Construct NSW

Digitalisation of Construction

Industry Report on

Digitalisation of Design and Construction of Class 2 Buildings in New South Wales

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NSW GOVERNMENT

WESTERN SYDNEY UNIVERSITY

Centre for Smart Modern Construction

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This report is an outcome of the contract research awarded to Professor Srinath Perera and Associate Professor Xiaohua Jin at the Centre for Smart Modern Construction (c4SMC) by the Office of the NSW Building Commissioner (OBC) to investigate into the state of digitalisation of the class 2 building sector of the NSW construction industry and develop a strategic framework that facilitates practicable and effective implementation, and enhances industry capability to meet the requirements of the *Design and Building Practitioners Act 2020*.

The authors wish to extend their gratitude to the OBC for entrusting the research team at c4SMC with this research project. Furthermore, the c4SMC wish to acknowledge the contributions of Matt Press, Yolande Nyss and Rebecca Evans for their inputs throughout the project, especially during survey design and its execution.

In addition to all designers and builders who responded to the survey, the c4SMC acknowledges contributions from the following institutions for encouraging their members to participate in the survey.

- Building Designers Association of Australia (BDAA)
- Australian Institute of Architects (AIA)
- Association of Consulting Architects Australia (ACA)
- Housing Industry Association (HIA)
- Engineers Australia (EA)
- Master Builders Association (MBA)

Finally, c4SMC wishes to thank all the nine interview participants, who represented NSW designers, builders, and software service providers for not only providing valuable insights at the interviews but also for participating in the pilot survey and further consultations.

Further information

For more information on this research, please visit Centre for Smart Modern Construction (c4SMC) website at: https://www.westernsydney.edu.au/c4smc

For more information or to comment on the report, please send an email to: c4smc@westernsydney.edu.au

MESSAGE FROM THE NSW BUILDING COMMISSIONER

It is with great pleasure I present the report on Digitalisation of Design and Construction of class 2 buildings in NSW. This piece of work is carried out to align with the implementation of *Design and Building Practitioners Act 2020*. To successfully navigate this new landscape, construction professionals are expected to refine their formal qualifications and become digital ready. Furthermore, digital capabilities will be fundamental to fully grasp the construction 4.0 opportunities that are now evolving in the construction sector.

This research, led by Professor Srinath Perera together with Associate Professor Sean Jin and their research team at the Centre for Smart Modern Construction (c4SMC), Western Sydney University, set out to investigate the state of digitalisation of the class 2 building sector of the NSW construction industry. It was a comprehensive study, where data was obtained via online survey and interviews from NSW designers and builders who are involved in class 2 building construction.

I wish to thank all of the professional bodies that supported this work and all designers and builders who participated in the survey and interviews - your views and time are much appreciated. I also acknowledge the NSW Government and the Hon. Kevin Anderson MP, Minister for Better Regulation and Innovation, for their ongoing support with the implementation of the Construct NSW transformation of which digitisation, capability building, law reform and research are key Pillars.

Finally, I wish to thank Professor Srinath Perera, the Director of the Centre, and his research team for their tireless efforts in delivering high quality research outcomes. Congratulations c4SMC on the successful completion of this project!

Adjunct Professor David Chandler OAM
NSW Building Commissioner

Image Source: Office of the Building Commissioner NSW

MESSAGE FROM THE DEAN, SCHOOL OF ENGINEERING, DESIGN AND BUILT ENVIRONMENT, WESTERN SYDNEY UNIVERSITY

I am pleased to present the report on Digitalisation of Design and Construction of class 2 buildings in NSW - a research led by Professor Srinath Perera together with Associate Professor Sean Jin and their research team at the Centre for Smart Modern Construction (c4SMC), Western Sydney University. The c4SMC was established in August 2017 as a unique industry collaborative research centre with the prime focus on engaging industry and developing the construction industry and its research and education platforms.

Digitalisation of Design and Construction is an industry relevant research to develop a classification of digital capabilities of designers and builders in NSW for class 2 buildings in order to facilitate the new regulations coming into effect with the *Design and Building Practitioners Act 2020*. Hence, it is anticipated that the research findings presented in this report would make significant contribution to the NSW construction sector. In addition, it would be contributing to the global discourse on digitalisation in the construction sector.

I would like to thank the NSW Building Commissioner - David Chandler OAM for entrusting this research project to c4SMC and his project team for support in coordinating the survey. While congratulating c4SMC on the successful completion of this project, I wish to thank Professor Srinath Perera, the Director of the Centre, and his team for their tireless efforts. The innovative, collaborative and inclusive way in which you work is impressive. I look forward to seeing more innovative and progressive projects led by c4SMC over the coming years.

Professor Mike Kagioglou

Pro Vice-Chancellor (International) – Europe and UK
Dean, School of Engineering, Design and Built Environment
Western Sydney University

Image Source: Kasun Gunasekara

ABOUT THE AUTHORS

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Professor Srinath Perera is the founding Director for the Centre for Smart Modern Construction (c4SMC) and holds a personal chair in Built Environment and Construction Management in the School of Engineering, Design & Built Environment at Western Sydney University. He is a Chartered Quantity Surveyor and a Fellow of the Australian Institute of Builders. He was admitted as a Fellow of the Royal Society of New South Wales in 2017. He is also a member of the Australian Institute of Project Management and the Australian Institute of Quantity Surveying. He is a board member of the International Council for Research and Innovation in Building and Construction (CIB). He holds a PhD from University of Salford, UK. Professor Perera is a pioneer in the field of construction informatics where his work contributed to the integration of AI technologies to construction management subsequently developing his research in the area of e-business and Blockchain in construction. He has over 200 peer reviewed publications and textbooks. He has received over 20 million dollars in research grants in his research career.

Dr Xiao-Hua (Sean) Jin, Associate Professor in Project Management, Western Sydney University

Dr Xiao-Hua (Sean) Jin is an Associate Professor in Project Management and the Director of Project Management Programs at Western Sydney University. He was a construction project manager before shifting to academia. He holds a PhD from the University of Melbourne, Australia. His main research interests include construction economics; project management; risk management; infrastructure procurement; relational contracting; and ICT in construction. Dr Jin has published over 100 peer-reviewed technical articles and been engaged in many industry-funded research projects. He received Building Research Excellence Award from the Chartered Institute of Building (CIOB). He is a member of the International Council for Research and Innovation in Building and Construction (CIB), the Australian Institute of Project Management (AIPM), and the International Centre for Complex Project Management (ICCPM). Dr Jin has served as an expert referee for the Australian government. He is also an editorial panel member for several internationally renowned journals.

