed workers move on to new projects (i.e. a new job, new day-to-day activities, a new priority). The secondary nature of OL in HAs supports the argument of Barlow and Jashapara (1998) where they explain that that those involved in construction projects are not afforded sufficient opportunity to feed experience they have gained from previous projects into future ones.

5.3 Contribution to organisational learning theory

This section discusses the theoretical contributions of this research. A number of the empirical contributions of this research provide associated theoretical contributions for OL. The main theoretical contributions are adapting OL to a new empirical setting of learning from defects in a HA environment; and, modifying an existing OL model to develop a specific process for HAs to learn from defects.

5.3.1 Adapting organisational learning to a new empirical setting of learning from defects in housing associations

Learning from defects at an organisational level is a frequent recommendation to reduce defects within the literature (e.g. Auchterlounie, 2009; Baiche, *et al.*, 2006). OL has previously been used to explore learning in the construction sector (e.g. Barlow and Jashapara, 1998; Scott and Harris, 1998) and more importantly how housing organisations (i.e. house builders or HAs) generally learn (e.g. Knauseder *et al.*, 2007; Berkhout *et al.*, 2006). However, despite this consistent recommendation to learn from defects, OL does not appear to have been used to explore how house builders or HAs in the UK learn from defects. This research adapted OL to a new empirical setting of learning from defects in a HA environment (see Sections 4.2.2, 4.3, 4.4 and 4.5 for further details).

5.3.2 Modifying an organisational learning model for learning from defects

In using OL in the new empirical setting the research found a number of contributions that both supported and contested the existing body of knowledge on OL (see Section 5.2.2 for further details). Based upon the findings from this research the author was able to modify the existing OL model to develop a situation specific OL process for HAs to learn from defects. This OL from defects model maintained the general premise of the adopted OL model from Berkhout *et al.* (2006) however some modifications to the existing model were necessary. Figure 5.2 shows the original model and the modified OL model to demonstrate the changes.

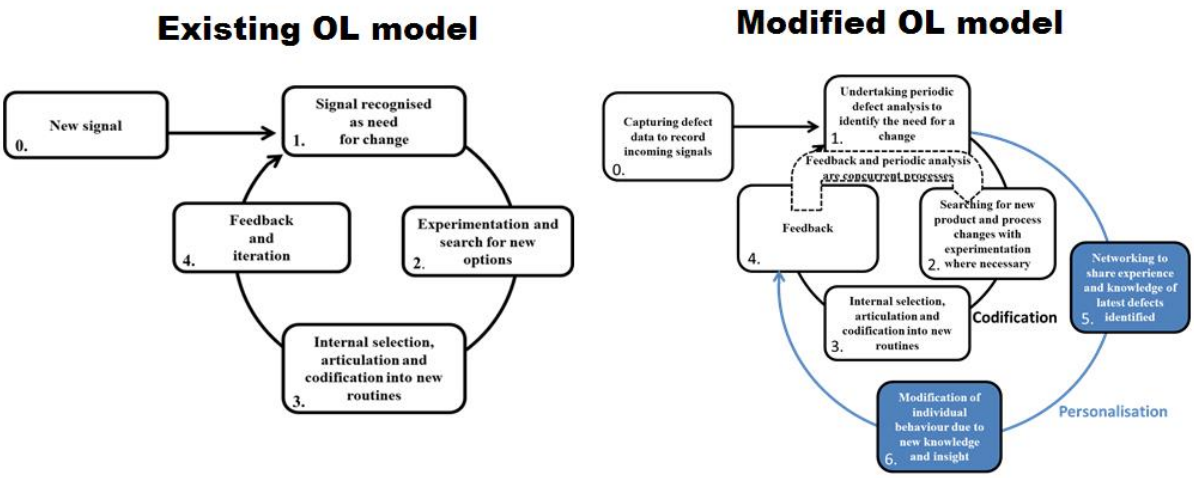

Figure 5.2: Existing OL model and modified OL model

The main modification to the model was to recognise that OL from defects contained a combination of learning approaches as proffered in the general management literature (e.g. Hansen *et al.*, 1999).

0. Capturing defect data to record incoming signal: The learning process for a HA starts with defect data recording; because of this the incoming signals concept within the existing model has been adapted to explicitly outline the need to capture defect data, thus promoting the recording of all new signals (defects) entering the organisation. This change is important as it is different to Berkhout *et al.* (2006) whereby HAs are actively recording all new signals in relation to the aspect they are seeking to learn from.

1. Undertaking periodic analysis to identify the need for a change: Following on from incoming signals, defect data analysis is found to be the primary enabler to recognising a need for a change to organisational routines and the catalyst to that subsequent change taking place within HAs. The signal recognised as need for a change construct within the model has been modified to ensure that the direct link between structured periodic analysis and the capability that analysis generates to identify problem areas and key signals of a need for change is recognised. This change is important as it is different to Berkhout *et al.* (2006) in that all of the HAs are actively seeking this evidence through data analysis (rather than relying on an ad-hoc event, for example extreme flooding of a housing site).

2. Searching for new product and process changes with experimentation where necessary: Since broad changes throughout the organisation via updates to ERs is the advocated approach to learning from defects within the HA environment, the model has been updated to acknowledge this. The model has also been further updated to recognise that there was very little evidence of experimentation of changes on a small scale within HAs.

3. Internal selection, articulation and codification into new routines: This construct remains the same as Berkhout *et al.* (2006). The HAs had a review panel (senior individuals from across the organisation) who selected changes. The HAs codified changes into organisational routine by updating their employers' requirements (ERs); and, articulated changes around the organisation (and outside) through the updated ERs, and various communication channels (email, staff intranet etc.). It is worth noting that this research found evidence of codifying and articulating change, where Berkhout *et al.* (2006) found very little evidence of codification or articulation of changes.

4. Feedback and periodic analysis as concurrent processes: The model has been updated to acknowledge the concurrent processes of 'feedback' and 'continuous review of performance/data analysis' to both determine the success of a change and identify new improvement opportunities. This update is important because Berkhout *et al.* (2006) found little evidence of positive feedback, which could have been due to the ambiguity in where this feedback could come from or the phenomenon observed. Where the OL from defects model differs is that OL from defects is measureable in that it is effective when it reduces defects (or the cost, disruption or danger that occurs as a result).

5. Networking to share experience and knowledge of latest defects identified: This change is especially important as it highlights the need to add a new additional construct to Berkhout *et al.*'s (2006) model to recognise that some HAs use a codification approach to learning as their primary approach and a personalisation approach to learning as a secondary approach to resolve issues that cannot be resolved via the primary approach.

6. Modification of individual behaviour due to new knowledge and insight: This change is especially important as it highlights the need to add a new additional construct to Berkhout *et al.*'s (2006) model to acknowledge the personalisation approach to learning and the emphasis on the individual to change their behaviour.

Table 5.2 below further outlines the theoretical contributions, positioned around the OL constructs of the modified OL model.

Table 5.2: Empirical evidence and contribution to OL

OL constructs	Empirical evidence	Associated contribution to OL
• Capturing defect data to record incoming signal (formerly new signal) • Undertaking periodic analysis to identify the need for a change (formerly signal recognised as need for change)	• HAs consistently capture, record and analyse defect related data to recognise signals which indicate a need for a change to current practice. • Changes to HA02's data analysis procedures helped them to enhance their learning.	• Corroborates Berkhout *et al.*'s (2006) assertion that novel situations are usually identified through continuous monitoring of signals. • Extends this monitoring of signals concept to suggest that OL may be enhanced where these signals are rigorously monitored and understood through the adoption of some form of statistical monitoring.
• Feedback and periodic analysis as concurrent processes (formerly feedback)	• Structured approach to defect data capture and analysis as feedback mechanisms by HAs. • HA02 stopped analysing their data their ability to identify improvement opportunities was reduced.	• Is in contrast to Barlow and Jashapara's (1998) and Scott and Harris's (1998) suggestions that feedback systems in place within the construction industry are unstructured and informal, and as a result ineffective. • Supports Barlow and Jashapara's (1998) and Scott and Harris's (1998) suggestions that unstructured and informal feedback systems are often ineffective. • Suggests that where HAs do not analyse defect data they resort to single loop learning

Table 5.2 continued…

OL constructs	Empirical evidence	Associated theoretical contribution
• Undertaking periodic analysis to identify the need for a change (formerly signal recognised as need for change)	• OL is affected when workload pressures increase for the centralised team responsible for defects management and the link between project level and organisational-level activities.	• OL is a secondary function for HAs and the 'day-to-day activities' take priority. Offers an explanation of why OL in the more project-based environment of the wider construction sector is difficult to implement (e.g. Winch, 1998) and supports the argument of Barlow and Jashapara (1998) that that those involved in construction projects are not afforded sufficient opportunity to feed experience they have gained from previous projects into future ones.
• Searching for new product and process changes with experimentation where necessary (formerly experimentation and search for new options)	• HAs primarily look to reduce defects via the introduction of broad product and system changes with limited experimentation on a small scale.	• Further emphasises that learning in house building is characterised by its focus on new policies, processes and routines (Berkhout *et al.*, 2006; Knauseder *et al.*, 2007). • Supports Knauseder *et al.*'s (2007) argument that housing organisations mainly apply one learning approach.
• Searching for new product and process changes with experimentation where necessary (formerly experimentation and search for new options)	• HAs openly invite proposals for adaptation options from internal staff. • When key senior individuals from HA02 were no longer involved in their quest to improve their learning their learning stopped.	• Contradicts the perception of workers within HAs that they are unlikely to have an influence on decisions within their organisations because managers are less encouraging and open to ideas for change from the workforce as presented in Knauseder *et al.* (2007). • Supports Knauseder *et al.*'s (2007) argument that leadership in house building can be a barrier to OL.
• Networking (new construct) • Modification of individual behaviour (new construct)	• Some HAs use a codification approach to learning as their primary approach and a personalisation approach to learning as a secondary approach to resolve issues that cannot be resolved via the primary approach.	• Supports Hansen *et al.*'s (1999) argument that organisations should adopt one primary learning approach and then use another approach in a supporting role.

5.4 Contribution to methodology

This research has made one unique contribution to methodology and also supports a number of the existing arguments in relation to action research (AR) and soft systems methodology (SSM).

The unique contribution to methodology from this research was to incorporate the principles of SSM into an AR approach. The principles of SSM, more specifically, formulating relevant purposeful activity models and debating the situation were incorporated into the action planning phase of the AR cycle in order to explore an ill-structured problem to identify desirable and feasible changes (see Section 4.3 for further details). This contribution supports a number of existing arguments in relation to SSM. For example, the adoption of SSM to explore an ill-structured problem supports Checkland's (2000) suggestion that SSM is suitable for problematical situations. For instance, the adoption of SSM principles after previously finding out about a problematical situation and adapting SSM to suit that specific situation both collaborates Winter's (2006) argument that the SSM principles can be converted into a situation-specific approach; and, supports Maqsood *et al.*'s (2005) argument that when practically applying SSM, the different stages/activities can be undertaken in any order, and with considerable iteration.

The utilisation of an AR approach also supports a number of existing arguments and findings in relation to AR and provides one interesting observation. For example, the finding that planned actions were implemented during the action taking phase supports Robson's (2002) suggestion that AR can promote organisational change. For instance, the finding that unplanned actions were developed and implemented by the HA independently of the researcher corroborates Susman and Evered's (1978) argument that AR facilitates the development of techniques to provide know-how to create settings for organisational learning (see Section 4.4 for further details). Finally, the finding from the action evaluation phase that all the changes had been abandoned also suggests that failure in an AR project could be seen in two ways and the research taken in two directions: a) that the AR had failed and the research finished, or b) that a new problem was there to be diagnosed and that AR was continuing on to the diagnosis phase.

5.5 Contributions to practice

This section discusses the contributions this research has made to practice. This research makes the following contributions to practice: an OL from defects model, feedback to HAs; and, informing an NHBC's standards raising initiative called defects hub. These are discussed in detail below.

OL from defects model

OL has been shown to be able to reduce defects and should be an ongoing priority for house builder and HAs. However HAs appear to be restricting themselves to a short-term solution of designing out defects without fully acknowledging the issue of workmanship on site. In addition, there is a need for house builders and HAs to address the negative perception home occupants have of them as indicated by the questionnaire, i.e. house builders are not customer focussed or interested in providing home occupants new homes they can be satisfied with. Therefore, the main contribution of this research for industry is the development of an OL from defects model for house builders and housing associations who construct new homes and/or those HAs who procure new homes through a Section 106 agreement to address the above issues. How this model should be used in practice and its associated potential benefits are outlined below. The information contained in Table 5.3 was similar to the feedback generally provided to the HAs used in this study. The model draws upon the findings from objectives 1-3.

Table 5.3: How HAs can use the OL model to reduce defects

Construct	What could be done	Actors involved	Potential benefits
0. Capturing defect data to record incoming signals	Capture: • All of the property information (property type, construction, location, completion date etc.) • Warranty policy numbers • Builders/contractors responsible • Categories of defects (by building area or trade) • Repair priority • Repair costs • The target date for work to be completed • The status of the work • Photographs of the defect and repair • A description of the damage exhibited. • A free text option for a manual text input to describe the defect in more detail or to input any additional comments • Details of the clerk of works or Employers agent on the scheme • Whether a complaint has been made	• Defects management team or similar	• The more detailed data captured the clearer the understanding could be. • Categorising defects and damage may provide the potential for faster reviews, and recording scheme and contractor information may allow for simpler monitoring.

Table 5.3 continued…

Construct	What could be done	Actors involved	Potential benefits
1. Undertaking periodic defects analysis to identify the need for change	Analyse: • The frequency of defects overall and by category • The cost of defects overall and by category • The number and type of defects that cause complaints • The number and type of defects that are deemed a H&S concern • The volume and type of defects per unit by developer, trade, region • The time taken to resolve defects • The volume and type of defects by completion date Identify: • Defects that pose a H&S concern • Defects that cost large sums to resolve • Defects that cause disruption and complaints • Problem developers or regions • High volume defects Whether newer properties are performing better	• Defects management team or similar • Quality team or similar • Design team or similar	• May develop a clear picture of performance • Could understand the cost, types, number and H&S implications of defects • Might gauge developer performance • Understand any regional variations in defects • Could potentially understand if newer properties are performing better • May provide HAs with the information to make informed decisions.
2. Searching for new product and process changes with experimentation where necessary	• Discuss problems and explore solutions through discussions with their finance, aftercare and development teams • Discuss problems and explore solutions through discussions with manufacturers and contractors installing systems • Explore sites that are performing better in the given problem area to determine whether there are any practices that can be adopted Where a clear solution is unavailable HAs could pilot changes on a small scale to monitor their effectiveness	• Defects management team or similar • Quality team or similar • Design team or similar • Development team or similar • Finance department or similar • Contractors • Manufacturers • Procurement department or similar	• Evidence based discussions may promote internal and external communication and inclusion. • Feedback to and from contractors and manufacturers. • The ability to test proposed changes on a small scale could determine large scale viability.
3. Internal selection, articulation and codification into new routines	Once a suitable solution has been identified: • In cases where formal changes are required develop a change process where a proposed change can be put forward and reviewed by an authorising panel, using the analysis to back-up proposals and needs for change Upon selection of a change: • The changes could be recorded within the ERs, specification documents and design guides • A summary of the approved changes could be circulated to key stakeholders via email and put on a staff intranet • Meetings with contractors and manufacturers could be arranged to discuss any changes in detail • Provide training sessions for internal staff affected to update their knowledge	• Development team or similar • Design team or similar • Review panel • Procurement department or similar • Contractors • Manufacturers • Site based staff	• A formal change process might provide a consistent structure for employees to report problems identified and suggest potential solutions, for the organisation to judge and adopt if suitable. • The key stakeholders may better understand the new changes implemented and the logic behind them.

Table 5.3 continued…

Construct	What could be done	Actors involved	Potential benefits
4. Feedback	• Initially HAs could use anecdotal feedback to confirm the feelings around the change • Undertake continuous performance monitoring (based upon year built Have a panel that meets and discusses the lessons learnt and review the success of the changes.	• Defects management team or similar • Review panel	• The potential ability to gauge the initial feelings surrounding the change, and then confirm the viability through structured review.
5 and 6. Networking to share experience and knowledge of latest defects identified; and, change in individual behaviour	• In addition to the primary approach to learning HAs should undertake stages 5 and 6 (after stage 1) where defects cannot be designed out. • Discuss problems with site teams to make them aware of construction issues • Contractor performance with relevant personnel to guide future awarding of contracts **Note:** networking needs to change individual behaviour in light of new knowledge	• Defects management team or similar • Site based staff • Quality team or similar • Procurement department or similar	• HAs may be able to consider which contractors to use based on performance • HAs could provide site teams with knowledge of 'problem' areas to watch • Site teams might be able to tailor their inspections

0. Capturing defect data to record incoming signals: The OL from defects model outlined in Table 5.3 is a process that starts with HAs *"capturing defect data to record incoming signals"*. This data is typically received externally of the HA from home occupants. The HAs may wish to have a defects management team (the team responsible for the aftercare service and managing defects and repairs post-completion) who records all of these contacts.

The defects management team could capture detailed and accurate information including: property details, the builder responsible for the build, the defect category, the repair priority, the cost of the repair, the damage exhibited, whether a complaint has been made on the case; and, the status of the work. The main benefit of capturing defect data is that it can potentially build up a profile and clear understanding of what is currently going wrong in the HA's new homes as well as any trends by developer etc. Categorising defects and damage might make data quicker to analyse.

1. Undertaking periodic defects analysis to identify the need for change: The second stage of the OL from defects process generally remains in the defects management team (or a similar team). The defects management team may wish to undertake periodic analysis of the data they have captured. HAs may also want to develop strategies to enable them to undertake ‘live data analysis’ as this could reduce the defects management team’s workload and reduce any potential of their learning reducing in time of high workload.

The defects management teams could analyse the defect data to identify the most costly, frequent, disruptive and dangerous defects for targeted defect reduction. The analysis could be undertaken on a unit basis and also in relation to developers and regions. The HA may then want to provide the data to their innovation champion(s) (design manager, quality manager or whoever in the HA is responsible for taking actions forward to drive change). The data analysis could enable the HA to identify areas of improvement and help them make informed decisions about future action; and, guide the HA’s innovation champion(s).

After identifying improvement areas there are two potential routes the HA can take, the codification route (no. 2) or the personalisation route (no. 5). These routes can either be taken separately or undertaken as concurrent activities. The codification route is discussed first.

2. Searching for new product and process changes with experimentation where necessary: The HA’s primary approach to reducing defects could be to design them out. The HA’s innovation champion(s) may want to review schemes that are performing well, undertake exploratory discussions and invite proposals from internal staff such as the quality team, design team, defects management team, procurement department and finance departments; and, external manufacturers and contractors to look for the best solution to stop past problems from making their way into future homes. Where there is no clear solution the innovation champion(s) could trial a range of solutions on a small scale to determine their suitability.

The main benefits of this part of the process are likely to be the evidence based discussions that include internal and external sources to gain a detailed understanding of the issues and solutions; and, the potential ability to test proposed changes on a small scale to determine large scale viability.

3. Internal selection, articulation and codification into new routines: Continuing on the codification route to learning, the innovation champion(s) may wish to expose the potential solutions (or best solution) to a review panel consisting of senior individuals from the HA (typically directors or department heads from all of the relevant departments) through the HAs formal change process.

The review panel could then impartially review the proposed solution to determine its viability when considered against the HA's strategy. If the proposed solution is accepted then it could be codified into the HA's routines through updates to their ERs, specifications, and design guides. The changes may then be cascaded through the HA to the teams and individuals affected by the change via email/updates on a staff intranet and training where necessary.

The main possible benefit of a formal change process is that it may provide a consistent structure for employees to report problems identified and suggest potential solutions. The main potential benefits of a review panel are the impartiality, seniority, and strategic knowledge of the HA. Finally, the cascading of information could be beneficial as the key stakeholders will likely better understand the new changes implemented and the logic behind them.

4. Feedback: Following on from stages 3 and/or 6 (depending on the 'codification' or 'personalisation' approach taken) it could be beneficial for the HA's defects management team to continue to record and analyse data (stages 0 and 1) to better understand whether the change has reduced the targeted defects. The HA may also want to use anecdotal feedback to identify any early significant issues; and, have a change review panel to review implemented changes a year or two after they have been implemented. The main benefits of this type of feedback are likely to be that its evidence based (in the long-term) and it could identify any pressing short-term concerns.

5 and 6. Networking to share experience and knowledge of latest defects identified; and, the modification of individual behaviour to reflect new knowledge and insight: The HA's secondary approach to reducing defects could be networking. Networking could involve the HA's innovation champion(s) discussing problems with site teams to make them aware of construction issues; and discussing contractor performance with relevant personnel to guide future awarding of contracts. The main benefits of networking is that it might enable the HA to consider which contractors to use based upon their previous performance; and it may provide the HA's site teams with knowledge of problem areas and areas to undertake detailed inspections on during construction.

As briefly outlined earlier, it is worth noting that the codification approach (steps 2 and 3) and personalisation approach (steps 5 and 6) can be undertaken at the same time. For example, to tailor site inspections after identifying a design defect until the changes have been made to the HA's ERs and implemented successfully.

Feedback to HAs

This research project has employed an AR approach and the action researcher worked with one HA to implement the learning process outlined in table 5.3. The initial results showed that the learning process had helped to improve the way they learnt from defects, which suggests that the learning from defects model has the potential to achieve successful learning. In addition to the direct intervention in HA02 the research findings and OL model were provided to the 11 remaining case study HAs to inform their learning. A number of HAs are currently reviewing how they learn from and reduce defects, and the research findings and model have been shown to help the HAs with this, for example, HA08 expressed their excitement at receiving the research findings and HA06 have reported that the research findings would help them to shape their procedural changes.

NHBC's defects hub

Due to the nature of the new home warranty whereby the first two years of the warranty are the builder's liability period (see Section 2.6) NHBC captures reduced volumes of data on defects during this period. Due to the reduced data volumes during the first two years post-completion NHBC have developed a strategic initiative called the "defects hub" which is aimed at increasing NHBC's knowledge of the number and types of defects occurring during the first two years post-completion. Over the course of this research project defect data was collected from the HAs. The defect data collected from the HAs consists of over 20,000 records. The defect data collected from the HAs has contributed to NHBC's defects hub and has fed into a number of standards raising activities, for example a campaign on how to limit internal services defects in new homes. In addition to the defect data captured as part of this research there is an ongoing relationship with two HAs to provide further data periodically for the defects hub.

5.6 Implications for policy

The implications for policy are twofold. First, defects are a problem in new homes, they pose H&S concerns and cause disruption to home occupants; therefore the main implication for policy is how drive the reduction of defects in new homes. Second, in addressing implication one the second implication for policy is how to encourage the ongoing learning from and reduction of defects within the house building sector. As the UK house building industry increases volume to contribute to reducing the housing shortage and achieving government production targets, there is potential for quality to suffer (evident in the increase in defects over the previous few years of recovery since 2008). The UK Government could tackle the problem of increasing defects, and the UK house building industry may benefit from a sector-wide change initiative to encourage the implementation of OL systems. The UK Government may wish to make HAs have to demonstrate OL systems in order to receive government grants as part of their funding criteria.

5.7 Limitations of research findings and areas for further research

There are a number of limitations with this research and its findings as well as areas for further research: these are discussed in Table 5.4 below.

Table 5.4: Limitations and areas for further research

Limitation	Areas for further research
Focussed on how UK HAs learnt from defects.	How UK house builders learn from defects.
Explored how HAs learnt from past defects (post-completion).	Explore how defects that are experienced during construction are translated from problems to OL.
For pragmatic reasons, limited time was spent with the HAs during the research, and the main participants (for interviews etc.) were self-selected by senior managers at the HAs.	Spend more time in a range of HAs and explore a number of functional departments (not just the defects management teams) to understand in more depth how HAs learn from defects.

Table 5.4 continued…

Limitation	Areas for further research
Due to the lack of research, this research was explorative in nature and aimed to better understand this phenomenon.	Undertake some more statistical research to compare and contrast the different learning systems used by HAs to understand their effectiveness at reducing defects to identify an optimum learning approach for HAs.
Explored the HA learning in a UK perspective only.	There is a lack of international research to explore learning from defects.
Adopted a process-based model of OL.	An interesting contrast would be to undertake research using a personalisation model to explore how HAs learn from defects. Would the findings be significantly different?
During the action planning phase, the action researcher was sympathetic to the HA in the use of SSM to explore their defects management and learning systems to identify desirable and feasible changes.	Produce prescriptive guidance in the form of a “best practice” guide for the HA to improve their learning based upon the amalgamated practices of other HAs. It would be interesting to determine whether the HA would have implemented the same changes given only suggested changes.
AR project failed to introduce long-term change in HA02 and was only able to gain insight and indications that the dashboard had helped improve the HA’s learning.	One way of extending the understanding of whether a dashboard (and suggested areas of analysis adopted) were able to enhance how HAs learn would be to introduce change into another HA to determine whether it improved their learning in the long-term by way of a longitudinal case study.
The impact of defects survey collected perspective from the UK’s leading warranty provider and approved inspector only.	An interesting contrast would be to collect data from other warranty providers and building inspectors to see whether their priority was different.
Impact of defects survey did not explore why the impacts were prioritised as they were in detail; and did not record the responses against specific individuals, so it is not possible to ask people why they responded as they did.	One way of exploring the impact of defects further would be to re-run the questionnaire survey by extending the survey to include the new impacts identified by the previous survey and also undertaking follow-up telephone interviews with participants to explore why they prioritised the specific aspects as they did.

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Appendix 1: Questionnaire survey and research ethics safeguards

Potential impact of new housing defects on the key stakeholders survey

Dear Sir/Madam,

This survey is part of a study on 'the investigation and analysis of new housing defects during the initial ten years after occupation' which is being conducted by Tony Hopkin, a Research Engineer in the School of Construction Management and Engineering at the University of Reading and the National House Building Council (NHBC). My supervisor is Dr. Shu-Ling Lu and can be contacted at S.Lu@Reading.ac.uk.

Your decision to participate in this study is voluntary. You can stop at any time and are not required to complete all of the questions within the survey. Your participation will be kept confidential to the degree permitted by the technology used. Identifying information will be removed from all forms.

Your identity will not be mentioned within any publications or presentations resulting from this survey. **By completing this survey, you understand that you are giving your consent for your responses, in anonymised form, to be used for the purposes of this research project.**

If you have any questions or concerns about this research, or wish to have a copy of the results, please contact Tony Hopkin at t.j.hopkin@pgr.reading.ac.uk

This survey aims to identify which aspects of defects have higher priority to key stakeholders (including the home buyer/occupier, house builder, warranty provider, and building inspector). **Note: a defect is defined as "the breach of any mandatory NHBC Requirement by the Builder or anyone employed by or acting for the Builder".*

In relation to a defect you have experienced please identify which of the numbers below best reflects your view of the description using the following guide:

	Not a priority	*Low priority*	*Medium priority*	*High priority*	*Essential*
Health and Safety implications	**1**	**2**	**3**	**4**	**5**
The potential danger the defect may pose to workers on site.	1	2	3	4	5
The potential danger the defect/regulatory non-compliance may pose to occupants of the home.	1	2	3	4	5
Other (please specify) ________________	**1**	**2**	**3**	**4**	**5**
Cost incurred	**1**	**2**	**3**	**4**	**5**
The cost for the builder of investigating the defect, either by internal staff or external specialists (including travelling costs).	1	2	3	4	5

The cost for the warranty provider of investigating the defect, either by internal staff or external specialists (including travelling costs).	1	2	3	4	5
The cost of the repair for the builder or warranty provider (including the cost of labourers, materials and equipment).	1	2	3	4	5
The cost for the builder for resolving complaints resulting from the defect (including any compensation or other fees paid).	1	2	3	4	5
The cost for warranty provider for resolving complaints resulting from the defect (including any compensation or other fees paid).	1	2	3	4	5
The cost that any warranty repairs will have on the builder (e.g. increased premium rating.)	1	2	3	4	5
The potential fines and legal action against the builder due to any regulation/legislation non-compliance.	1	2	3	4	5
The potential fines and legal action against an approved inspector for breach of contract due to any regulation/legislation non-compliance.	1	2	3	4	5
The cost potential cost for the warranty provider of rectifying regulatory non-compliance.	1	2	3	4	5
Other (please specify) ________________	**1**	**2**	**3**	**4**	**5**
Disruption caused	**1**	**2**	**3**	**4**	**5**
The disruption to the builders existing construction programme remediating defects instead of undertaking current work (e.g. shared equipment usage etc.).	1	2	3	4	5
The disruption caused by having to arrange for trades to return (including follow up communication).	1	2	3	4	5
The disruption caused by trades returning.	1	2	3	4	5
Other (please specify) ________________	**1**	**2**	**3**	**4**	**5**

Please could you add further comments regarding your selection:

Appendix 2: Interview schedule and research ethics safeguards, example of consent given, and example interview notes

Information and consent email confirmation

Dear xxx

I look forward to meeting with you to discuss the defects information held by NHBC and xxx, and how this data might be used to further improve the standard of new homes.

As discussed, we are in the process of meeting widely with industry to gather as much information on defects as possible; including examples of the information stored by your company. We will be able to use any example data provided by individual companies to help highlight to them the differences and improvement opportunities compared to the wider sample.

[I will be joined at the meeting by my colleague] [As you will know, my name is] (delete as appropriate) Tony Hopkin (T.J.Hopkin@pgr.reading.ac.uk, TSBE Centre, Whiteknights Campus, Reading, RG6 6UR). [Tony is] [I am] an Engineering Doctorate candidate at the University of Reading undertaking this work on behalf of NHBC as part of an investigation and analysis of new housing defects.

Areas we are particularly interested in include: how you collect and analyse your post completion repair data? how this feeds back into your build processes? and, what tools you utilise to undertake this? You will be free to choose not to answer any question we ask during our meeting. With your permission we would like to take notes for analysis, copies of which will be available upon request.

The meeting notes and any archival data you are able to provide will be kept securely at NHBC premises and destroyed two years after the completion of the project in August 2017. The data will be used for academic and NHBC purposes only. All data provided by contributors and included in the wider sample data set, along with any notes or transcripts will be treated as confidential and held anonymously. Copies of the completed academic research and any publications will also be available upon request. The research design for this work has been granted full ethical approval by the University of Reading.

Could you please confirm the following by return of email:

1. You have read the information relating to this project and any questions have been answered to your satisfaction.

2. You understand that your participation is voluntary and that you have the right to withdraw from the project any time.

3. You understand that your personal information will remain confidential to the researcher and their supervisor at the University of Reading, unless your explicit consent is given.

4. You understand that your organisation will not be identified either directly or indirectly without your consent.

5. You agree to the arrangements described above in so far as they relate to my participation.

Should you have any further questions about the study, or do not accept any of the above, please feel free to contact me. If you require any further information regarding the Engineering Doctorate programme at the University of Reading, please contact Dr Shu-Ling Lu (s.lu@reading.ac.uk).

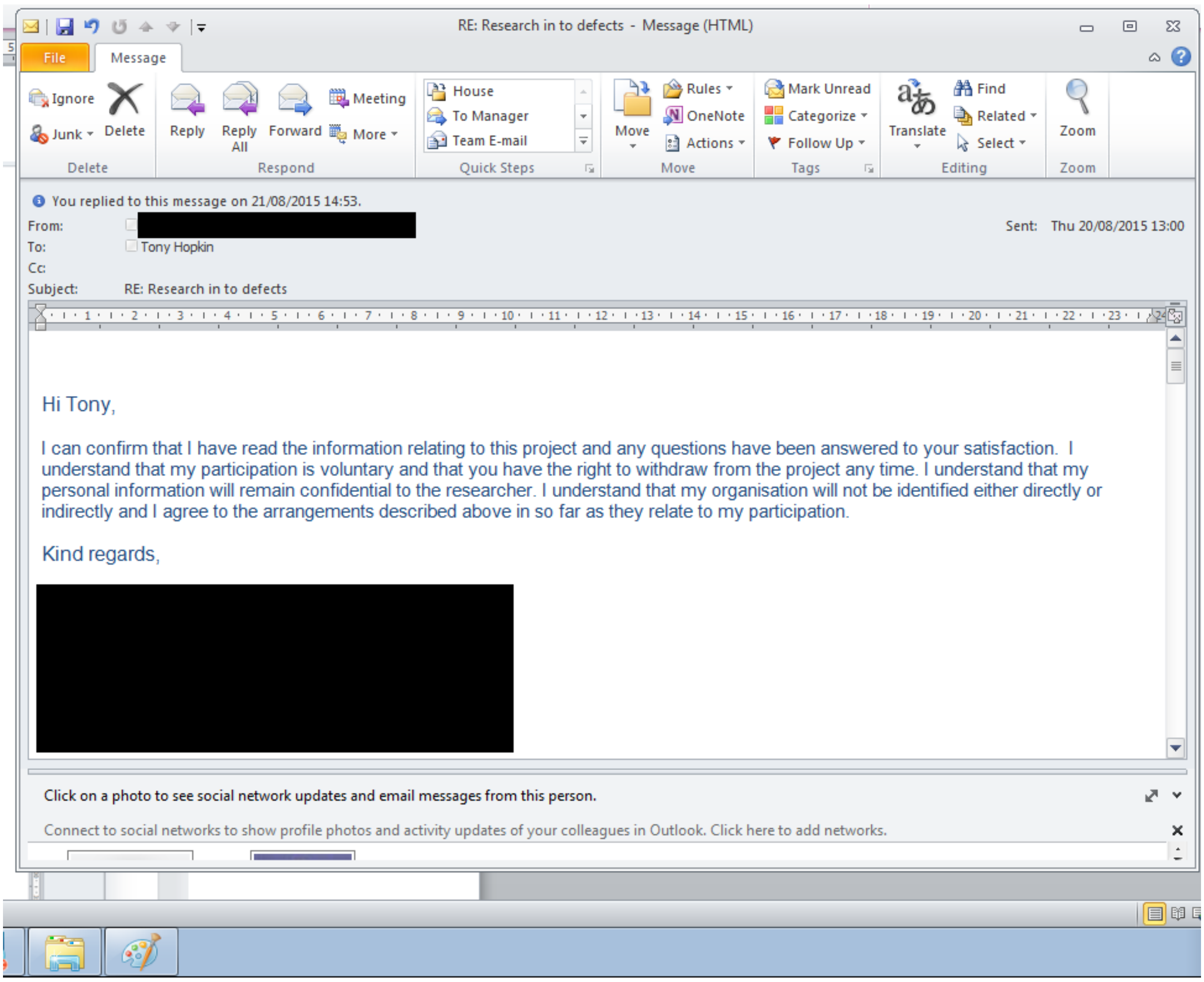
Regards,

[Tony] [Other at NHBC]

Interview Schedule

1) Do you capture/record post completion defect data?
2) At what level i.e. cost, type etc. what categories do you use? Why?
3) Do you analyse the data?
4) What is analysed?
5) How frequently is the analysis undertaken?
6) Why do you analyse defect data?
7) What's done with it? How are the findings from the analysis used?
8) How do you decide that the findings present a need for a change?
9) If a change is needed, how do you identify change options, and how is the change decided/selected and by who?
10) Once selected, how are the new processes communicated around the company?
11) When implemented, do you monitor the new processes to make sure they remain viable? And how do you determine that they are not, if not?
12) Do you have any barriers to change?