Marini Samaratunga, Research Associate, Centre for Smart Modern Construction, Western Sydney University

Marini is the research associate for the c4SMC since 2019. She is also a sessional academic in disciplines of Built Environment and Project Management at University of Sydney, Western Sydney University, and University of New South Wales (UNSW). She obtained MSc in Architecture and BSc in Built Environment (Honours) from the University of Moratuwa, Sri Lanka. Marini has over 15 years of professional experience as an academic, researcher and registered international Architect. She is nearing completion of her PhD from UNSW, with a full scholarship from Cooperative Research Centre for Low Carbon Living (CRC for LCL). Her doctoral research is a subset of an NSW public project titled 'Validating and improving the energy performance of BASIX-affected dwellings', which is in collaboration with NSW planning and infrastructure, NSW office of environment and heritage, Department of industry, innovation and science, and City council of Sydney. Her main research interests are in sustainability, energy performance in buildings, and post-occupancy behaviour in energy consumption.

Kasun Gunasekara, Doctoral Researcher, Centre for Smart Modern Construction, Western Sydney University

Kasun is a doctoral researcher and a tutor at the c4SMC conducting research in the fields of data analytics and performance measurement in construction. He is a Certified Quantity Surveyor (CQS) having over five years of professional experience and currently serves as a Councillor at the NSW Chapter of Australian Institute of Quantity Surveyors (AIQS). He obtained BSc (Hons) in Quantity Surveying and PgDip in Construction Law & Dispute Resolution from the University of Moratuwa, Sri Lanka. He is a recipient of the prestigious Iwata Foundation Scholarship from the Pacific Association of Quantity Surveyors (2015) and the Centre for Smart Modern Construction Postgraduate Scholarship (2018). He is also a team member that won 'Constructathon 2019', the first construction hackathon in Australia and a project manager of CIB Student Chapter of Western Sydney University that won the Vice Chancellor's Excellence Award for University Engagement and Sustainability in 2020.

EXECUTIVE SUMMARY

This research project set out to review the state of digitalisation of the class 2 (multi-unit) building sector of the NSW construction industry with specific reference to the production of design drawings and as-built drawings.

It involved a detailed worldwide literature review followed by gathering data through a quantitative survey of class 2 building designers and builders (including developers). The survey also included questions related to the size and structure of these businesses, providing a current market snapshot of NSW's class 2 building sector.

The survey received 542 valid responses from 347 designers and 195 builders, resulting in a sample size that achieved a 90% confidence level. This data was then further verified and expanded through a series of qualitative interviews involving building designers, builders and software service providers representing small, medium and large companies.

A large proportion of the sample were registered members of peak industry bodies representing designers and builders including the Building Designers Association of Australia (BDAA), Australian Institute of Architects (AIA), Association of Consulting Architects Australia (ACA), Housing Industry Association (HIA), Engineers Australia (EA) and Master Builders Association (MBA).

Composition of the Market

The research found that 80% of the designers and builders involved in class 2 construction are businesses with less than 20 employees. Designers were more likely to be employed in micro-level organisations (zero to four employees) (59%) as compared to builders (44%). Across both players only a small proportion (5%) were part of large organisations (over 200 employees).

The experience of designers and builders tended to aggregate within two thresholds: 26% had up to five years of experience and 36% had over 20 years of experience. This result appeared to highlight the challenge of sustaining new businesses and the organisational maturity required to become an experienced operator.

The turnover of businesses appeared to align with their size, with 67% of designers having annual turnovers of less than $1 million and 40% of builders having a turnover of less than $2 million. Investment in research and development (R&D) was low across the sample, with 15% of businesses having no investment at all and 39% investing less than 1% of turnover. Designers and builders tended to outsource IT services, with only 38% of businesses having in-house support.

The digital capability of the workforce was predominantly supported by ad-hoc 'on-the-job' type training (47%), with no specific training occurring within around a third of businesses. The research also found that builders were twice as likely to have no specific digital training as compared to designers.

Current Digital Capabilities

A new strategic framework was developed to categorise the digital capabilities of the designers and builders, with four stages of increasing maturity: basic, advanced, smart and transformative.

The research found that the majority of class 2 builders (57%) and designers (48%) are in a basic stage of digitalisation, either submitting PDF files that have been converted from a computer aided design (CAD) platform or using two-dimensional CAD files. Around 42% of the sector was leaning towards mid-levels of maturity, however less than one-third (29%) had reached a 'smart' capability equivalent to the use of building information models (BIM). The three most popular design software packages were AutoCAD, Revit and Sketch-up, each indicating around 30% usage by both designers and builders.

Key Drivers and Barriers

The research sought to understand the reasons why designers and builders were at their current level of digital maturity and identify the factors likely to support or hinder transformational change into the future.

The top drivers of digitalisation were achieving greater accuracy and trustworthiness (70%), improving quality and standards (66%) and delivering on time, budget and quality (61%). In contrast, the top barriers were the cost of software and licenses (67%), the cost of hardware (57%) and inadequate design fees (55%).

The Future State of Digitisation

Considering all of the responses, the research finds that based on the current state and reported drivers of change it will likely take up to ten years before class 2 designers and builders reach a level of 'smart' digital maturity where advanced capabilities such as BIM and Digital Twins are widespread. Investment in training and capability building would likely be the most impactful enablers for a faster trajectory towards higher digital maturity, followed by work to reduce barriers related to costs and system interoperability supported by a common data environment.

It is suggested that the strategic framework for digitalisation presented in this research could be adopted as a formal method of measuring and facilitating the progressive digitalisation of the sector. It may also be beneficial for other jurisdictions to consider undertaking similar research to help produce a national view.

Construct NSW, Data and Research

Construct NSW is the industry transformation strategy that is being implemented by the NSW Government to build industry capability and confidence in class 2 buildings. Pillar 6 of that strategy deploys research and quantitative data to inform policy and industry engagement. This digitalisation research expands on the strategy's commitment to deliver change through evidence-based insights.

Image Source: Office of the Building Commissioner NSW

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LIST OF ACRONYMS & INITIALISMS

2D/ 3D	:	Two Dimensional/ Three Dimensional
ABD	:	As-Built Drawing
ABS	:	Australian Bureau of Statistics
ACA	:	Association of Consulting Architects Australia
ACCC	:	Australian Competition and Consumer Commission
AEC	:	Architecture, Engineering and Construction
AIA	:	Australian Institute of Architects
AR	:	Augmented Reality
BASIX	:	Building Sustainability Index
BCA	:	Building Code of Australia
BDAA	:	Building Designers Association of Australia
BIM	:	Building Information Model
c4SMC	:	Centre for Smart Modern Construction
CAD	:	Computer Aided Design
CDE	:	Common Data Environment
CNC	:	Computer Numerical Control
DA	:	Development Application
DBP Act	:	Design and Building Practitioners Act
DfMA	:	Design for Manufacture and Assembly
DT	:	Digital Twin
DWG	:	Drawing (CAD programs filename extension)
EA	:	Engineers Australia
ERP	:	Enterprise Resource Planning
FM	:	Facilities Management
HIA	:	Housing Industry Association
ICT	:	Information and Communication Technology
IFC	:	Issued for Construction
IoT	:	Internet of Things
LAN	:	Local Area Network
LiDAR	:	Light Detection and Ranging
MBA	:	Master Builders Association
MR	:	Mixed Reality
NAS	:	Network-Attached Storage
OBC	:	Office of the Building Commissioner
PDF	:	Portable Document Format
PM	:	Project Management
R&D	:	Research and Development
RO	:	Research Objective
SaaS	:	Software as a Service
SFDDC	:	Strategic Framework for Digitalisation of Design and Construction
SME	:	Small and Medium-sized Enterprises
SSP	:	Software Service Provider
V-PDF	:	Vector-based Portable Document Format
VR	:	Virtual Reality

1 INTRODUCTION

The onset of industry 4.0 is affecting all sectors of the economy and construction is no exception. The McKinsey Global Institute report (Manyika et al. 2017) identified construction as the second least digitalised industry globally. The architecture, engineering and construction (AEC) sector is responding to these pressures and the Australian industry is keen to adapt (Gajendran & Perera 2016).