Example of consent given



RE: Research in to defects - Message (HTML)

You replied to this message on 21/08/2015 14:53.

From: [redacted]

To: Tony Hopkin

Cc:

Subject: RE: Research in to defects

Sent: Thu 20/08/2015 13:00

Hi Tony,

I can confirm that I have read the information relating to this project and any questions have been answered to your satisfaction. I understand that my participation is voluntary and that you have the right to withdraw from the project any time. I understand that my personal information will remain confidential to the researcher. I understand that my organisation will not be identified either directly or indirectly and I agree to the arrangements described above in so far as they relate to my participation.

Kind regards,

[redacted]

Example interview notes

Company: HA02

Location: HA02's premises

Date: 24 June 2015

Time: 12pm

Attendees: Tony Hopkin (TH) (Researcher), Aftercare Team Administrator (ATA), Head Clerk of Works (HCoW), Asset Manager (AM), and Quality Manager (QM)

<u>Interview notes</u>

TH: Do you capture/record post completion defect data?

ATA: Yes we capture all data relating to any defect we are notified of during years 0-10 post completion. We record this data in our defects log.

TH: At what level i.e. cost, type etc. (what sort of information do you collect)?

ATA: We record all of the property information we need, such as property type, the address of the property, what it is made out of (construction type), the date it was completed. We also record the warranty policy numbers, whether we have made a claim against the warranty, the details of the builders/contractors who constructed the properties, how much any repairs have cost us, any estimated cost savings (where we have had the developer/contractor undertake the repair at their own cost or made a successful claim against the warranty), and the current status of the work. We manually input a text description of the identified problem so we can keep a record of what is wrong with the property.

TH: Do you use any categories to record the types of defect occurring, say by building area?

ATA: At the moment we do not classify/record defects against a building area.

TH: Do you analyse the data?

AM: Yes, we do.

TH: What do you analyse?

AM: We currently look at frequency of defects we are experiencing in general (overall), the cost we spend on repairing any defects (where monies are spent). Me, ATA, and HCoW also sit down and look through the text descriptions so we can pick out any frequent issues (areas of high volume).

TH: How frequently is the analysis undertaken?

AM: We undertake a weekly review of the defects logs for our asset management team meetings. We provide an analysis of a value for money log and the defects log for the senior leadership team on a monthly basis. We also undertake analysis of the value for money log and defects log for discussions between myself and QM at our bi-monthly meetings (between the asset management and development directorates).

TH: Why do you analyse defect data?

AM: Analysing defects allows us to monitor our contractors levels of performance and also the way in which different products and systems perform. From this we can identify areas of strength or weakness and potential areas that require change and overall lessons we have learnt from previous experience.

TH: Can you provide some more detail on how the findings from your analysis are used?

AM: The lessons learnt and technical review/defects analysis can inform the future shaping of our employers requirements.

QM: The information held allows us to make informed decisions about which systems, products and contractors to use or discuss concerns with based upon previous performance.

HCoW: the knowledge of what is going wrong on site and making it through to completion also allows me to provide my site team with knowledge areas to watch during their inspections. So, I know that we’ve got a problem with balconies, single ply membranes. Personally, I’d stop using them, but that’s not the case. So I’ve told my clerk of works to look keep an eye on their installation to make sure that there are no issues and that they have not been damaged as they are being put in.

TH: How do you decide that the findings present a need for a change?

AM: QM and I discuss the issues at our meetings. Typically areas of change are decided on a case by case basis where we feel specific defects are causing us a particularly large concern. But the analysis provides us with the information to make those informed decisions.

TH: If a change is needed, how do you identify change options?

QM: Our lessons learnt and defects logs allow us to identify which areas are performing well and which less so, and this can be used to shape our employers requirements. I also ask key people in our development and asset management directorates if they can offer any solutions to the problem, and I'll talk to manufacturers if they have any innovative solutions

TH: So how is the change decided/selected and by who?

QM: Our employer's requirements are formally reviewed every year with the senior leadership team (directors).

TH: Once selected, how are the new processes communicated around the company?

QM: Our employer's requirements are a formal document. I also discuss changes/performance with contractors and manufacturers through meetings.

HCoW: I also put together a report for discussions with my team and provide this to AM for his asset management meetings.

AM: We provide an analysis of a value for money and defects log for the senior leadership team on a monthly basis, and we also undertake analysis of the value for money and defects log for discussions at mine and QMs bi-monthly meetings to keep other areas of the business informed of issues, changes or opportunities.

TH: This sounds interesting, have you got any examples of how this works in practice?

AM: We've updated our employer's requirements so that we no longer use timber frame construction for properties over three storeys, because of a number of instances of cracking. We had reports of a number of instances of cracking. HCoW's clerk of works team investigated and found a large number of timber frame properties above 3 storeys in height had significant cracking due to movement of the timber frame. ATA, HCoW, and I sat down during our weekly tam meeting and HCoW raised this as a potential area of weakness. We discussed the issue and we thought there could be a solution to this problem. I discussed this with QM (in the development team) and he said he would seek a solution.

QM: After some internal discussions with other technical colleagues we decided that we wouldn't build in timber frame if we were going over three storeys. I put this proposal our senior leadership team to review, and they agreed and put it in our new ERs.

TH: When implemented, do you monitor the new processes to make sure they remain viable?

AM: Yes, we use anecdotal feedback to investigate the early opinion around a change, to see if there are any show stoppers. We also use ongoing performance monitoring (keep looking at repairs) and have scheme review panels to look at long-term performance.

TH: And how do you determine that changes are successful or not, if not?

AM: Long-term, if the change has reduced the defect then it is successful.

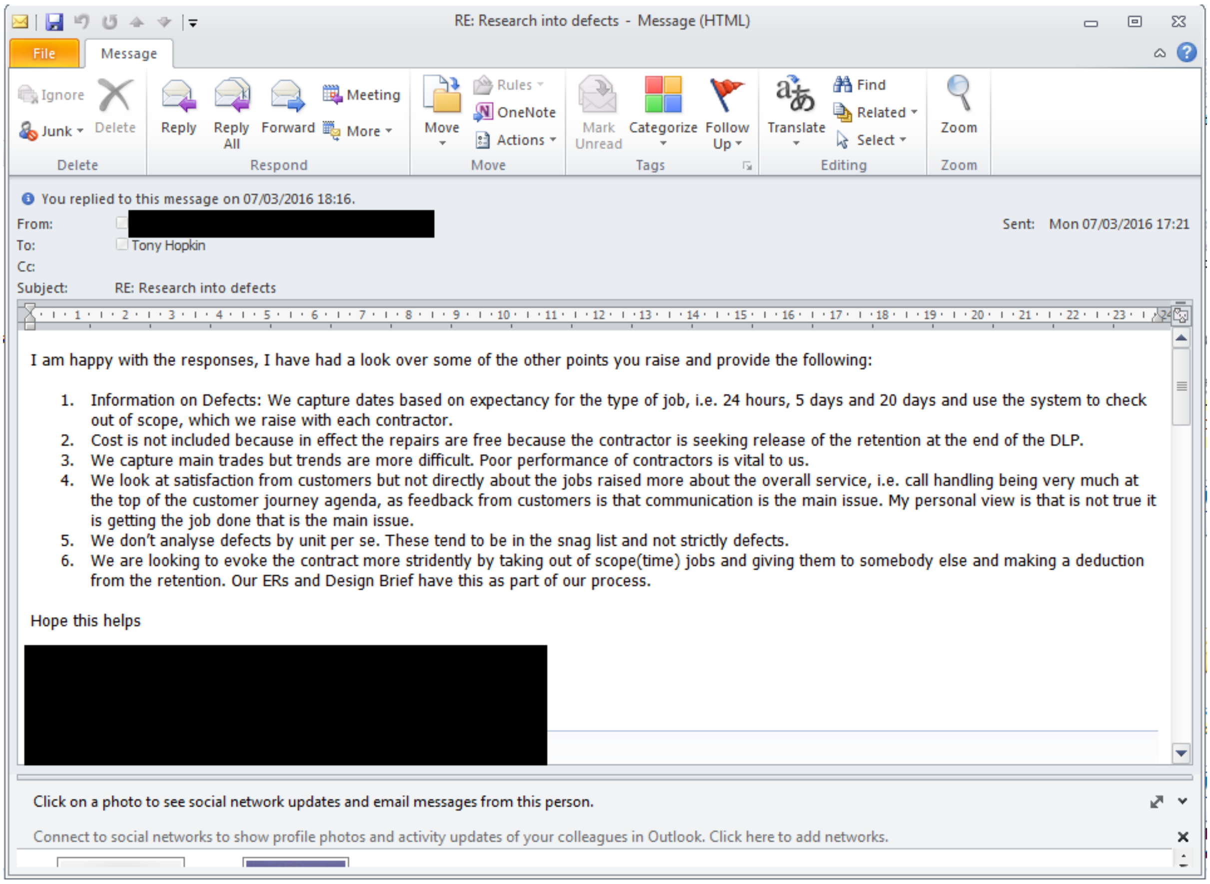
TH: Do you have any barriers to change?

ATA: The IT setup. Our development and asset management teams typically have different access to different drives.

QM: This is frustrating and does sometimes make sharing information difficult.

End interview

Example of member check



RE: Research into defects - Message (HTML)

You replied to this message on 07/03/2016 18:16.

From: [redacted]

Sent: Mon 07/03/2016 17:21

To: Tony Hopkin

Cc:

Subject: RE: Research into defects

I am happy with the responses, I have had a look over some of the other points you raise and provide the following:

1. Information on Defects: We capture dates based on expectancy for the type of job, i.e. 24 hours, 5 days and 20 days and use the system to check out of scope, which we raise with each contractor.
2. Cost is not included because in effect the repairs are free because the contractor is seeking release of the retention at the end of the DLP.
3. We capture main trades but trends are more difficult. Poor performance of contractors is vital to us.
4. We look at satisfaction from customers but not directly about the jobs raised more about the overall service, i.e. call handling being very much at the top of the customer journey agenda, as feedback from customers is that communication is the main issue. My personal view is that is not true it is getting the job done that is the main issue.
5. We don't analyse defects by unit per se. These tend to be in the snag list and not strictly defects.
6. We are looking to evoke the contract more stridently by taking out of scope(time) jobs and giving them to somebody else and making a deduction from the retention. Our ERs and Design Brief have this as part of our process.

Hope this helps

[redacted]

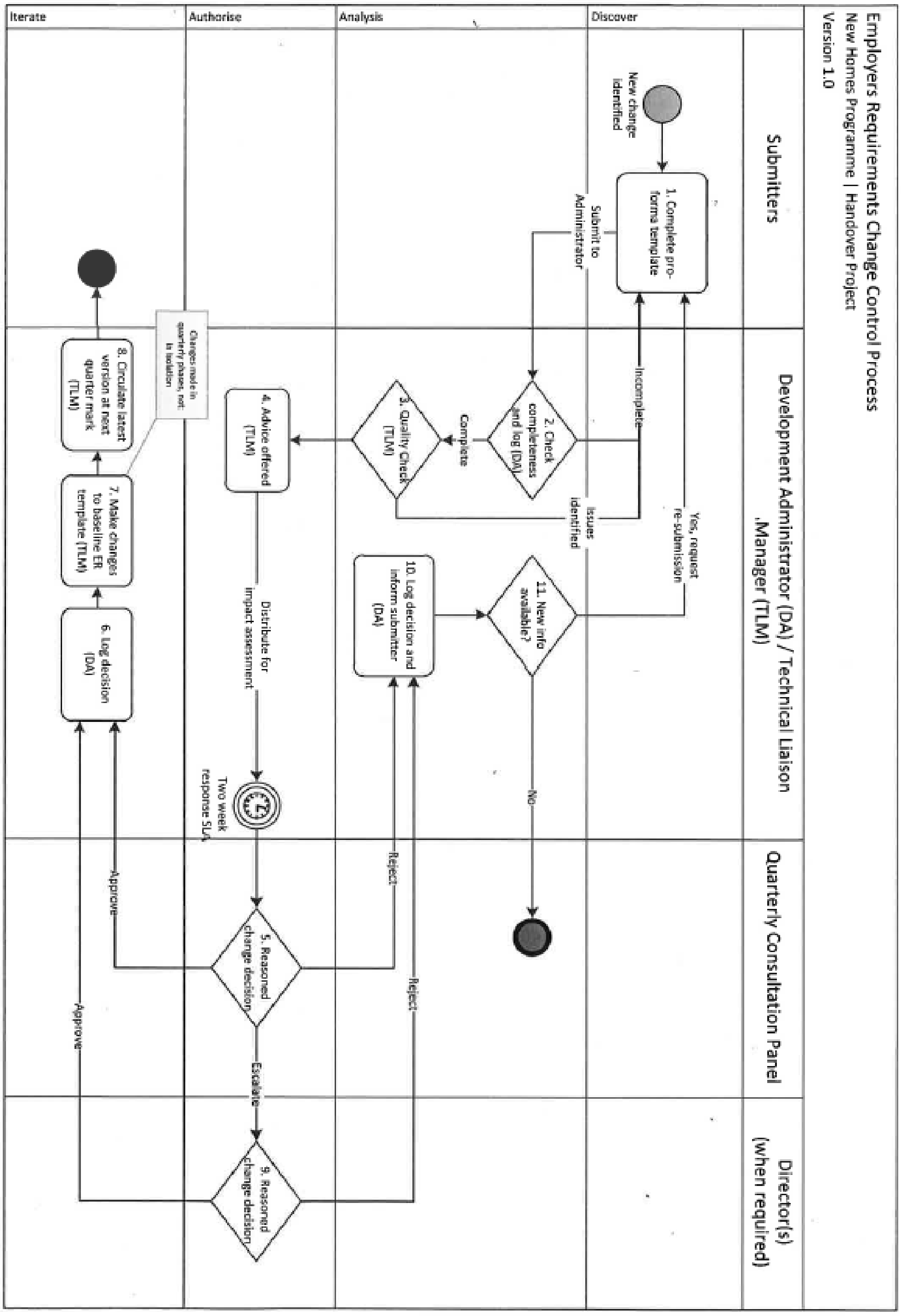
Click on a photo to see social network updates and email messages from this person.

Connect to social networks to show profile photos and activity updates of your colleagues in Outlook. Click here to add networks.