In NSW, there is significant momentum to improve the quality of class 2 building construction. Aligned with the recommendations of Shergold and Weir (2018), NSW Government has pursued a number of reforms including the passage of new legislation and the establishment of the Office of the Building Commissioner led by David Chandler OAM. The *Design and Building Practitioners Act 2020* and the *Residential Apartment Buildings (Compliance and Enforcement Powers) Act 2020* passed by NSW Parliament in June 2020 were designed to restore public confidence in the residential apartment building industry through a range of levers. Further, the *Design and Building Practitioners Act 2020* established new requirements related to design and building documentation to strengthen accountability (Chandler 2019; NSW Legislation 2020).

This research aimed to develop a strategic framework for digitalisation of class 2 building designs and as-built drawing declarations that facilitates a feasible and effective implementation. The report examined the state of digitalisation of the class 2 building sector in NSW. It reviews the state of digitalisation of design drawing practices employed by NSW design practitioners ("designers") and, similarly, the state of digitalisation for as-built drawings (ABD) by NSW building practitioners ("builders").

This research sought to benchmark the state of digitalisation in class 2 building drawings throughout construction from inception through to completion. It also explored the levels of awareness, acceptance, and willingness of related organisations to undertake further digitalisation of their daily building design and construction operations to propose a framework for digitalisation of the sector.

Main Objectives of the Study	
RO #1	To determine the status of digitalisation in producing design drawings by Designers from inception to production of issued for construction (IFC) drawings.
RO #2	To determine the status of digitalisation in producing as-built drawings (ABD) by builders.
RO #3	To determine the feasible status of digitalisation to be achieved in producing design drawings.
RO #4	To determine the feasible status of digitalisation to be achieved in producing as-built drawings.
RO #5	To identify the drivers for and barriers to improving the status of digitalisation in design and construction.

1.1 Digitalisation in Construction

1.1.1 Digital Maturity in The Australian Context

In Australia, the construction sector is not making full use of the potential of digital technologies (Chief-Economist 2017; Westerman, Bonnet & McAfee 2012). The level of investment in ICT and the state of management capabilities influence the state of digital maturity of organisations (Westerman, Bonnet & McAfee 2012). A digital maturity model proposed by the Chief-Economist (2017) provides a template to model the state of Australian construction industry (Figure 1.1).

According to this framework, at the early stages of digital maturity, construction organisations may use basic technologies such as connectivity to the internet, having a website and using email to better communicate with stakeholders. At the middle stages of digital maturity, organisations may implement a more integrated, strategic approach to using digital technologies, such as the use of technology in advanced ways to improve their operations, i.e. cloud computing, social media, e-commerce, internet of things (IoT) and big data analytics.

At the advanced stages of digital maturity, organisations may shift from simply digitising business operations to combining digital technologies in innovative and transformative ways. Reaching digital maturity is a dynamic and evolving process that requires continual exploration of new ways to utilise technology to increase productivity and retain their competitive edge.

This report presents the mapping of the state of digitalisation of the NSW class 2 building sector to this digital maturity model (Section 5.4.1).

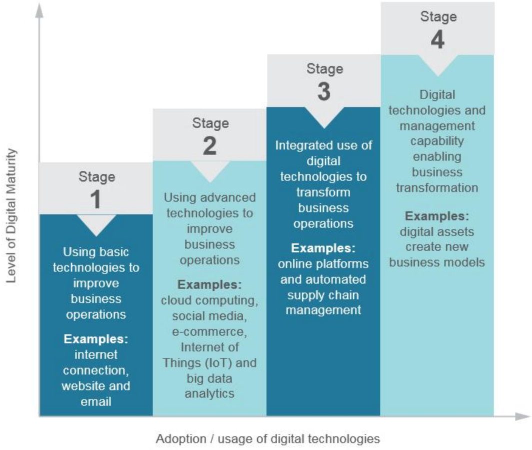

Figure 1.1 - Proposed four stages of digital maturity in Australian industries (Chief Economist 2017)

1.2 Construct NSW: Keeping Up with the Pace of Digitalisation

Following the recommendations of Shergold and Weir (2018), the NSW Government legislated the *Design and Building Practitioners Act 2020* to reform and enhance the regulation of the class 2 building industry. It also appointed the NSW Building Commissioner to execute the Construct NSW transformation strategy to improve the capabilities of the industry. The six pillar strategy includes establishing a customer-focused regulatory framework, risk profiles and ratings, improving skills and capability, strengthening standards and contracts, enhanced use of digital platforms and greater application of data and research.

Digitalising the NSW building industry and moving away from analogue record keeping has high potential to deliver substantial public benefits through increased regulatory efficiency and improved industry productivity (NSW Government 2020b) . The NSW Planning Portal is being evolved to become a wider platform that consumes all information across the building lifecycle (planning, construction, occupation) in a single digital location. In this way the increasing digitalisation of the construction documentation aligns with the desire for the establishment of a "single source of truth to contain a building's certificates on a common platform, which will go with a building forever and be available to future owners and maintainers" (NSW Government 2020a). Furthermore, this technology approach will be even more relevant in the post-COVID era as it will enable remote operation and more efficient management of building design and procurement.