Appendix 3: Example document extracts

HA01

HA01's formal change control process



HA02

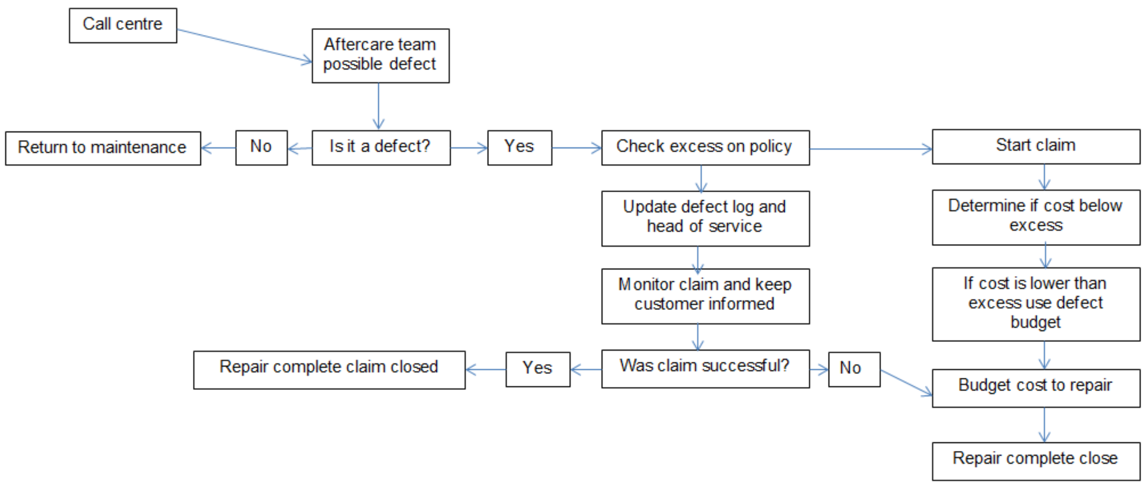
Extract from HA02's original defects log

DATE LOGGED	VFM LOG & DATE ENTERED	REF NO	SITE / ADDRESS / SCHEME	COUNTY / EMPLOYER REGION	REFERRED BY	BUILD DATE	WARRANTY PERIOD OR EXPIRY DATE	WARRANTY NUMBER	NATURE OF THE DEFECT	Cost of making good	POTENTIALLY VALID WARRANTY CLAIM?	DATE WARRANTY CLAIM MADE
08/01/2013	NOT ON VFM LOG NO SAVINGS MADE	LD2	[redacted]	HAMPSHIRE		2009	2021	[redacted]	Panel loose & other bleached and deflected	TBC		
		LD4	[redacted]	HAMPSHIRE		2009	2021	[redacted]	Heating costs / undersized 200p units?			
01/02/2013	NOT ON VFM LOG NO SAVINGS MADE	LD5	[redacted]			2009	2021	[redacted]	Heating design issues / costs			
18/01/2013	NOT ON VFM LOG NO SAVINGS MADE	LD6	[redacted]	HAMPSHIRE		2009	2021	[redacted]	Roof leak over 12, very poor detailing			
02/04/?	NOT ON VFM LOG NO SAVINGS MADE	LD7	[redacted]	HAMPSHIRE		2009	2021	[redacted]	ATAG boiler problems. Service manager prev wrote in Feb to PRS (installers) and no action taken.			
21/01/2014	NOT ON VFM LOG NO SAVINGS MADE	LD8	[redacted]	DORSET		2009	2021	[redacted]	Leak via leadwork at change in roof levels, 5 yr old property.			

Cont…

CONTRACTOR/DEVELOPER	Local/National Builder?	KEY CONTACT	STATUS	Case Status	Estimated Savings	AGREED ACTIONS
[redacted]	Local	[redacted]	[redacted]	Claim Closed (Unsuccessful)		SC looking into quotes for replacment cladding
[redacted]	Local	[redacted]	[redacted]	Claim Closed (Unsuccessful)		
[redacted]	National	[redacted]	[redacted]	Claim not Submitted (pass back to Repairs)		Alec took paper to xxx recommending £50k worth of wortk to rectifiy bad design.
[redacted]	National	[redacted]	[redacted]			
[redacted]	National	[redacted]	[redacted]			
[redacted]	Local	[redacted]	[redacted]	Claim Closed (successful)	£6,000	scaffold erected to unit and defect made good
[redacted]	Local	[redacted]	[redacted]	Claim not Submitted (pass for Repairs)		
[redacted]	National	[redacted]	[redacted]	Claim Closed (successful)	£20,000	Visited site on Monday the 1st of July to see client. Paths ,drainage, bt,gas ,gardens are all affected by this claim. xxx have agrred to start work on defect on the 2nd of july and finish all £20,000.

HA02's defects investigation procedure flow chart



HA02's defects investigation procedure document

HA02

[redacted]

PROCEDURE

[redacted]

[redacted] DEFECT INVESTIGATION PROCEDURE

Approved by:	Asset Manager [redacted]		
[redacted]tive date:	02 Ju[redacted]	[redacted] date:	01 June 2017
Author & respon[redacted]ible officer: [redacted]			
Status:	Approved	[redacted]ion:	1.0

1 Policy links [redacted]

- Investigation Procedure Flowchart (Version 1) 28/04/2015
- [redacted]

[redacted]

2 Procedure

[redacted] Defects are administered by the [redacted] within [redacted]. As described by the Royal Institute of Chartered Surveyors Latent Defects are defects that are not apparent at the time of completion but which subsequently become apparent months or years later. In the event that latent defects are discovered after completion of the works has been certified the contractor will be liable for direct costs reasonably incurred by the client as a result. This will/may include the cost of any appropriate remedial wo[redacted]re[redacted]by the client.

[redacted]

2.1 Request received from either the Call Centre, [redacted]or a Surveyors Report.

2.2 Once the request is received it is reviewed to confirm it falls within the Latent Defect definition described above, if not it is passed back to [redacted]

2.3 The [redacted] will investigate the claim and collate information regarding the insurance cover to confirm if policy covering property is a [redacted] Insurance Policy.

2.4 The [redacted] will Log details on the Defect Log held on following path [redacted]

2.5 The [redacted] team will check the excess of the Policy from documents retrieved to determine if the cost can be met via the insurance provider or if cost is to be covered from Latent Defects budget.

Page No: 1

2.6 The [redacted] will log claim with relevant Insurance provider if relevant supplying all releva[redacted] from referral process. M[redacted] appointment for relevant insurance assessor to attend [redacted]

2.7 If accepted as a Latent Defect but the anticipated cost is below the excess, the Clerk of W[redacted]n a minimum of two quotes. Authorisation for works will be provided to the [redacted] as necessary of [redacted] or a subcontractor to undertake the works. The [redacted] or will raise the appropriate order using the [redacted] system ensuring that the Purchase Order is authorised in line with financial permissions.

2.8 The [redacted] Administration [redacted] will monitor claim through to completion, keeping the customer informed of actions taken to resolve.

2.9 Once resolved close the claim on the Latent Defects [redacted] saved to include on the Value for Money Log or repo[redacted] Bimonthly meetings with Quality [redacted] Manager.

3 [redacted]

3.1 Letters and emails to be responded to within 10 working days

4 Performance monitoring

4.1 Performance Monitoring is undertaken by review of the Latent Defects Log involving the Asset Manager [redacted], [redacted] and [redacted] at regular meetings.

[redacted]

5 Process map

[redacted]

Key:			
	[redacted]	▭	Start/Stop position
	GLT	□	Process [redacted]
	Approving body	▱	[redacted]
		◇	Decision
		⬡	Preparation [redacted]

Review Date of Procedure June 2017 [redacted]

[redacted]

6.1 The following appendices are attached to [redacted]

Investigation Procedure Flowchart [redacted]

Page No: 2

Extract from HA02's updated defects log

DATE LOGGED	Year logged	TARGET COMPLETION DATE	Completed in time?	VFM LOG & DATE ENTERED	REF NO	UPRN NUMBER	SITE / ADDRESS / SCHEME	PROPERTY TYPE	CONSTRUCTION TYPE	COUNTY / EMPLOYER REGION	REFERRED BY	BUILD DATE	WARRANTY PERIOD OR EXPIRY DATE
27/06/2016	2016	25/07/2016	Y	ONGOING	LD137	[redacted]	[redacted]	Block of Extra Care	Brick and block	Devon	[redacted]	2016	2026
28/07/2016	2016	07/08/2016	Y	ONGOING	LD138	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
28/07/2016	2016	07/08/2016	Y	ONGOING	LD139	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
28/07/2016	2016	07/08/2016	Y	ONGOING	LD140	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
28/07/2016	2016	07/08/2016	Y	ONGOING	LD141	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
28/07/2016	2016	07/08/2016	Y	ONGOING	LD142	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
04/08/2016	2016	14/08/2016	Y	ONGOING	LD143	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
05/08/2016	2016	15/08/2016	Y	ONGOING	LD144	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
24/08/2016	2016	03/09/2016	Y	ONGOING	LD145	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
24/08/2016	2016	03/09/2016	Y	ONGOING	LD146	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
24/08/2016	2016	03/09/2016	Y	ONGOING	LD147	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
24/08/2016	2016	03/09/2016	Y	ONGOING	LD148	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023
24/08/2016	2016	03/09/2016	Y	ONGOING	LD149	[redacted]	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2023

Cont…

25/08/2016	2016	04/09/2016	Y	ONGOING	LD151	[redacted]	House	Timber frame	Dorset	[redacted]	2015	2025
25/08/2016	2016	04/09/2016	Y	ONGOING	LD152	[redacted]	House	Timber frame	Dorset	[redacted]	2015	2025
25/08/2016	2016	04/09/2016	Y	ONGOING	LD153	[redacted]	House	Timber frame	Dorset	[redacted]	2015	2025
25/08/2016	2016	04/09/2016	Y	ONGOING	LD154	[redacted]	House	Timber frame	Dorset	[redacted]	2015	2025
30/08/2016	2016	09/09/2016	Y	ONGOING	LD155	[redacted]	House	Timber frame	Dorset	[redacted]	2013	2025
07/09/2016	2016	17/09/2016	Y	ONGOING	LD156	[redacted]	House	Brick and block	Somerset	[redacted]	2015	2025
15/09/2016	2016	20/09/2016	N	ONGOING	LD157	[redacted]	Flats	Timber frame	Wiltshire	[redacted]	2015	2024

WARRANTY NUMBER (HYPERLINK CERT)	NATURE OF THE DEFECT / DAMAGE	CATEGORY	REPAIR PRIORITY	CONTRACTOR/DEVELOPER	Local/National Builder?	KEY CONTACT / CLERK OF WORKS	STATUS	Case Status	Estimated Savings	AGREED ACTIONS	Cost of making good	Potential liability	POTENTIALLY VALID WARRANTY CLAIM?	Complaint made?
[redacted]	DPC Issues	External Walls	Routine	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N

Cont…

[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Incorrect ventilation	Pitched and Flat Roofs	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Garden Claim	External Works	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Garden Claim	External Works	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Garden Claim	External Works	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N
[redacted]	Garden Claim	External Works	Urgent	[redacted]	National	[redacted]	Use Hyperlink to Document File	Being investigated		Allocated to investigator		Not known at this point	Waiting feedback	N

HA03

HA03's company document

General

1. How many units per annum have you procured through direct contracting in the last decade?

2010-11	154
2011-12	267
2012-13	81
2013-14	297
2014-15	262

2. How many units per annum have you procured through s.106 obligations?

2010-11	356
2011-12	504
2012-13	849
2013-14	611
2014-15	1163

3. What quality management/control measures are currently in place within your organisation and how do you verify [redacted]onstructed building is built to your required standards/quality? For example; what stages do these systems cover (e.g. design, pre-construction, on site etc.), where were they derived from, how long have they been in place and often are they adapted and updated? Finally, does your quality management system change depending on procurement route?

Prior to start on site, provisions are made for standards, quality and def[redacted] management in our contracts, development agreements and Employer's Requirements. All are reviewed for each scheme and the ER's are updated on a periodic basis. We have just completed a full review of the ER's and will carry out an annual review from now onwards.
We employ EA's to monitor and manage the delivery of the contract from pre-contract to completion of 12 month defect inspections and retention release. The EA's visit sites at least once a month to monitor performance against programme, quality of workmanship and materials and health and safety.
Our internal Technical Advisors visit sites once a week to monitor progress on site and identify any quality or health and safety issues that need to be reported to the EA.
2 weeks prior to handover, our TA and EA visit the units with the

[redacted]
developer/contractor to snag the properties, identifying any works outstanding or not satisfactorily completed. At handover, that list is reviewed to check that all works have been completed. The definition of Practica[redacted] 'available for beneficial occupation' means that we do take properties with works still outstanding. [redacted] EA visit at around 11 months after completion to inspect and create a final list of works to be completed. The final list of works is agreed with the resident who signs to confirm the works are completed before the retention is released.

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on final

Defects/repairs

4. Do you budget for defects and post completion repairs? If yes, on what basis (e.g. cost per plot etc.), and does this change depending on procurement route?

Our contracts allow for retention of a percentage of the contract sum to be held back until the defects period has ended and all defects have been signed off as satisfactorily completed. Our standard retentions are between 3% and 5% of the contract sum, but we will seek to apply higher percentages where we believe there may be a greater risk of poor performance. We also make an allowance of £500 per property

5. Do you record defect information? If so, what is recorded, in what format, by whom and for what purpose? (e.g. do you record cost, number of defects, and what categories are they recorded as? i.e. doors, plumbing, electrical etc.) Finally, is detailed defect information received directly from contractors and/or internal staff after inspection?

Currently, defects are recorded on our [redacted] Housing Management System and a weekly 'Works in Defects' report is produced. The reports record the nature of the defect, the developer, address, scheme name, target date for works to be completed and status of the works. Developers are sent weekly lists of any works that are outstanding beyond the target date.

[redacted] is working towards introducing a new IT system that will allow all defects to be recorded as individual works orders and assigned to the relevant Developer. The new system will allow defects to be categorised and costed.

Defects are reported through 3 routes:

1. **Works outstanding at Practical Completion**
   Lists of outstanding works are recorded by the EA/TA and passed to Developer. The lists are uploaded to New Property Information Packs so that they are available to the rest of the business. Contracts require outstanding works to be completed within 6 weeks of PC.
2. **Ad-hoc defect reporting**
   Defects are reported by residents to our Connect Customer Service Centre.

[redacted]

[redacted]t Advisors record the defects and report them to the developer, giving a target date for completion of the works.

3. 12 month defect inspection
   Our EA and TA inspect the properties with the developer around 11 months after the PC date and create a conclusive list of defects. Once the agreed list of defects have been rectified, the reside

6. Do you currently analyse the defect data you store? If so, who analyses it, how is it analysed and for what purpose? (e.g. how often do you analyse the data, and at what level i.e. by development, at organisational level or by contractor etc.) Finally, what is done with the information after it has been analysed? For example, does it feed in to how you approach future developments; choose contractors etc. and ultimately who make these procedural decisions and how are they communicated throughout the organisation.

→ Excel/ Spreadsheet

A weekly 'Works in Defects' report is produced and made available to all of the Development team. [redacted] team maintains a record of all outstanding defects across the majority of the business. At the moment, there are some [redacted] housing management systems still in use in the Hampshire and Oxfordshire areas that are not able to produce the information [redacted] is acquiring a new IT system within the next year that will allow for more detailed and comprehensive recording of defects across all areas of the business.

7. Based upon your defect experience, what overall levels of defects do you encounter per year, and what do you find are the major areas of defects? (e.g. structure, foundations, roofs etc.)