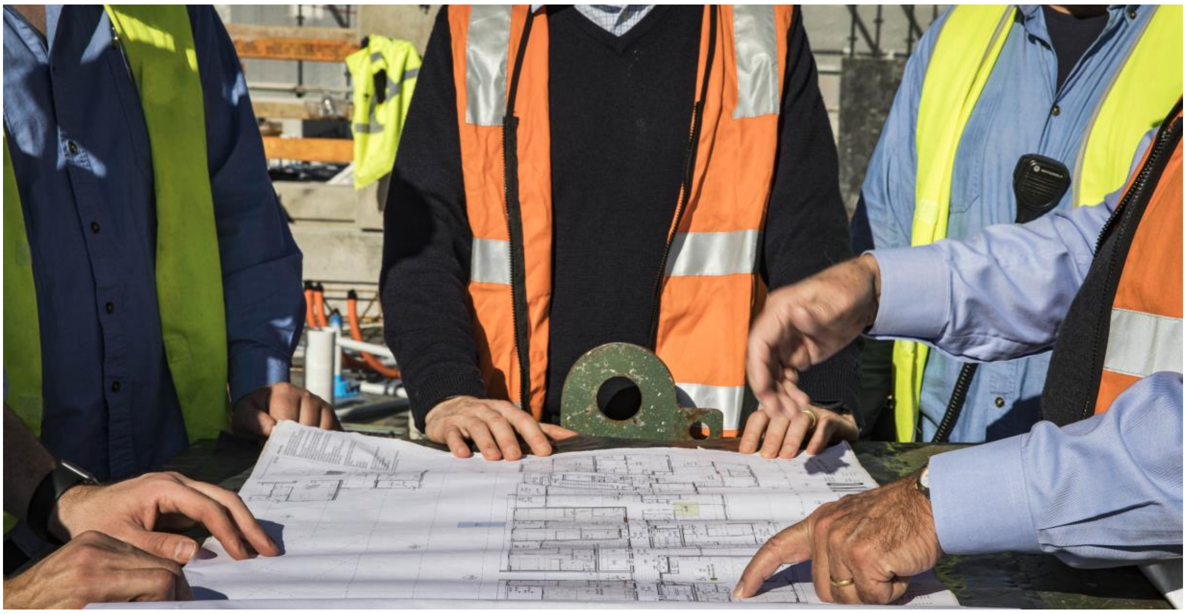

Image Source: Office of the Building Commissioner NSW

2 RESEARCH APPROACH

The research was limited to the class 2 building sector in NSW. The entire study was carried out in three phases, as illustrated in the research methodology map in Figure 2.1. Phase 1 mainly involved literature review of digitalisation in both the local and international construction industries. In Phase 2, nine interviews were conducted, of which the findings of first four interviews were used to define the parameters of the survey questionnaire. The findings of the remainder interviews were used to validate the findings of the survey. Of the nine interviewees, three were designers, three were builders and the other three were vendors of building software. In Phase 3, a 32-question survey of designer and builders was carried out. The research was conducted with the application of the standard research and ethics protocols of the Western Sydney University.

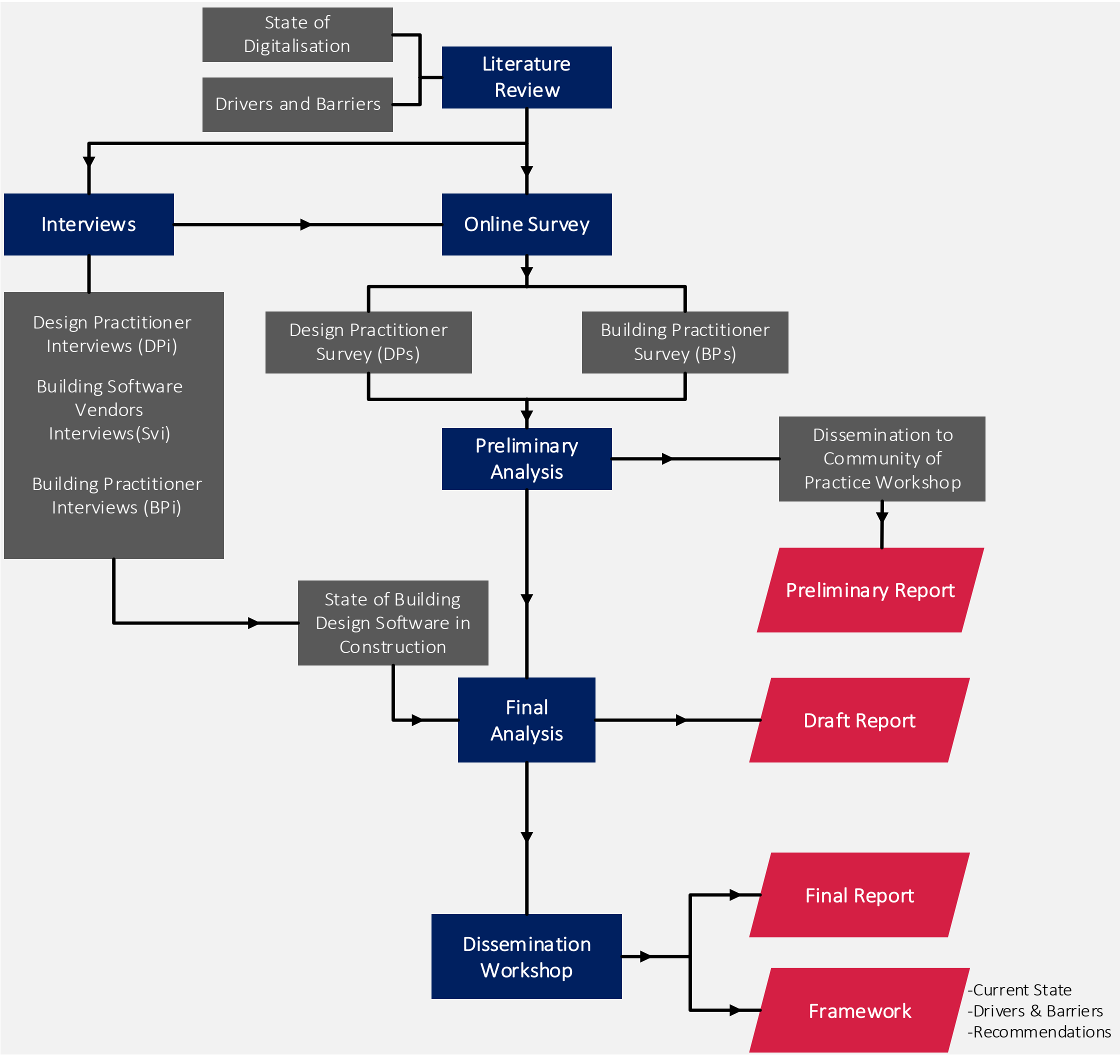

Figure 2.1 - Research methodology map

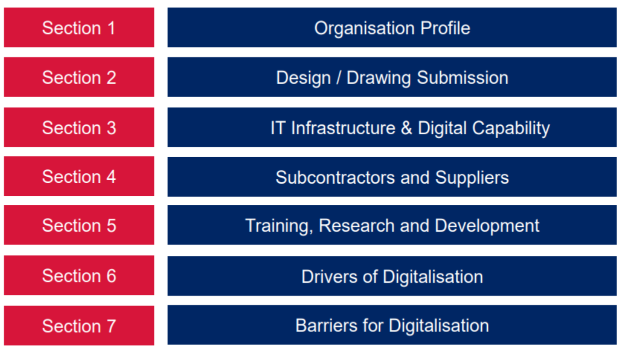

Figure 2.2 - Composition of the survey

The composition of the survey questions is indicated in Figure 2.2.

The survey included relevant members of peak industry bodies such as the Building Designers Association of Australia (BDAA), Australian Institute of Architects (AIA), Association of Consulting Architects Australia (ACA), Housing Industry Association (HIA), Engineers Australia (EA), Master Builders Association (MBA).

The survey population included designers and builders that are engaged in design and or construction of class 2 buildings. As shown in Table 2.1, a target population of 30,465, including 18,742 designers and 11,723 builders, has been estimated based on unique email addresses of potential respondents.

Table 2.1- Survey population estimate

Survey Population Estimate	Population supplied	Proportion applicable	Population estimated
Registered Architects	4,442	100%	4,442
Building Designers Association of Australia (BDAA)[1]	2,000	40%	800
Engineers Australia (EA)[2]	27,000	50%	13,500
Population of design practitioners in NSW (Designers)			18,742
Population of building practitioners in NSW (Builders)[3]			11,723
Population of design & building practitioners (Designers & Builders)[4]			30,465

1 considered NSW members and possible overlap with registered Architects.
2 Assumed that not all EA NSW members are relevant and people who would do class 2 building design.
3 Through Fair Trading.
4 Based on unique email addresses of the respondents.

The sample recruitment process is indicated in Figure 2.3. The survey received a total of 542 responses. These are categorised in Table 2.2.

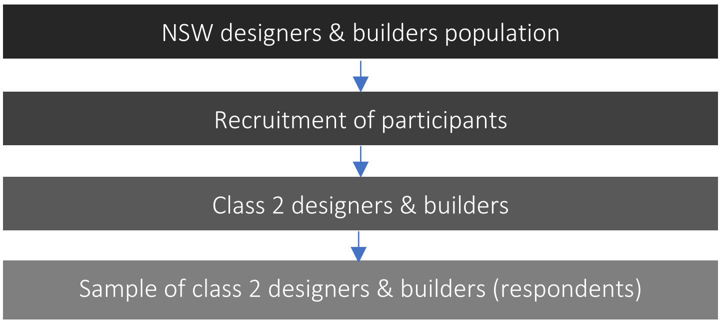

Figure 2.3 - Sample recruitment process

Table 2.2 - Survey responses

Designers		Builders		Combined (Designers & Builders)	
Total designers recruited	619	Total builders recruited	523	Total designers & builders recruited	1142
Not involved in class 2 building design	8	Not involved in class 2 building construction	12	Not involved in class 2 building design or construction	20
Do not wish to participate in the survey	20	Do not wish to participate in the survey	28	Do not wish to participate in the survey	48
Effective total designers	591	Effective total builders	483	Effective total designers & builders	1074
Completed the survey	347	Completed the survey	195	Completed the survey	542
Response rate for designers (347 /591)	59%	Response rate for builders (195 / 483)	40%	Response Rate for total designers & builders (542/1074)	50%
Statistical confidence level	90%	Statistical confidence level	83%	Statistical confidence level	95%

3 SURVEY RESULTS AND FINDINGS

3.1 Introduction

The main findings are related to organisation profile, design / drawings submission, IT infrastructure & digital capability, subcontractors and suppliers, training, research and development, drivers of digitalisation, and barriers for digitalisation.

3.2 Section 1 – Organisation Profile

3.2.1 Organisation's business setup

The industry is well organised with 81% formed as companies, increasing to 93% in the case of builders (Table 3.1). These results are as expected due to the nature of design practices and builder operations. The greater the liability, the greater the tendency for companies to be organised as limited liability entities.

Table 3.1 - Class 2 designers and builders business set-up

Business Setup	Designers	Builders	Combined
Sole Trader	69	6	75
Partnership	18	6	24
Company	255	181	436
Other	5	2	7

3.2.2 Experience in designing / constructing class 2 buildings

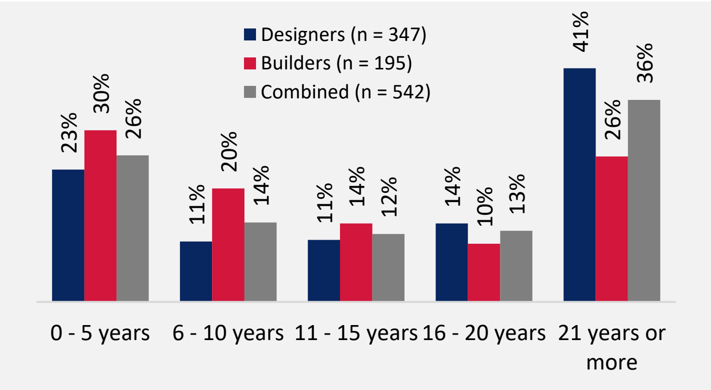

Figure 3.1 - Experience in designing/ constructing class 2 buildings

As revealed in Figure 3.1, over 40% of designers and over 25% of builders have over 20 years of experience. Over 50% of the survey population has more than ten years' experience. These indicate that the majority of respondents are fairly experienced.

3.2.3 Organisation size by number of people employed

Figure 3.2 provides a clear picture of the organisation size with over 95% falling in the category of micro and small and medium-sized enterprises (SME). About half of designers and builders are micro-sized organisations. These results are similar to the overall economic analysis provided by the Australian Bureau of Statistics (ABS).

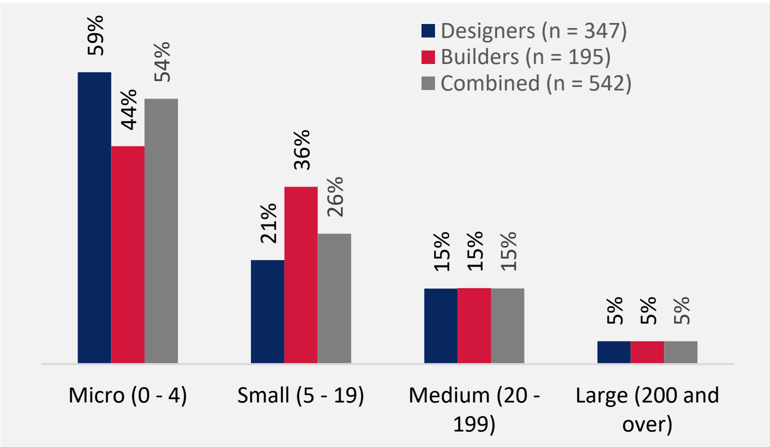

Figure 3.2 - Organisation size by number of people employed

3.2.4 Number of class 2 buildings designed / constructed in the last six years

As shown in Table 3.2, on average over 60% of the respondents have completed up to five class 2 buildings in the last six years. Nearly 73% of the designers have designed up to ten class 2 buildings in the same period.

Table 3.2-Number of class 2 buildings designed / constructed in the last six years

Number of class 2 buildings	Designers	Builders	Combined
1-5	189	136	325
6-10	63	30	93
11- 15	28	7	35
16 - 30	31	11	42
31 and over	36	11	47

3.2.5 Average annual turnover in the last three years

Figure 3.3 and Figure 3.4 show that two thirds (67%) of the designers fall into the category of under $1 million in annual turnover. 40% of builders' turnover is under $2 million. It confirms that majority of respondents are small builders or designers.