8. Do you experience differently levels and types of defects depending on the procurement route?

HA04

HA04's defects report

Dev Scheme Ref	Dev Scheme Name	Local Authority	Stock	Units	Units Occupied	End of DLP	Total No. Defects	Avg. Defects per Unit (DLP Year)	Avg. Defects per Unit (KPI Year)	Overdue	Due	DLP - Due for Completion	In Time (DLP Year)	In Time (KPI Year)
W2406	[redacted]	Reigate and Banstead	Leasehold - S Ownership	73	7	25/06/2016	15	0.2	0.2	2	12	3	33%	33%
W2421	[redacted]	Aylesbury Vale	Leasehold - S Ownership	8	0	17/03/2016	10	1.2	1.2	1	9	1	0%	0%
W43620	[redacted]	Hounslow	Affordable Rented Properties	12	12	09/11/2015	25	2.1	0.0	0	0	25	100%	
W5002	[redacted]	Elmbridge	Affordable Rented Properties	24	20	23/06/2016	2	0.1	0.1	0	2	0		
W5007	[redacted]	Reigate and Banstead	Affordable Rented Properties	15	13	25/06/2016	2	0.1	0.1	1	1	1	0%	0%
W50290	[redacted]	Reading	Affordable Rented Properties	30	30	09/03/2016	42	1.4	1.4	3	6	36	72%	72%
W50320	[redacted]	Hillingdon	Affordable Rented Properties	9	9	09/11/2015	8	0.9	0.2	0	0	8	100%	100%
W50380	[redacted]	Hounslow	Affordable Rented Properties	8	8	25/03/2016	19	2.4	2.4	2	11	8	75%	75%
W50600	[redacted]	Wandsworth	Affordable Rented Properties	7	7	28/08/2015	19	2.7	0.4	0	0	19	68%	67%
W50620	[redacted]	Hounslow	Affordable Rented Properties	5	5	16/02/2016	14	2.8	1.6	1	1	13	92%	86%
W50630	[redacted]	Hounslow	Affordable Rented Properties	6	6	22/01/2016	5	0.8	0.3	1	0	5	80%	50%
W50700	[redacted]	Reigate and Banstead	Affordable Rented Properties	1	1	05/11/2015	1	1.0	0.0	0	0	1	100%	
W50740	[redacted]	Hounslow	Affordable Rented Properties	1	1	22/01/2016	0	0.0	0.0	0	0	0		

Extract from HA04's defects log

Interest	Stock	Request Ref	Supplier Name	Repair Type	Date Reported	Date Completed	Priority	Maint Responsibility	Scheme Name T2 Code	SOR Code	SOR Code Desc	Task Text
Owned and Managed	Affordable Rented Properties	866375		\Defect (zero orders only)	01/10/2015 16:57	02/10/2015 14:36	Routine 20 Days	Full Maint Responsibility	Russell Square + Victoria Road (P5007)	DEF012	Carry Out Following Repairs: Miscellaneous Defects	Carry Out Following Repairs: Miscellaneous Defects Extra Description:
Owned and Managed	General Needs Woking PFI	866289		\Defect (zero orders only)	01/10/2015 10:22	01/10/2015 15:30	Woking Immediate	Full Maint Responsibility	Woking PFI (A0001)	DEF005	Carry Out Following Repairs: Plumbing	Carry Out Following Repairs: Plumbing Extra Description: Blocked Toilet
Owned and Managed	General Needs Woking PFI	866241		\Defect (zero orders only)	30/09/2015 16:58	30/09/2015 18:00	Woking Immediate	Full Maint Responsibility	Woking PFI (A0001)	DEF005	Carry Out Following Repairs: Plumbing	Carry Out Following Repairs: Plumbing Extra Description:
Owned Only	Leasehold - S Ownership	866064		\Defect (zero orders only)	29/09/2015 13:54	01/10/2015 15:34	Routine 20 Days	Structural & Communal	Russells Square (S2406)	DEF006	Carry Out Following Repairs: Heating	Carry Out Following Repairs: Heating Extra Description:
Owned and Managed	General Needs Woking PFI	865953		\Defect (zero orders only)	28/09/2015 15:58	28/09/2015 16:33	Woking Urgent 7 Days	Full Maint Responsibility	Woking PFI (A0001)	DEF004	Carry Out Following Repairs: Electrics	Carry Out Following Repairs: Electrics Extra Description: Electrical Socket For Washing Machine Not Working.
Owned and Managed	Affordable Rented Properties	865852		\Defect (zero orders only)	28/09/2015 10:25	29/09/2015 12:38	Routine 20 Days	Full Maint Responsibility	Russell Square + Victoria Road (P5007)	DEF005	Carry Out Following Repairs: Plumbing	Carry Out Following Repairs: Plumbing Extra Description:
Owned and Managed	General Needs Woking PFI	865836		\Defect (zero orders only)	28/09/2015 09:21	28/09/2015 10:30	Woking Immediate	Full Maint Responsibility	Woking PFI (A0001)	DEF005	Carry Out Following Repairs: Plumbing	Carry Out Following Repairs: Plumbing Extra Description: Bathroom Leak From Cistern-toilet Making Floor Wet
Owned and Managed	General Needs Woking PFI	865783		\Defect (zero orders only)	25/09/2015 14:55	25/09/2015 15:30	Woking Immediate	Full Maint Responsibility	Woking PFI (A0001)	DEF006	Carry Out Following Repairs: Heating	Carry Out Following Repairs: Heating Extra Description:
Owned and Managed	Leasehold - S Ownership	865717		\Defect (zero orders only)	24/09/2015 17:50	01/10/2015 16:35	Routine 20 Days	Structural & Communal	Russells Square (S2406)	DEF012	Carry Out Following Repairs: Miscellaneous Defects	Carry Out Following Repairs: Miscellaneous Defects Extra Description: Communal Carpet

HA05

Extract from HA05's defects log

Address	Full postcode	Borough	Responsibility	UPRN (unique property reference number)	Description of repair reported	Resident Name	Resident Telephone Number	Resident Email	Pre-inspection date	Pre-inspection photos received?	Link to folder	True defect?	Action required?

Description of works required	Insurance company referred to (if applicable)	Date works referred to insurance company (if applicable)	Reason why repairs were not referred to insurance company and Peabody are liable for the cost	Contractor	Estimated cost	Actual cost	Date works completed	Post Inspection Date	Post-inspection result	Post-inspection photos received?	Notes if post-inspection failed	Resolution to failed post-inspection

HA07

Extract 1 from HA07's defects log

CUSTOMER CARE

Report for January

Number of incoming communications from residents including defects (defects listed below spreadsheet)

Development	Amount
[redacted]	29
	43
	38
	15
	35
	23
	19
	17
Totals	219

Individual defects (54 reported)

	Address	Defect	Reported	Timescale	Issue	Completed	Notes
1	[redacted]	Water leaking	06/01/2014		Defect	21/01/2014	[redacted]
2	[redacted]	Water leaking	06/01/2014	24 Hours	Defect	21/01/2014	[redacted]
3	[redacted]	Cold air coming through gap in window and door	06/01/2014	5 Days	Defect	14/01/2014	[redacted]
4	[redacted]	Bathroom door handle loose and lights in lounge keep blowing replaced number of times	06/01/2014	24 Hours	Defect	29/01/2014	[redacted]
5	[redacted]	Damp in ceiling no leak from above	06/01/2014	24 Hours	Defect	29/04/2014	[redacted]
6	[redacted]	Damp above window in living room	07/01/2014	5 Days	Defect	13/01/2014	[redacted]
7	[redacted]	No heating	07/01/2014	24 Hours	Defect	10/01/2014	[redacted]
8	[redacted]	Shower knob keeps falling off and shower not fixed properly	08/01/2014	5 Days	Defect	05/02/2014	[redacted]
9	[redacted]	Hot water takes whole day to heat up, pipes banging behind tiles and floor boards in bedroom extremely loud	08/01/2014	5 Days	Defect	13/01/2014	[redacted]
10	[redacted]	FED difficult to open	08/01/2014	24 Hours	Defect	07/02/2014	[redacted]
11	[redacted]	Signal aerial due to high winds camview attending want HA07 to attend too	08/01/2014	5 Days	Defect	13/01/2014	[redacted]
12	[redacted]	Latent water leak	08/01/2014	5 Days	Defect		[redacted]
13	[redacted]	Latent plasterwork and tv aerial (as per Craig and PRP)	08/01/2014	20 Days	Defect	28/01/2014	[redacted]
14	[redacted]	Water leaking through balcony door	08/01/2014	5 Days	Defect	28/01/2014	[redacted]
15	[redacted]	No heating - key with Jason	10/01/2014	24 hours	Defect	14/01/2014	[redacted]
16	[redacted]	Latent Defect - leak under seal on window - balcony	13/01/2014	5 days	Defect	17/01/2014	[redacted]
17	[redacted]	Extractor fan very noisy - when turned off has no heating	13/01/2014	24 hours	Defect	20/02/2014	[redacted]
18	[redacted]	No hot water from the bath tap	13/01/2014	24 hours	Defect	28/01/2014	[redacted]
19	[redacted]	Water coming through front door during heavy rain and winds causing damage	14/01/2014	5 days	Defect	17/02/2014	[redacted]
20	[redacted]	Lift has broken down	15/01/2014	24 hours	Defect	15/01/2014	[redacted]
21	[redacted]	Water ingress in the window	15/01/2014	5 days	Defect	19/02/2014	[redacted]
22	[redacted]	Leak in the ceiling cupboard in basement	15/01/2014	24 hours	Defect	21/02/2014	[redacted]
23	[redacted]	Leak outside flats 19 and 26	15/01/2014	24 hours	Defect	19/02/2014	[redacted]
24	[redacted]	No heating and overflow is constantly running	16/01/2014	24 hours	Defect	10/02/2014	[redacted]
25	[redacted]	Leak on en suite toilet at the bottom	16/01/2014	5 days	Defect	03/02/2014	[redacted]
26	[redacted]	Leak from the roof to their balcony	16/01/2014	5 days	Defect	18/02/2014	[redacted]
27	[redacted]	No hot water	16/01/2014	5 days	Defect	28/01/2014	[redacted]
28	[redacted]	1, En suite shower has had a leak and there is green mildew marks on the shower base. 2, The dishwasher door does not open fully. 3, Firestrips around the doors are falling out. 4, FED spy hole laminate is marked and it is also damaged to the side of the door	17/01/2014		Defect	12/02/2014	[redacted]

Cont…

29	[redacted]	TV aerial not working	17/01/2014	5 days	Defect	28/01/2014	[redacted]
30	[redacted]	There is an inch gap around the balcony door causing a draft in the flat	17/01/2014		Defect	25/02/2014	[redacted]
31	[redacted]	There is a leak possibly from under the bath, the water must have been leaking a while as the floor boards are slightly higher and the surrounding area wet.	20/01/2014	24 hours	Defect	13/02/2014	[redacted]
32	[redacted]	Latent defect - the ran is running constantly cannot swithc off only by fuse board. There doesn't seem to be a spur visable to control it. There is no power at the boost switches, we can only assume that the internal circuit board is at fault.	20/01/2014	5 days	Defect	26/02/2014	[redacted]
33	[redacted]	Latent defect - Bath water does not stay hot, runs hot for a short while then runs cold. Seems to be a problem at this site	20/01/2014	5 days	Defect	13/02/2014	[redacted]
34	[redacted]	Under cupboards lights keep flickering and regulary go odd, and several times 'zones' have tripped out	20/01/2014	5 days	Defect	28/01/2014	[redacted]
35	[redacted]	The resident has reported that there is a pipe leaking from under his kitchen sink	20/01/2014	24 hours	Defect	04/02/2014	[redacted]
36	[redacted]	Damp patch on the kitchen / diner ceiling brown around the edges and grey in the middle. Not sure if the leak has stopped - there is a bedroom above this leak (possibly from the en suite at the back.	20/01/2014	5 days	Defect	28/03/2014	[redacted]
37	[redacted]	TV Signal not working again, intercom camera, she is not able to see when visitors buzz her during the evening. Kitchen hot tap has become loose again	20/01/2014	5 days	Defect	20/01/2014	[redacted]
38	[redacted]	Latent Defect - the resident has reported that the trickle vents are letting in rain when they are closed. She reported this before christmas and was asked to monitor with trickle vents close but still leaking	20/01/2014	5 days	Defect	14/02/2014	[redacted]
39	[redacted]	Nomico recalled as per Alex as extractor fan not working and not made good around area	21/01/2014	5 days	Defect	07/02/2014	[redacted]
40	[redacted]	Resident's reported leak through their ceiling	21/01/2014	24 hours	Defect	13/02/2014	[redacted]
41	[redacted]	There is a gap in the unit work top in the kitchen to the LHS of the hob and liquids are getting into this causing the worktop to swell. A Hills operative attended and advised the resident that the work top would need replacing	22/01/2014	EOD	Defect	13/02/2014	[redacted]
42	[redacted]	Main toilet not flushing and en suite toilet is sluggish	22/01/2014	5 days	Defect	13/02/2014	[redacted]
43	[redacted]	Low pressure ener-g believes it is a pressure reducing valve that needs looking at	23/01/2014	5 days	Defect	03/02/2014	[redacted]
44	[redacted]	Latent defect - issue with the tundish - hadnt been serviced resident has now had done and passed to PRP to go to Higgins as latent	23/01/2014		Defect	31/01/2014	[redacted]
45	[redacted]	Leak in kitchen sink	23/01/2014	24 hours	Defect	10/03/2014	[redacted]
46	[redacted]	Toilet not flushing - no water coming from the back	23/01/2014	24 hours	Defect	23/01/2014	[redacted]
47	[redacted]	Damp patches appearing in the property around the partitions between room 1 and 2	27/01/2014	5 days	Defect	07/02/2014	[redacted]

Extract 2 from HA07's defects log

April - June 2015	
Reason Code	**All Other Sites April - June 2015**
Electrical	1
Sanitary Ware	1
Plumbing	0
Taps / Showers	1
Heating	2
Water Penetration	4
Windows	1
Doors	1
Ironmongery	0
Kitchen Units	0
Other	1
White Goods	1
Extractor Fans / Ventilation	0
Main Entrances / Gates	1
Entry Phone	0
Telephone	0
Flooring	2
Cleaning	0
Lift	1
Decoration	0
	17

HA08

HA08’s defects report 1

Scheme Area Description	Scheme Unit Count	No. of Properties with Defects	Number of Defects	Defects Per Unit	% Properties with Defects	Defects Completed on Target	Defects Not Completed on Target	Percentage In Target
[redacted]	8	8	45	5.63	100%	13	32	28.9%
[redacted]	32	26	127	3.97	81%	31	96	24.4%
[redacted]	6	4	6	1.00	67%	1	5	16.7%
[redacted]	10	9	61	6.10	90%	21	40	34.4%
[redacted]	56	47	239			66	173	
[redacted]	24	12	48	2.00	50%	16	32	33.3%
[redacted]	5	5	38	7.60	100%	0	38	0.0%
[redacted]	13	13	63	4.85	100%	0	63	0.0%
[redacted]	18	18	101			0	101	
[redacted]	43	36	182	4.14	82%	2	180	1.1%
[redacted]	2	1	4	2.00	50%	0	4	0.0%
[redacted]	2	2	10	5.00	100%	0	10	0.0%
[redacted]	2	2	5	2.50	100%	0	5	0.0%
[redacted]	10	7	39	3.90	70%	0	39	0.0%
[redacted]	4	3	21	5.25	75%	0	21	0.0%
[redacted]	20	15	79			0	79	
[redacted]	10	8	23	2.30	80%	10	13	43.5%
[redacted]	6	5	25	4.17	83%	6	19	24.0%
[redacted]	24	19	53	2.21	79%	19	34	35.8%
[redacted]	9	6	15	1.67	67%	9	6	60.0%
[redacted]	**49**	**38**	**116**			**44**	**72**	
[redacted]	40	30	132	3.30	75%	45	87	34.1%
Overall - Total	**251**	**196**	**897**	3.57	78%	**173**	**724**	19%

HA08’s defects report 2

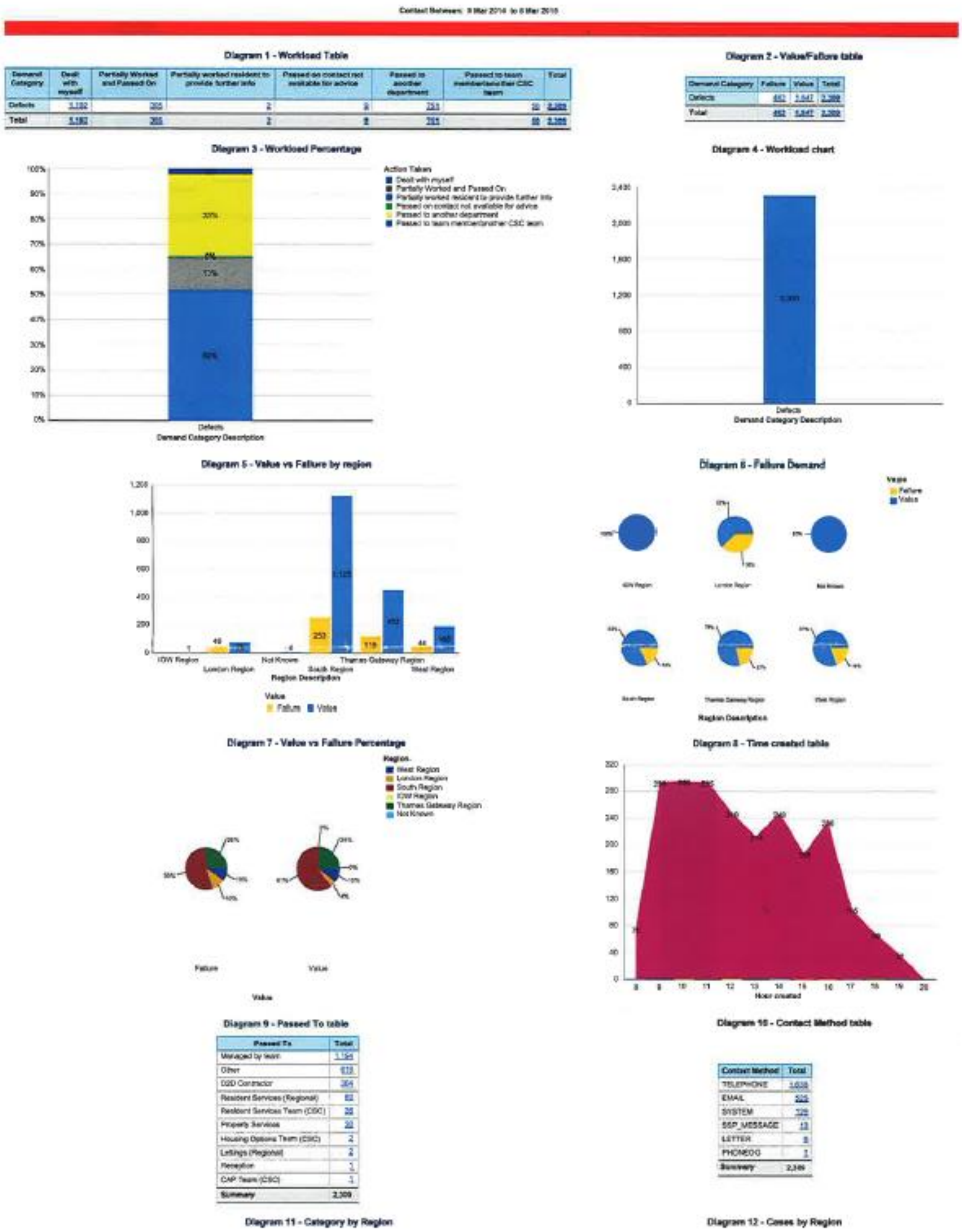
Defects Project Measures

Measure	Found in	Baseline period	Baseline	Jun-15	Sep-15	Dec-15	Mar-16	Jun-16	Notes
Resident Satisfaction with repairs & defects service (% satisfied)	New Homes Survey' results	Schemes reaching End of Defects 1st April 2014- 31st March 2015	53%						Include 'n/a' as satisfied- 6 - monthly reports
Defects per unit	MIT defects report	Schemes reaching End of Defects 1st April 2014-31st March 2015	3.59						
% of units with defects	MIT defects report	Schemes reaching End of Defects 1st April 2014-31st March 2015	78%						note data inaccurate due to repeat & cancelled logs but will improve over time. Also defects not always closed out but should improve with AC in post. 6 monthly reports.
Defects completed within target	MIT defects report	Schemes reaching End of Defects 1st April 2014-31st March 2015	19%						
Failure demand	CSC Demand analysis report- Diagram 5, value vs failure	Defects logged 9/3/14-8/3/15	20%	8%					
chase-up calls	CSC Demand analysis report- Diagram 14, type of enquiry, 'I'm chasing'	Defects logged 9/3/14-8/3/15	20%	8%					
How do I' calls	CSC Demand analysis report- Diagram 17, Demand type, 'how do I'	Defects logged 9/1/15-8/3/15	0%	0%					Note demand type only introduced in Jan 2015 so this data can only be used for interest.
% of jobs for which we have completion data	bespoke report run from [redacted]	Defects logged 9/3/14-8/3/15							

Extract from HA08's defects log

Scheme Area Description	Property ID	Job No	Job Status	Job Description	Trade Description	Contractor Name	Expense Description	Raised Date	Completion Date	Overall Target Date	Overall Target Met	Repair Address Line 1	Repair Address Line 2	Repair Address Line 3	Repair Address Line 4	Repair Postcode	Number of Defects
[redacted]	40162	752046	60	FED trim is missing - raised at handover	DEFECT GENERAL		Defects	21 Mar 14 13:09:02	28 Apr 14 14:34:00	24 Apr 14 00:00:00	Out of Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40162	752048	60	The 3 fans are not working in the property	DEFECT GENERAL	[redacted]	Defects	21 Mar 14 13:10:33	28 Apr 14 14:34:00	24 Apr 14 00:00:00	Out of Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40162	752049	70	fold down shower seat missing noted at handover	DEFECT GENERAL	[redacted]	Defects	21 Mar 14 13:11:49	22 Jul 14 14:34:00	24 Apr 14 00:00:00	Out of Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40163	751082	60	Boiler pipework dripping (Containable)	DEFECT PLUMBING	[redacted]	Defects	4 Mar 14 18:29:50	18 Mar 14 14:37:00	3 Apr 14 00:00:00	In Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40163	751083	60	Power supply to washer/dryer not working.	DEFECT ELECTRIC	[redacted]	Defects	4 Mar 14 18:32:09	2 Apr 14 14:38:00	3 Apr 14 00:00:00	In Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40163	751084	60	3 extractor fans not working (bathroom/kitchen)	DEFECT ELECTRIC	[redacted]	Defects	4 Mar 14 18:39:25	19 Mar 14 14:38:00	3 Apr 14 00:00:00	In Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40163	751085	60	Sealent behind kitrchen top missing	DEFECT GENERAL	[redacted]	Defects	4 Mar 14 18:42:03	2 Apr 14 14:38:00	3 Apr 14 00:00:00	In Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40163	769784	40	Please refix door handles	DEFECT GENERAL	[redacted]	Defects	16 Dec 14 14:07:43		20 Jan 15 00:00:00	Out of Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40164	751365	60	Socket from the oven not working - no power Oven has been checked all ok, still no power	DEFECT ELECTRIC	[redacted]	Defects	11 Mar 14 11:31:32	28 Apr 14 14:20:00	10 Apr 14 00:00:00	Out of Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40164	751760	60	Electrics to oven are not working	DEFECT ELECTRIC	[redacted]	Defects	17 Mar 14 14:54:10	20 May 14 14:55:00	16 Apr 14 00:00:00	Out of Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1
[redacted]	40164	752051	60	toilet seat not provided at sign up	DEFECT GENERAL	[redacted]	Defects	21 Mar 14 13:15:14	28 Apr 14 14:33:00	24 Apr 14 00:00:00	Out of Target	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1

Overview of HA08’s defects dashboard



	IOW Region	London Region	Not Known	South Region	Thames Gateway Region	West Region	Total Region
Defects	1	121	4	1,378	571	234	2,309
Total	1	121	4	1,378	571	234	2,309

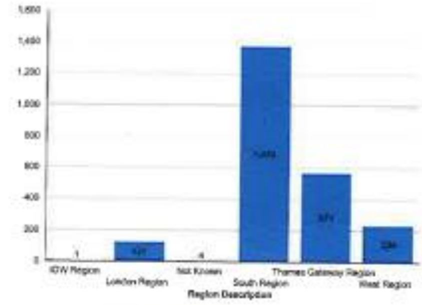


Diagram 13 - Pareto graph

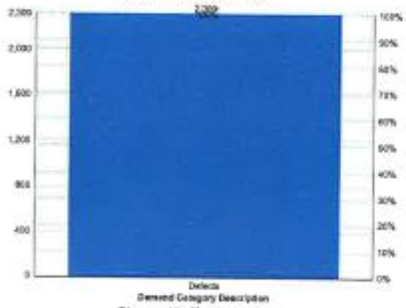


Diagram 14 - Type of Enquiry

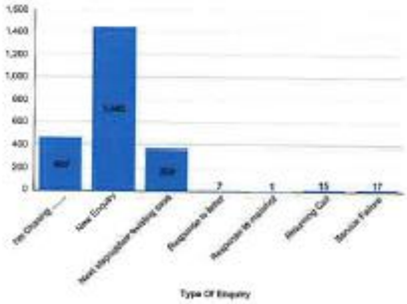


Diagram 15 - Month created

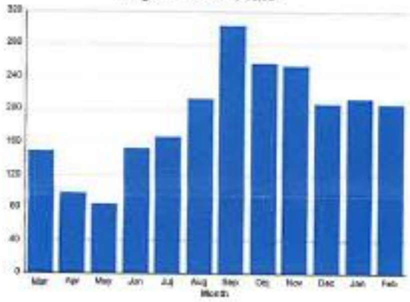
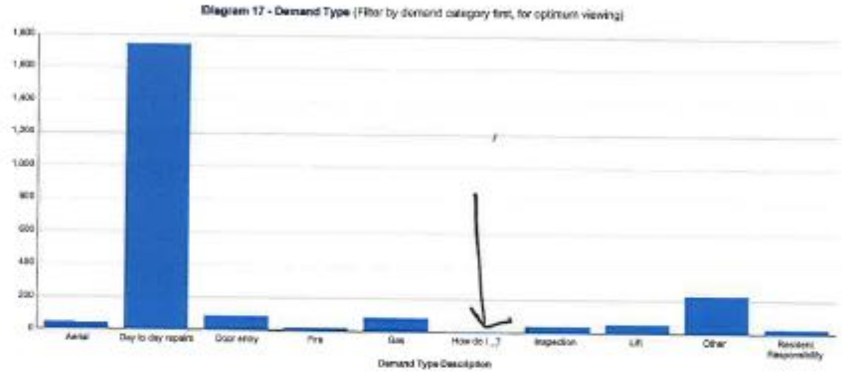


Diagram 17 - Demand Type (Filter by demand category first, for optimum viewing)



Overview of HA08’s post-handover defects management procedure

POST HANDOVER

Defects Administration

[redacted]

Post Handover: Defects Administration

Introduction

[redacted]

The [redacted] Co-ordinator is responsible for processing the [redacted] tenures [redacted] also handle defects for [redacted] outright sale homes. The Service Centre will [redacted] telephone support during office hours for periods when the Aftercare Co-ordinator is [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] Managed Homes

The following procedures apply in respect of remedying defects during the Defects Liability Period (DLP) for all newly built homes.

[redacted].

1. At least 3 months prior to handover the project manager should complete the [redacted] in accordance with the process referred to in the Client Liaison section. It is important [redacted] database before handover.
2. Form [redacted] must be completed immediately any unit is handed over and sent to the Aftercare Co-ordinator at [redacted] copied to others as per the mailing list contained within the form.

> The "Planned Maintenance Module" (PMM) is the software used by [redacted] to record handover dates and related information as set out on the J4 form. In particular it links properties to a "contract" that provides details of the contractor for the DLP. The PMM application assumes that all properties are input at the outset and it is therefore important to provide a list of all the properties in a scheme at the time of the first handovers in a phased scheme (this is in order to avoid setting up multiple entries for the same scheme). In order to do this the [redacted] form requires that a list of all the properties are provided once only at the first set of handovers so that the Aftercare Co-ordinator can enter these into the PMM. In rare cases when changes to postal addresses/units occur after the first series of handovers the project manager will need to send a revised list and details to the Aftercare Co-ordinator.

3. For all new homes the Aftercare Co-ordinator enters details from the [redacted] into the [redacted] Module that links to the [redacted] system. The Aftercare Co-ordinator will also set up details of the main contractor and main consultant in [redacted]. Together this provides the Service Centre with information that a unit is in defects and enables the processing of repair requests accordingly via the main contractor.
4. The Project Manager should forward copies of outstanding works at handover to the generic email address [redacted] to inform the Aftercare Co-ordinator of the status of existing defects. Properties should be listed by postal address as well as plot number.

Note: The reinvestment team is responsible for recording handover and defects period information in the Planned Maintenance Module for major repairs schemes.

> ***Wherever possible the Group wants to send defects to contractors by email.***
>
> - The project managers should raise this with the main contractor before handover. It is important that the contractor can provide a mailbox that acts as a central collection point for all reported defects and enquiries. The mailbox should be continually monitored by staff capable of forwarding the contents to the appropriate person in their organisation or taking appropriate action themselves to ensure that defects are remedied promptly in accordance with contractual requirements.

- When defects job tickets are emailed to the contractor there is an additional facility in the system that automatically copies the emailed job ticket to both the Employer's Agent (or contract administrator) and the project manager for information. The project manager should therefore ensure that consultants are able to provide an appropriate mailbox address that acts as a central collection point for all reported defects and enquiries. The mailbox should be continually monitored by staff capable of forwarding the contents to the appropriate person in their organisation.
- The [redacted]must contain email addresses appropriate for each individual scheme.

4. The Development Analyst uses the information on the [redacted]o audit information in the [redacted]Database.
5. The Aftercare Co-ordinator passes the relevant information from the [redacted]e Out of Hours (OOH) contractor who provides emergency repair cover for [redacted] via a separate contract. It is important that information on any out of hours cover that the main contractor is willing to provide during the defects period is carefully noted on the [redacted] so that the OOH contractor receives this information.
6. [redacted] tenants and residents should be given the direct dial number for reporting defects to the Aftercare Co-ordinator. This number will divert to the OOH contractor outside office hours. The project manager should ensure that tenants managed by another RSL are given appropriate contact details.
7. When a tenant reports a repair on a property that is within the defects liability period, the Aftercare Co-ordinator forwards details to the main contractor on a job ticket.
8. If a tenant or resident reports an emergency defect outside of normal working hours OOH contractor will record the details and pass on to the contractor's OOH service, if one is provided. In the absence of an emergency service from the main contractor, the OOH contractor will arrange for someone to attend site to 'make safe', and will send details of the fault and any action taken to [redacted]so that the Aftercare Co-ordinator can log and progress the [redacted]o the office.
9. The Aftercare Co-ordinator will regularly chase up completion notices from contractors and will notify the project manager of any information they have been unable to obtain. The project manager should contact contractors and Employer's Agents to follow up as appropriate.
10. If the Aftercare Co-ordinator is unsure of whether or not an item is a defect, or cannot interpret from the residents report what the cause of the defect is, they should contact the Quality Controller (QC), giving them the resident's contact and access details as well as information about the reported defect. The Quality Controller should arrange to inspect the defect and report back to the Aftercare Co-ordinator as soon as possible. It is important that during this process the resident is made aware of the diagnosis process and any subsequent remedy recommended by the QC. If the QC finds that there is a defect on site then it should be logged and remedied in the normal way.
11. For items that are found not to be contractual defects, the Aftercare Co-ordinator should follow the Non-defects Process.

Note: The Project Manager must keep the Aftercare Co-ordinator updated on progress with defects by emailing [redacted] whenever the status of a defect changes.

The Project Manager must also ensure that the information stored on [redacted] is up to date by emailing [redacted]mmediately at [redacted] if there are changes to the contact details outlined in the [redacted]orm. This email should contain the exact information that is required to go on [redacted] along with a note of whether the information applies to the whole scheme or just individual blocks. The Project Manager should make it clear that this information should be updated urgently.

Any changes should also be immediately forwarded to the OOH contractor, so that they have an up to date record, as they are unable to access Orchard.

The project manager remains responsible for their projects during [redacted] defects liability period. In particular they are responsible for:

1. Assisting the Aftercare Co-ordinator when requested to make decisions on whether a repair request can be designated as a defect.
2. Providing the Aftercare Co-ordinator with simple supplementary information on any special features / modern technology in a particular scheme.
3. Noting defects reported on schemes, either by reviewing job tickets [redacted] automatically copied by email or by using [redacted] to view [redacted] history.
4. Informing the Aftercare Co-ordinator of any reported repairs that they do not consider to be defects.
5. Looking for any repeated failures of a building component e.g. multiple boiler breakdowns and investigating and following up with the contractor (with the help of the Employer's Agent/Contract Administrator).
6. Investigating if a large volume of job tickets are issued. Volume itself is an indication of problems and the project manager should find out what is going wrong and discuss any appropriate action with the help of the Employer's Agent / Contract Administrator).
7. Taking appropriate follow up action if the OOH Contractor reports attendance at an emergency defect including completing the counter-charge form [redacted]
8. Noting the history of defects, monitoring ongoing reports and using these for information at the end of the DLP inspection.
9. Notifying the Aftercare Co-ordinator when units can be "closed off" after the end of the DLP.

Note that there is separate guidance on handling Complaints about defects in Complaints Handling.

Liquidation Procedure - when a contractor goes into administration during the defects period

Should a contractor go into administration during the defects liability period the Project Manager should immediately contact the administrator to establish a procedure for dealing with defects and any retention that is held by [redacted]

Standard procedure in such circumstances is for the group to remedy defects themselves and charge all costs against the retention. The Project Manager should contact the Aftercare Co-ordinator to inform them that the contractor has gone into liquidation and will not be handling defects, requesting that the Aftercare Co-ordinator continue to assess whether repairs reported are defects or not and record this on [redacted] and instructing them to arrange for repairs to be carried out in the same way as for non-defects.