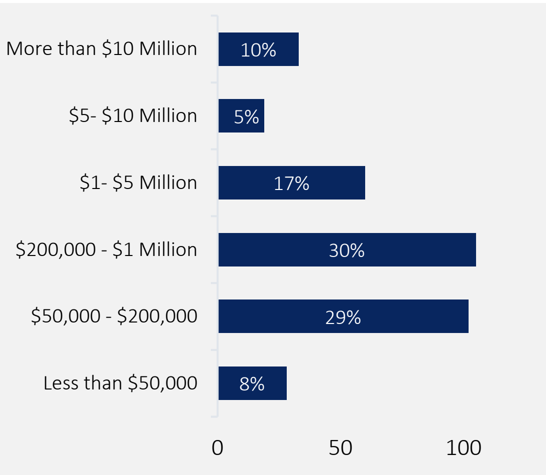

Figure 3.3 - Average annual turnover in the last three years for designers

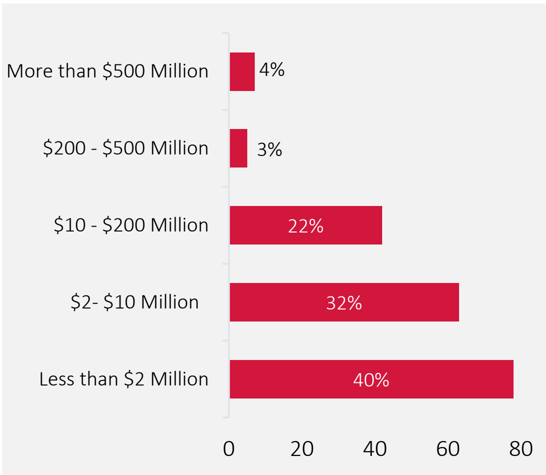

Figure 3.4 - Average annual turnover in the last three years for builders

3.2.6 Builders involvement in class 2 building design

A significant portion (43%) of builders are involved in the design of class 2 buildings they construct. This is likely to reflect the proportion of builders that are also developers.

3.3 Section 2 - Design / Drawings Submission

3.3.1 Design services offered

Architectural design is mostly performed in-house (over 80%), as shown in Figure 3.5. There is also considerable level of digitalisation in design practices, with 86% of designers offering 3D model/walkthrough services and 70% offering BIM services where the majority is done in-house. Further, nearly 80% of designers prepare as-built drawings, either in-house or out-sourced while 82% provide design application services to their clients. Among the top three design services offered, larger-scale designers are more likely to outsource architectural design services than micro and small-sized designers and medium-scale designers are more likely to outsource interior design services than micro and small-sized designers.

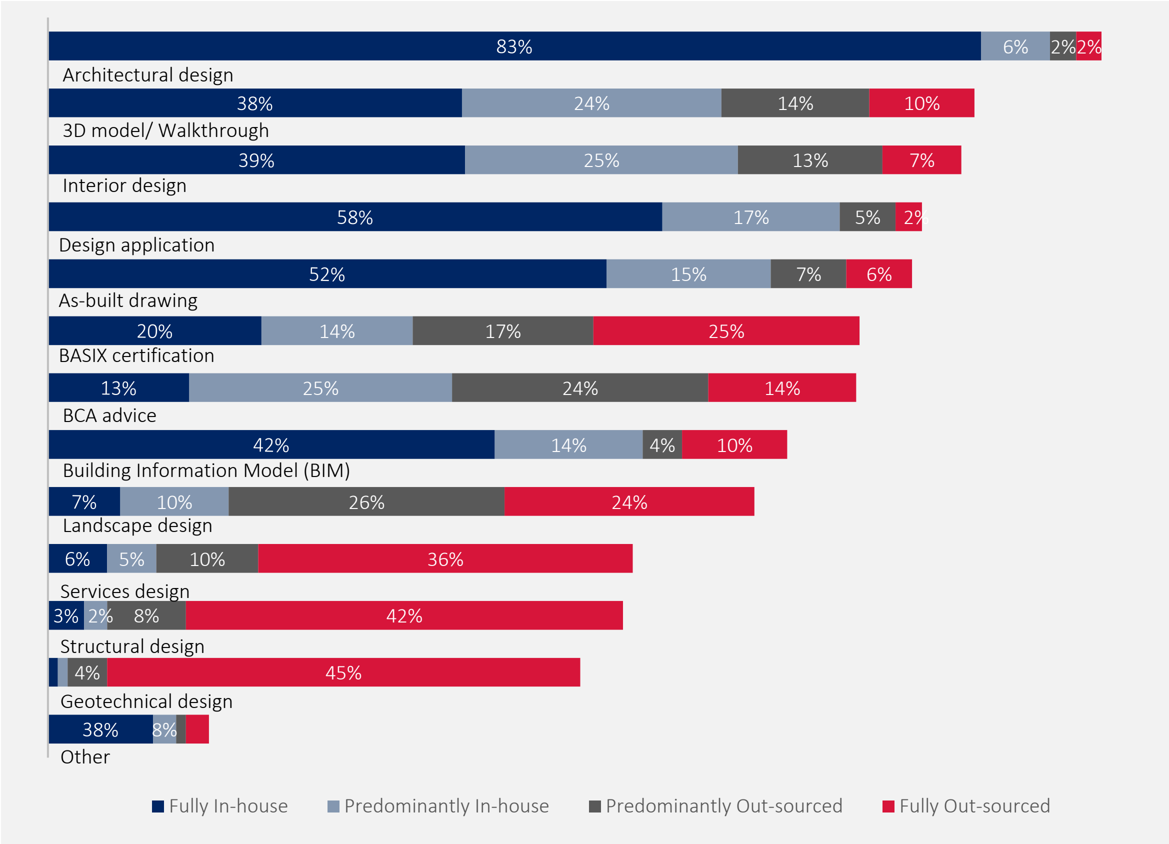

Figure 3.5 - Design services offered (in-house and outsourced)

3.3.2 Formats for submission of DA

More than 73% of all documents submitted to councils for development application (DA) are digitally prepared and converted to PDF (see Figure 3.6). This indicates a high level of digitalisation in design drawing submission already being practised in the industry although the requirement to submit BIM or other 3D models is less than 2% for any of the IFC documents.

3.3.3 Preparation of as-built drawings

More than half (53%) of designers provide as-built drawings for developers and/or builders.