HA12

Extract from HA12's defects log

Site	Plot	Dates raised	Log ref	Issue	Abstract	Where	Category
400 4	1	03/02/2015	11979	22899	SHELF - WARDROBE - REINFORCE	BED1	GENLAB
400 4	1	03/02/2015	11979	22901	SHOWER DROPPED - ENSUITE	EN1	GENLAB
400 4	1	03/02/2015	11979	22902	LEAK - KITCHEN SINK	KITCHE N	PLUMBNG
400 4	1	13/02/2015	12170	23345	MANHOLE COVER - BROKEN - IN PA	EXT	GENLAB
400 4	3	15/01/2015	11622	22017	door - top floor bedroom - ope	BED1	CARPTRY
400 4	3	18/02/2015	12254	23478	MERLIN ESTATES REPONSIBILITY -	EXT	ROADS
400 4	3	22/06/2015	14390	28972	fence - back garden - posts rotted - fence not secured to wall - NFA	GARDEN	FENCING
400 4	5	04/02/2015	11995	22936	MAN HOLE COVER - EXTERNAL BLOC	EXT	GENLAB
400 4	6	18/02/2015	12253	23477	ceiling - master bedroom - wet	BATH	PLUMBNG
400 4	6	25/03/2015	12786	24876	TOILET - CLOAKROOM - CONSTANTL	CLOAK	PLUMBNG
400 4	7	22/01/2015	11760	22379	MANHOLE COVER - PARKING SPACE	EXT	GENLAB
400 4	7	02/02/2015	11943	22806	FLEXI HOSE - COOKER EXTRACTOR FAN - NOT BEEN FITTED CORRECTLY	KITCHE N	APPLIANC
400 4	7	02/02/2015	11944	22807	MAKING GOOD - KITHCEN - Once w	KITCHE N	GENLAB
400 4	7	16/02/2015	12187	23373	EXTRACTOR FAN - ENSUITE - Home	EN1	ELECTRL
400 4	7	18/02/2015	12248	23463	2 EXTERNAL HALF LATERNS - STAY	EXT	ELECTRL
400 4	7	05/03/2015	12494	24013	EXPANSION VESSELS- DOES THERE	WHOLE HSE	PLUMBNG
400 4	7	31/03/2015	12896	25089	EMAIL - FENCE AND ACCESS GATE	EXT	GENLAB
400 4	7	01/05/2015	13507	26591	DOOR HANDLE - DINNING ROOM - F	LOUNGE	GENLAB
400 4	7	10/06/2015	14178	28399	SERVICE PLATE - LOUNGE -	LOUNGE	ELECTRL
400 4	7	10/06/2015	14178	28400	CEILING LIGHT - ENSUITE -	EN1	ELECTRL
400 4	7	22/06/2015	14392	28974	CEILING BOARD - CAR PORT - PLO	EXT	GENLAB
400 4	7	08/09/2015	15917	33656	MAKING GOOD - LOUNGE WALL - FO	LOUNGE	GENLAB
400 4	9	21/01/2015	11740	22313	CLOAKROOM TOILET - WHEN FLUSHE	CLOAK	PLUMBNG
400 4	9	22/04/2015	13316	26161	CEILING JOINT - DOWNSTAIRS LOUNGE -	LOUNGE	GENLAB
400 4	9	22/04/2015	13316	26162	DOOR - ENSUITE MASTER BEDROOM - STICKING	EN1	GENLAB
400 4	9	22/04/2015	13316	26163	HEAVY CRACK LINE - TOP LANDING -	STAIRS	GENLAB
400 4	9	22/04/2015	13316	26166	CRACKS - BANNISTER & UPRIGHTS	STAIRS	GENLAB
400 4	9	22/04/2015	13316	26167	CRACK LINE - TOP FLOOR BATHROOM - CORNER WALL	BATH	GENLAB

Appendix 4: Proposed defects categorisation

This categorisation was based upon NHBC's categorisation.

Building Element	Sub Element
MVHR	
GSHP	
ASHP	
CHP	
PV	
Solar Panel	
Land quality	
Building near trees	
Strip and trench fill foundations	
Raft, pile, pier & beam foundations	
Raft foundations	
Piled foundations	
Pier and beam foundations	
Vibratory ground improvement	
Walls below dpc	Stability
Walls below dpc	Masonry
Walls below dpc	Mortar mix
Walls below dpc	Clear cavity
Substructure & ground bearing floors	Ground floor slab - thickness
Substructure & ground bearing floors	Ground below fill
Substructure & ground bearing floors	Fill provides full and consistent support
Substructure & ground bearing floors	Hazardous material in fill
Substructure & ground bearing floors	Backfill to trenches adequately compacted
Substructure & ground bearing floors	Blinding
Substructure & ground bearing floors	Damp proof membrane
Substructure & ground bearing floors	Damp proof course
Substructure & ground bearing floors	Thermal insulation
Substructure & ground bearing floors	Slab level
Basements	Tanking
Basements	DPCs and cavity trays
Basements	Drainage
Basements	Pump system
Basements	Movement joints
Basements	Structural stability
Suspended ground floors	Resistance to ground contaminants
Suspended ground floors	Radon protection
Suspended ground floors	Damp-proofing
Suspended ground floors	Ventilation
Suspended ground floors	In-situ concrete floor
Suspended ground floors	Pre-cast concrete floor
Suspended ground floors	Timber floor
Suspended ground floors	Thermal insulation
Suspended ground floors	Softwood boarding - fixing
Suspended ground floors	Chipboard flooring - type/fixing
Suspended ground floors	Oriented strand board - type/fixing
Suspended ground floors	Plywood decking - fixing
Suspended ground floors	Other proprietary decking - fixing

Drainage below ground	Inappropriate design
Drainage below ground	Design to minimise risk of blockage
Drainage below ground	Laying pipework
Drainage below ground	Protection of pipework
Drainage below ground	Construction of access points and gullies
Drainage below ground	Cesspools
Drainage below ground	Septic tanks/treatment plants
Drainage below ground	Surface water soakaways
Drainage below ground	Testing for obstructions
Drainage below ground	Damage by construction work
External masonry walls	Fire resistance
External masonry walls	Bricks - materials
External masonry walls	Blocks - materials
External masonry walls	Stone masonry - materials
External masonry walls	Mortar
External masonry walls	Cavity trays
External masonry walls	Dpcs
External masonry walls	Wall ties
External masonry walls	Lintels
External masonry walls	Thermal insulation
External masonry walls	Rendering
External timber framed walls	Timber grade
External timber framed walls	Timber preservation/durability
External timber framed walls	Movement joints
External timber framed walls	Inadequate anchoring
External timber framed walls	Inadequate fixings
External timber framed walls	Inadequate cavity width
External timber framed walls	Breather membranes
External timber framed walls	Wall ties
External timber framed walls	Thermal insulation
External timber framed walls	Vapour control layers
External timber framed walls	Cavity barriers/fire-stopping
Internal walls	Bricks/blocks - type/strength
Internal walls	Timber - grade
Internal walls	Timber - moisture content
Internal walls	Plasterboard - thickness/type
Internal walls	Damp-proof courses
Internal walls	Masonry partitions - construction
Internal walls	Timber stud partitions - construction
Internal walls	Proprietary partitions - construction
Internal walls	Sound insulation - separating walls
Internal walls	Sound insulation - partitions to WC
Internal walls	Fire resistance
Timber/concrete upper floors	Sound insulation
Timber/concrete upper floors	Timber joists - selection/location/support
Timber/concrete upper floors	Joist hangers
Timber/concrete upper floors	Joist cut and fit to hangers
Timber/concrete upper floors	Trimmed/trimming joists supported
Timber/concrete upper floors	Joists trimmed to steelwork
Timber/concrete upper floors	Multiple joists fixed together
Timber/concrete upper floors	Strutting of floor joists
Timber/concrete upper floors	Notching and drilling of joists

Timber/concrete upper floors	Softwood boarding
Timber/concrete upper floors	Chipboard flooring - type/thickness
Timber/concrete upper floors	Chipboard flooring - fixing
Timber/concrete upper floors	Oriented strand board flooring
Timber/concrete upper floors	Plywood flooring
Timber/concrete upper floors	Proprietary floor decking
Timber/concrete upper floors	Timber floating floors
Timber/concrete upper floors	In-situ concrete floors
Timber/concrete upper floors	Precast concrete floors
Timber/concrete upper floors	Fire-stopping
Steelwork	Structural performance
Steelwork	Durability
Staircases	Timber staircases
Staircases	Joinery finish
Staircases	Concrete staircases
Staircases	Handrails
Staircases	Balustrades
Doors, windows & glazing	Security - resistance to unauthorised entry
Doors, windows & glazing	Timber durability/treatment
Doors, windows & glazing	Glazing - materials not to standards
Doors, windows & glazing	Protection against damp
Doors, windows & glazing	Ironmongery
Doors, windows & glazing	Location and fixing
Doors, windows & glazing	Glazing - protection from damage
Doors, windows & glazing	Glazing - installation
Fireplaces chimneys & flues	Unsuitable bricks
Fireplaces chimneys & flues	Mortar mix
Fireplaces chimneys & flues	Fireplaces and hearths
Fireplaces chimneys & flues	Flues
Fireplaces chimneys & flues	Chimneys
Fireplaces chimneys & flues	Terminals
Fireplaces chimneys & flues	Provision of combustion area
Curtain walling & cladding	Curtain walling - location / fixing
Curtain walling & cladding	Curtain walling - weather resistance
Curtain walling & cladding	Curtain walling - glazing
Curtain walling & cladding	Curtain walling - control of condensation
Curtain walling & cladding	Curtain walling - allowance for movement
Curtain walling & cladding	Curtain walling - within tolerances
Curtain walling & cladding	Rainscreen - location/fixing
Curtain walling & cladding	Rainscreen - weather resistance
Curtain walling & cladding	Rainscreen - allowance for movement
Curtain walling & cladding	Rainscreen - within tolerances
Curtain walling & cladding	Insulated render - fixing
Curtain walling & cladding	Insulated render - weather resistance
Curtain walling & cladding	Insulated render - within tolerances
Curtain walling & cladding	Brick slip cladding - fixing
Curtain walling & cladding	Brick slip cladding - weather resistance
Curtain walling & cladding	Slate/tile hanging
Curtain walling & cladding	Timber cladding
Curtain walling & cladding	UPVC Cladding
Curtain walling & cladding	Brick slip cladding
Light steel framed walls/floors	Loadbearing walls/external infill walls

Light steel framed walls/floors	Insulation
Light steel framed walls/floors	Breather membranes
Light steel framed walls/floors	Wall ties and fixings
Light steel framed walls/floors	Vapour control layers
Light steel framed walls/floors	Cladding
Light steel framed walls/floors	Non-loadbearing internal walls
Light steel framed walls/floors	Separating walls - sound insulation
Light steel framed walls/floors	Joists - type/location/support
Light steel framed walls/floors	Joists - drilling/holes
Light steel framed walls/floors	Joists - restraint strapping
Light steel framed walls/floors	Joists - overlapping
Light steel framed walls/floors	Joists - reinforcement
Light steel framed walls/floors	Decking/ceilings - fixing
Light steel framed walls/floors	Separating floors - sound insulation
Light steel framed walls/floors	Services - protection from damage
Light steel framed walls/floors	Fire resistance
Flat roofs & balconies	Structural timber
Flat roofs & balconies	Galvanised steel
Flat roofs & balconies	Aluminium
Flat roofs & balconies	GRP
Flat roofs & balconies	Other materials
Flat roofs & balconies	In-situ reinforced concrete structure
Flat roofs & balconies	Pre-cast concrete structure
Flat roofs & balconies	Profiled metal roof
Flat roofs & balconies	Timber structure
Flat roofs & balconies	Structural decks
Flat roofs & balconies	Drainage
Flat roofs & balconies	Thermal insulation/vapour control layer
Flat roofs & balconies	Waterproofing
Flat roofs & balconies	Guarding to balconies
Pitched roofs	Design of loadbearing structure
Pitched roofs	Design/capacity of roof drainage
Pitched roofs	Timber durability
Pitched roofs	Wall plates
Pitched roofs	Restraint/holding down straps
Pitched roofs	Trussed rafters - storage/handling
Pitched roofs	Trussed rafters - erection
Pitched roofs	Trussed rafters - bracing
Pitched roofs	Trad cut roof - timber size/grade
Pitched roofs	Trad cut roof - stability
Pitched roofs	Water tank supports
Pitched roofs	Fascias, bargeboards & soffits
Pitched roofs	Installation of roof covering
Pitched roofs	Flashings and weatherings
Pitched roofs	Fire stopping
Pitched roofs	Thermal insulation
Pitched roofs	Ventilation
Pitched roofs	Roof drainage
Internal services	Cold water service - design
Internal services	Hot water service - design
Internal services	Electrical service - design
Internal services	Gas service - design

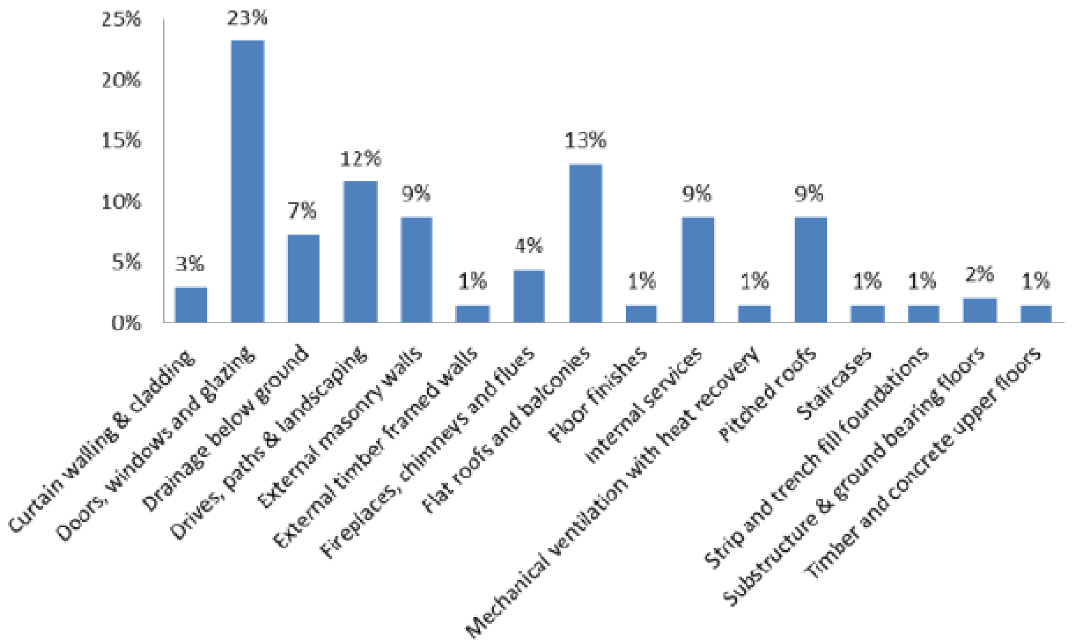
Internal services	Space heating - design
Internal services	Soil & waste systems - design
Internal services	Precautions against corrosion
Internal services	Materials and appliances
Internal services	Extract ducts - installation
Internal services	Hot/cold water service - installation
Internal services	Electrical service - installation
Internal services	Gas service - installation
Internal services	Meters - installation
Internal services	Space heating - installation
Internal services	Soil & waste systems - installation
Wall and ceiling finishes	Plastering
Wall and ceiling finishes	Plasterboard and dry lining
Wall and ceiling finishes	Ceramic wall tiling
Floor finishes	Screeding
Floor finishes	Tile finishes
Floor finishes	Flexible sheet and tile finishes
Floor finishes	Wood finishes
Finishing and fitments	Cupboards and fitments
Finishing and fitments	Finishings and internal trim
Finishing and fitments	Protection from damage
Painting and decorating	Painting on wood
Painting and decorating	Painting on metal
Painting and decorating	Painting on masonry or render
Painting and decorating	Painting on plaster or dry-lining
Painting and decorating	Wood stain and varnishing
Painting and decorating	Wallpapering
Garages	Damp proof course
Garages	Doors, windows and glazing
Garages	Floors
Garages	Foundations
Garages	Lintels and beams
Garages	Mortar
Garages	Roof
Garages	Wall ties
Garages	Walls
Drives, paths & landscaping	Provision of access to home
Drives, paths & landscaping	Garden areas - waterlogging
Drives, paths & landscaping	Patios and decking
Drives, paths & landscaping	Ground stability
Drives, paths & landscaping	Roads, drives, car parks & paths
Drives, paths & landscaping	Freestanding walls/retaining structures
Drives, paths & landscaping	Garden areas - free from obstructions
Drives, paths & landscaping	Garden areas - prepared for cultivation
Drives, paths & landscaping	Guarding, handrails & steps
Drives, paths & landscaping	Landscaping

Damage Description
No Damage
Inevitable future damage
Unsatisfactory finishes
Cracking / movement
Damp / water penetration
Loose / missing
Failure to perform
Erosion
Spalling / delamination
Corrosion / decay / rot
Sound transmission
Risk to health and safety
Contamination
Condensation