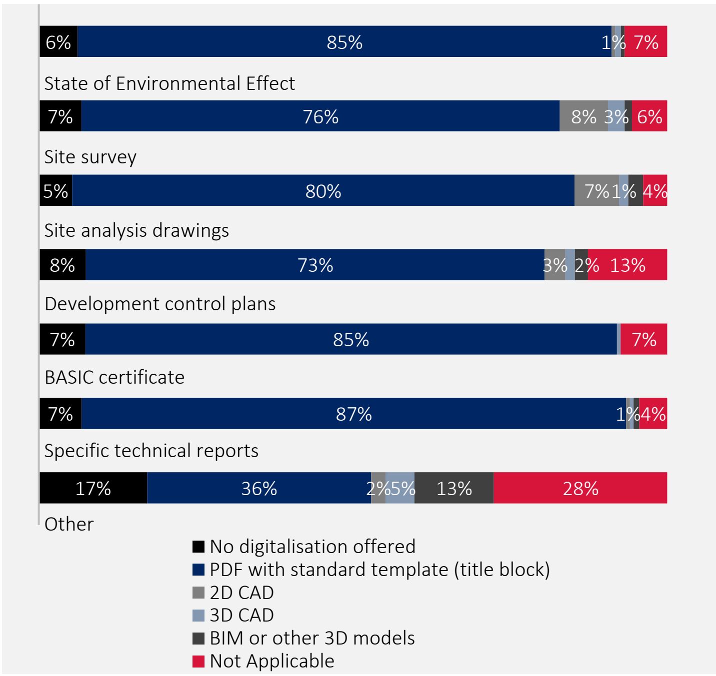

Figure 3.6 - Formats for submission of development applications

3.3.4 Format for submission of IFC drawings approved for construction

The majority (over 80%) of all documents submitted to councils relating to issued-for-construction designs are in PDF format (see Figure 3.7). The use of 2D CAD files (10%) or 3D BIM (3%) is rare.

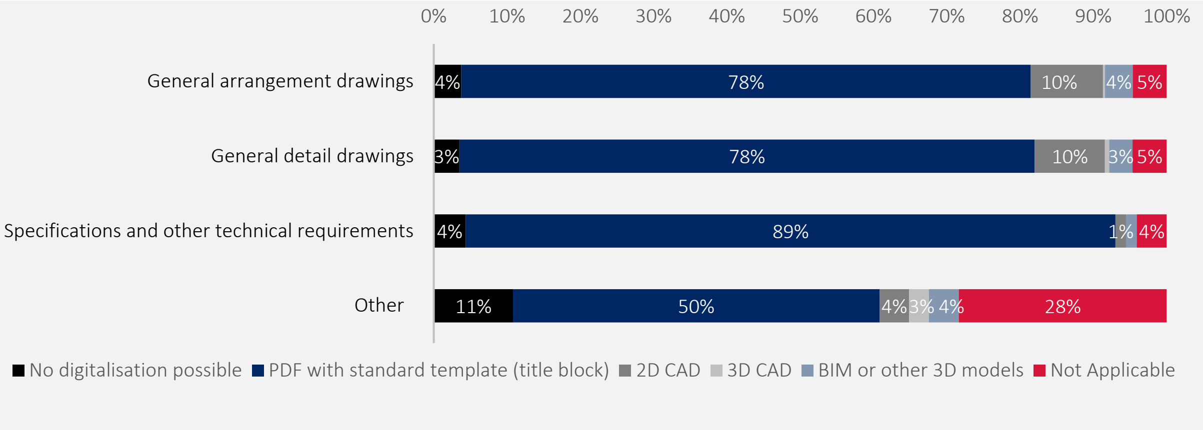

Figure 3.7 - Format for submission of Issued-for-Construction (IFC) drawings Approved for Construction

3.3.5 Standardisation of design approval

90% of designers prefer a standardised process for approval of building designs across all jurisdictions within NSW. 89% of designers prefer a standardise level of detail of design information to be submitted for approval of building designs across all jurisdictions within NSW. There is an overwhelming desire for greater level of standardisation of design submission processes across both players, and the NSW Planning Portal will likely be an enabler for this transformation (www.planningportal.nsw.gov.au).

3.3.6 Familiarity with the DBP Act 2020

Around 5% of designers and 20% of builders had never heard about the changes required by *Design and Building Practitioners Act 2020* (DBP Act) (see Figure 3.8). Further 34% knew very little about the DBP Act. However, designers were more aware of the new legislation than builders. These results indicate there is significant amount of work to be done in educating the sector.

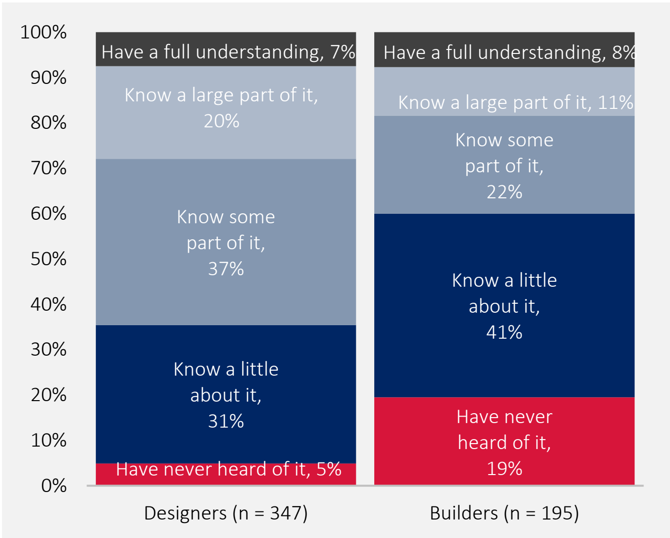

Figure 3.8 - Familiarity with changes required by the Design and Building Practitioners Act 2020

3.3.7 Preparation of as-built drawings by builders

While 88% of builders prepare as-built drawings, the majority (65%) is outsourced (see Table 3.3). But importantly, 12% indicate that they do not prepare as-built drawings, which may indicate scope for improvement.

Table 3.3 - Preparation of as-built drawings by builders

Preparation of as-built drawings	Count
In-house	45
Outsourced	127
Not prepared	23

3.3.8 Formats for as-built drawing submission

Builders submit as-built drawings in many formats (see Figure 3.9). PDF is the predominant format used that vary from 35% to 42% for architectural, structural, services designs and surveys. It is also noted that 23% to 30% of builders are using DWG and CAD file formats. Further 3% use BIM formats for architectural design.