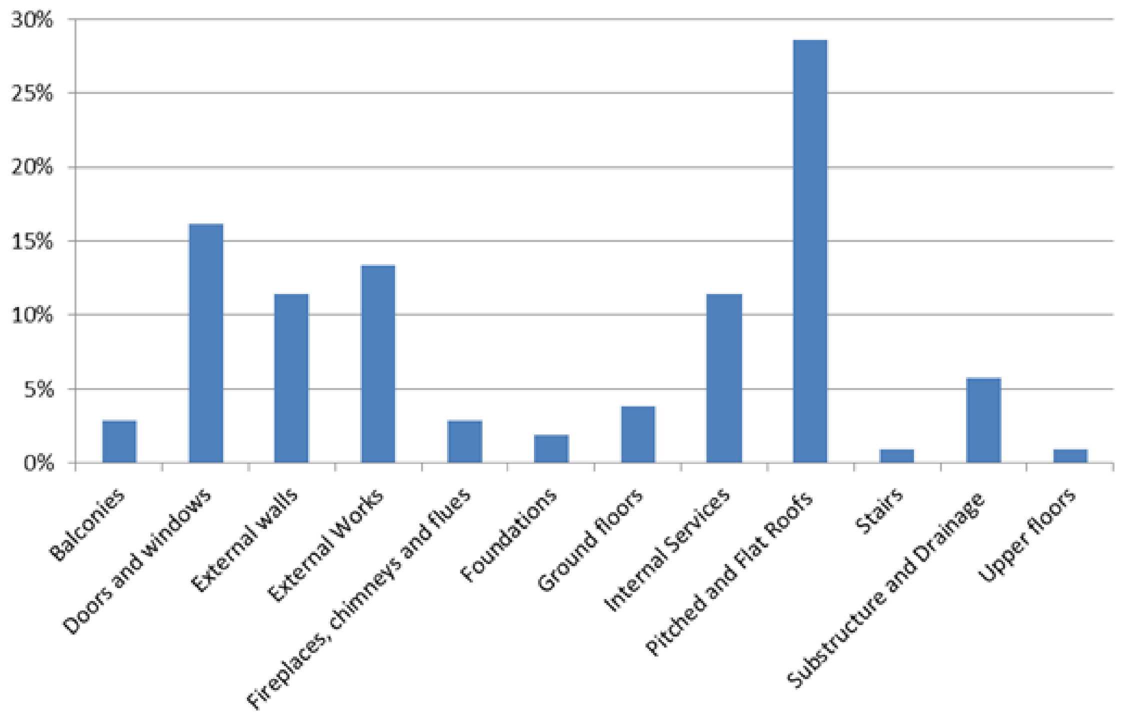
Appendix 5: Analysed defect data

HA02

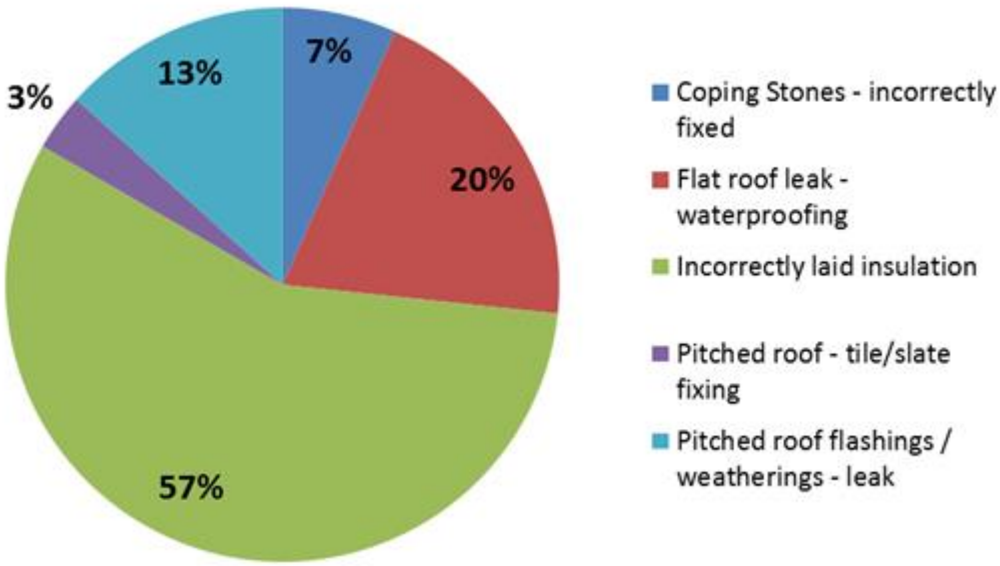
<u>Original defects log</u>



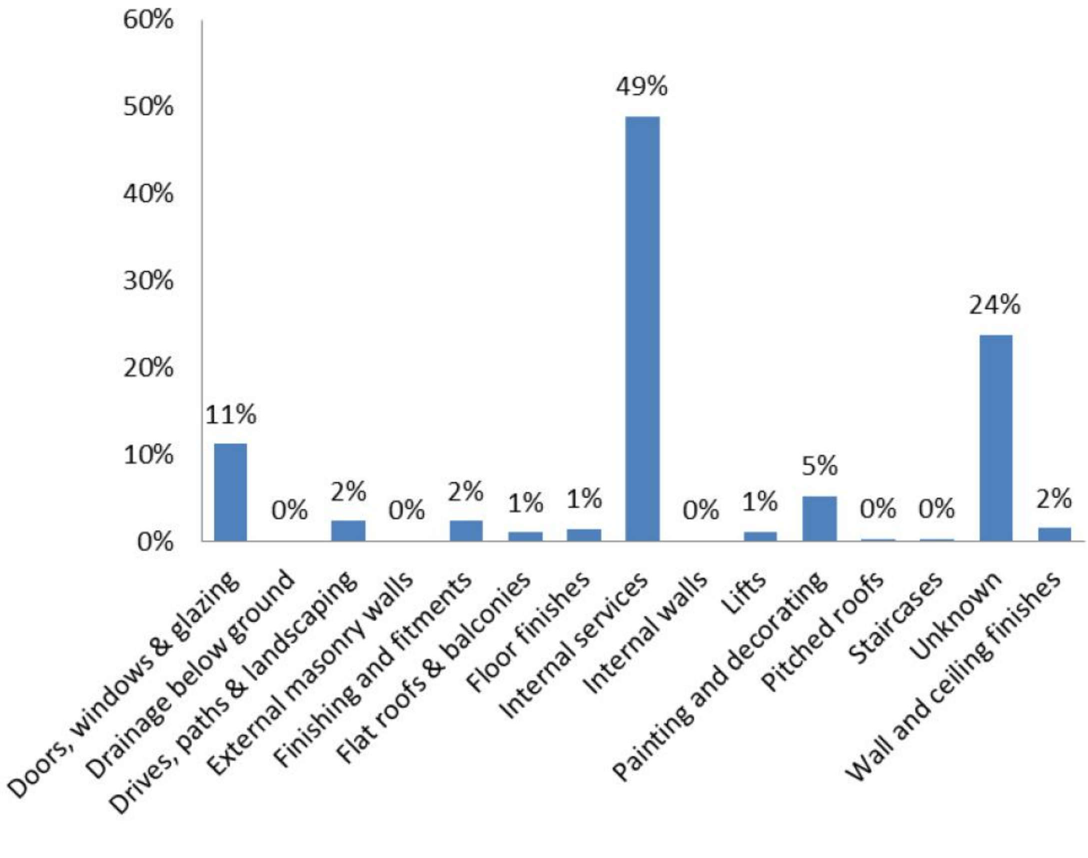
<u>Second defects log (for live data dashboard)</u>



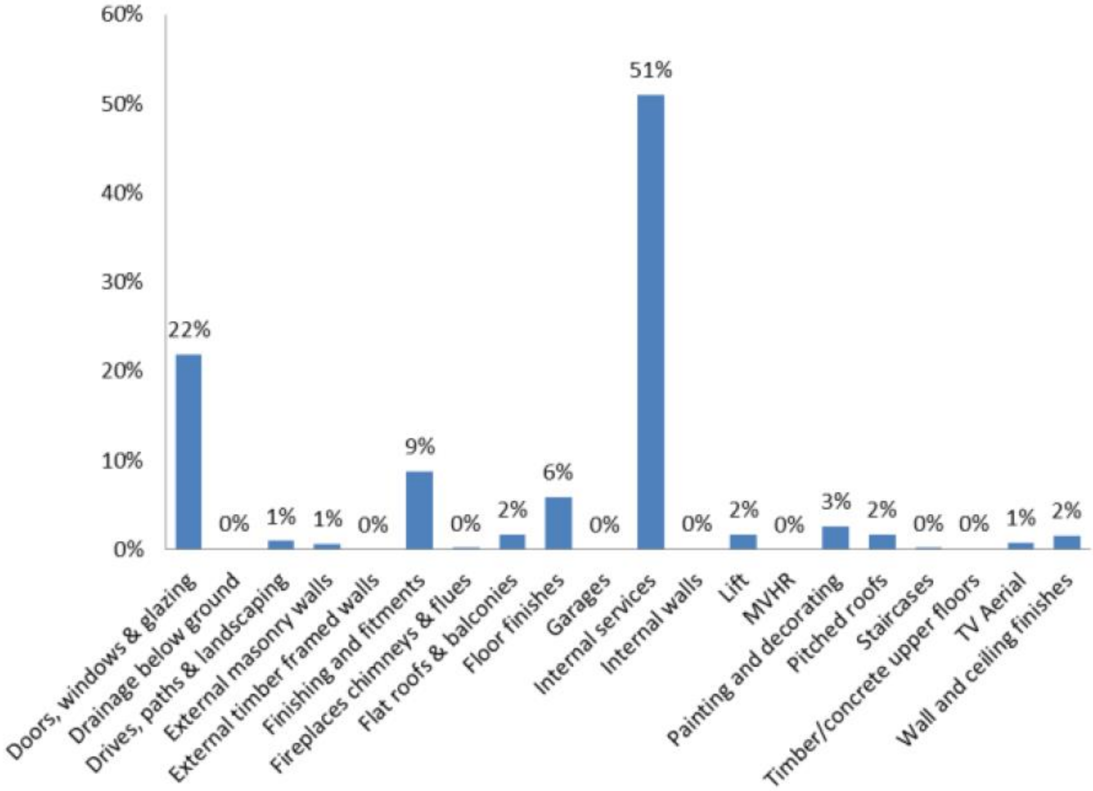
Roof defects (as identified from live data dashboard analysis



HA04



HA07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6%
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3%
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0%
1%
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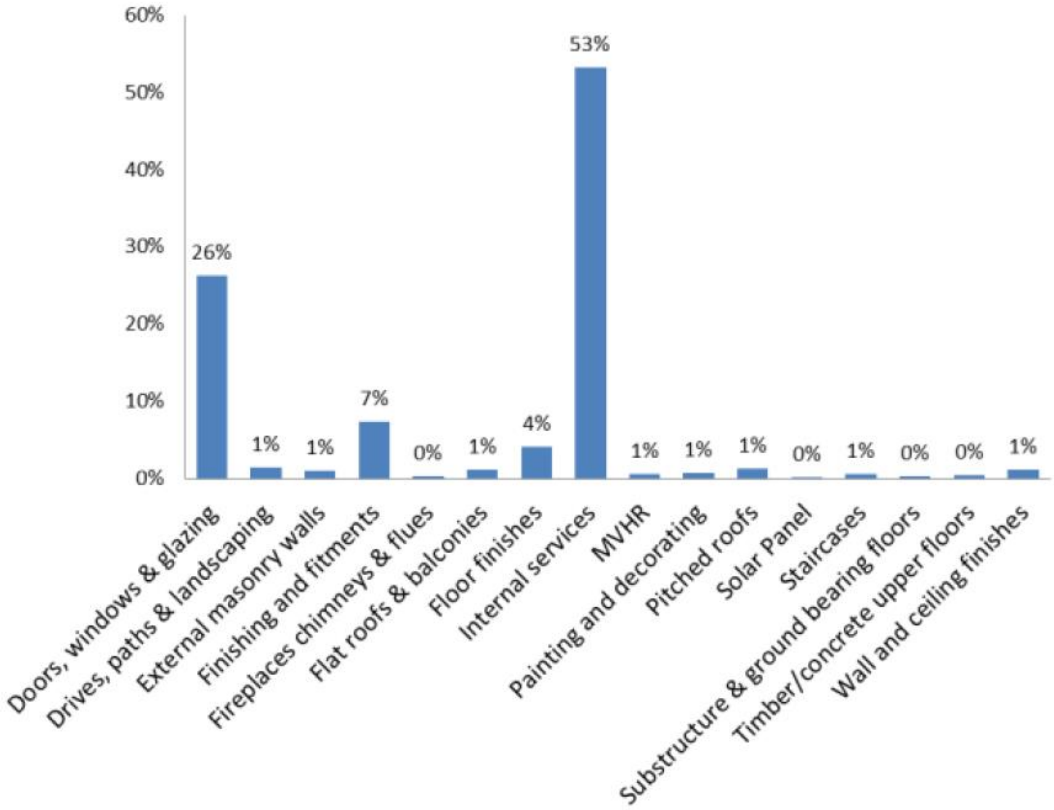
Doors, windows & glazing
Drainage below ground
Drives, paths & landscaping
External masonry walls
External timber framed walls
Finishing and fitments
Fireplaces chimneys & flues
Flat roofs & balconies
Floor finishes
Garages
Internal services
Internal walls
Lift
MVHR
Painting and decorating
Pitched roofs
Staircases
Timber/concrete upper floors
TV Aerial
Wall and ceiling finishes

HA08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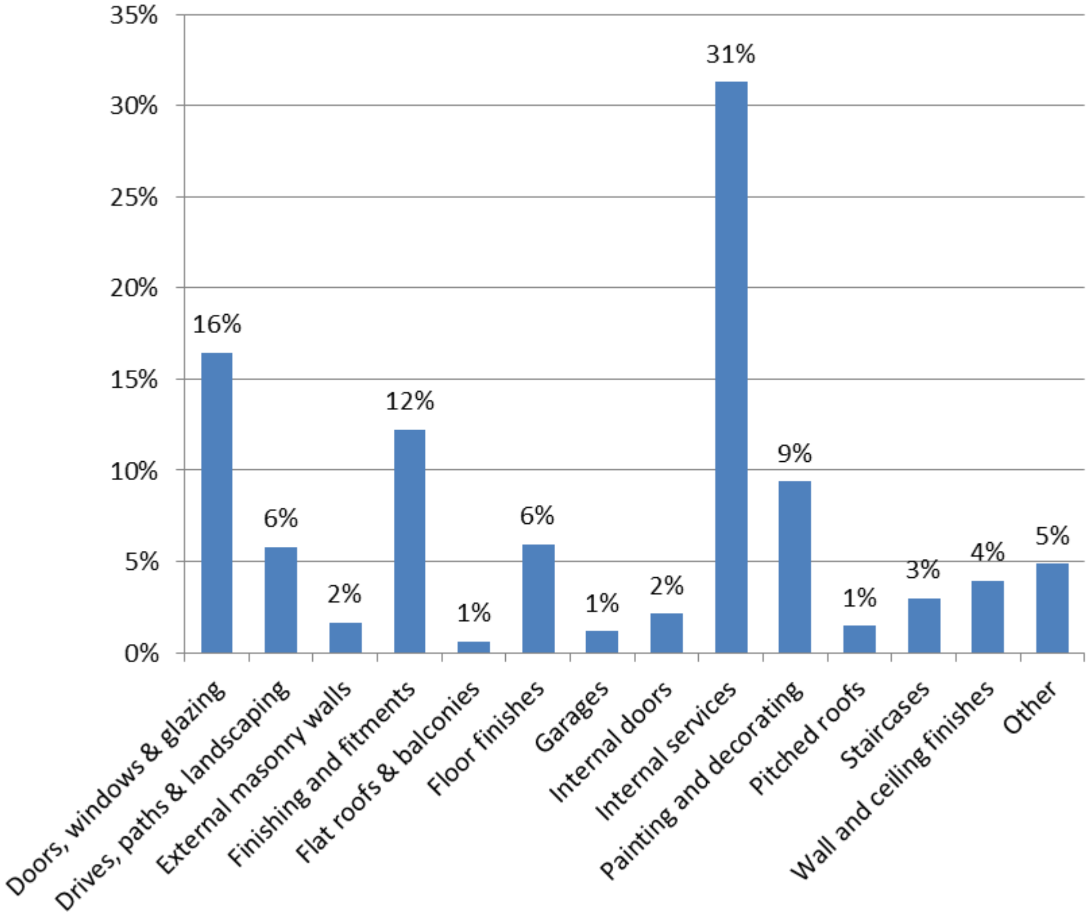
Doors, windows & glazing
Drives, paths & landscaping
External masonry walls
Finishing and fitments
Fireplaces chimneys & flues
Flat roofs & balconies
Floor finishes
Internal services
MVHR
Painting and decorating
Pitched roofs
Solar Panel
Staircases
Substructure & ground bearing floors
Timber/concrete upper floors
Wall and ceiling finishes

HA12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1%
3%
4%
5%
Doors, windows & glazing
Drives, paths & landscaping
External masonry walls
Finishing and fitments
Flat roofs & balconies
Floor finishes
Garages
Internal doors
Internal services
Painting and decorating
Pitched roofs
Staircases
Wall and ceiling finishes
Other