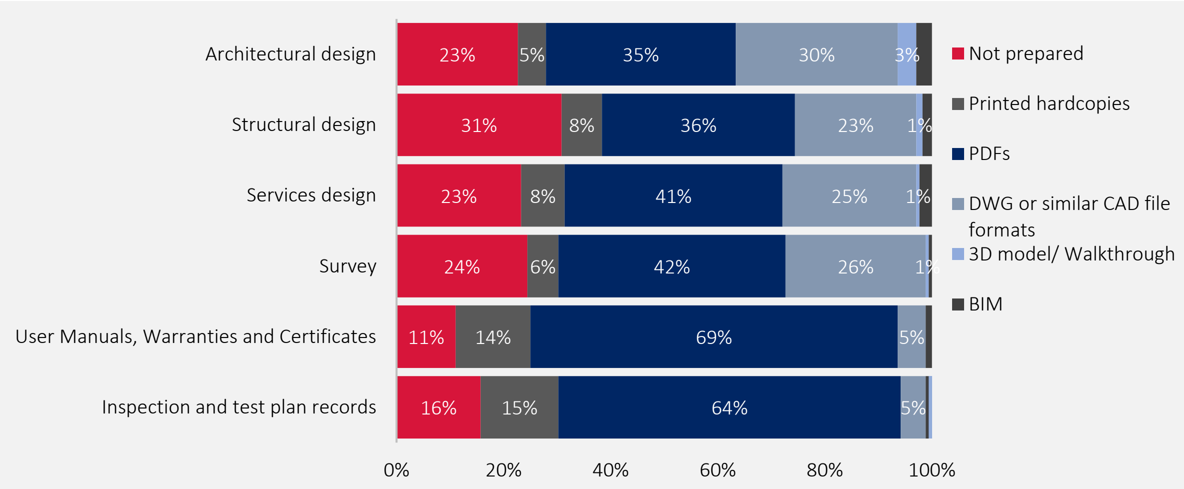

Figure 3.9 - Formats for as-built drawing submission

3.4 Section 3 - IT Infrastructure & Digital Capability

3.4.1 Software used for class 2 building designs and as-built drawings

AutoCAD, Revit and SketchUp are the most popularly used software for building design and as-built drawings. Two thirds (60%+) of designers and builders use AutoCAD followed by Revit, SketchUp and ArchiCAD (see Figure 3.10). One third (31%) of designers have a very good level of usage of AutoCAD (Medium - High). Usage of Revit is high in around a third (32%) of designers followed by high usage of ArchiCAD by a quarter (25%) of designers. There is no significant difference between designers and builders in their usage level of the identified popular software.

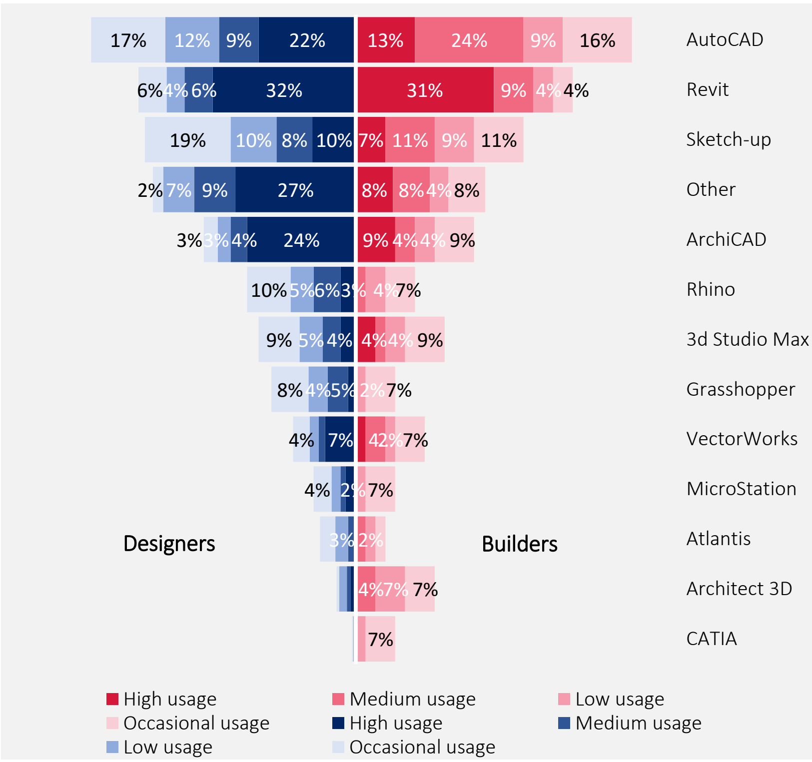

Figure 3.10 - Software used for building design and as-built drawings (Designers vs Builders)

3.4.2 Use of document management and project management software

Microsoft Project for schedule management, Aconex for document management and Buildsoft for cost management are the most popular software used by designers and builders, as shown in Figure 3.11. 37% of the designers and 61% of builders use Microsoft Project while Primavera is used by a significantly lesser number of organisations (5% and 14% respectively). Nearly 42% of designers and 31% of builders use Aconex as a document management software. This is followed by Procore which has overall 27% usage. Buildsoft is used by over 35% of the builders followed by Aconex with over 32% and BlueBeam over 29%. Cost management software does not seem to be much used by builders except for Buildsoft which is used by 35% at various levels. However, the survey only focuses on designers and builders and expressly excludes quantity surveyors working in the consultancy sector. Furthermore, builders use MS Project significantly more while designers use Aconex significantly more. Micro and small designers and builders use MS Project and Aconex significantly less than medium and large players.

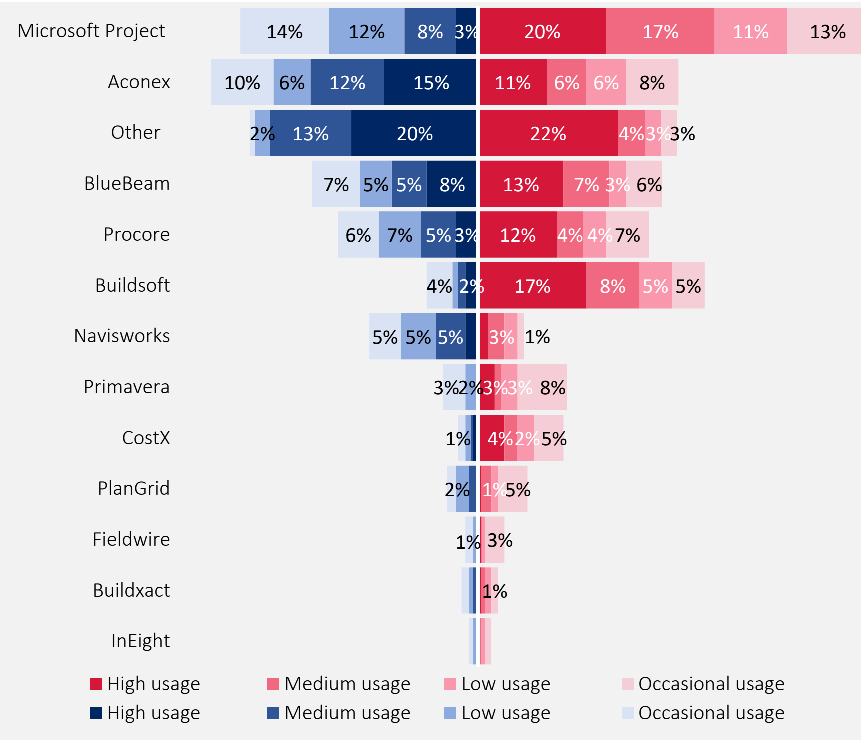

Figure 3.11 - Use of document management and project management software by designers and builders

3.4.3 Level of digital maturity of organisations

Based on the digital maturity classification of the Office of Chief Economist, the majority of designers and builders have a basic level of digital maturity and the two groups have very similar profiles in this regard (see Figure 3.12). About half (52%) of both designers and builders are at the basic level of maturity whereas 42% are on advanced level and 6% on the integrated level of maturity. None of the designers or builders indicated to be at the fourth or highest level of digital maturity. This indicates scope for greater level of digitalisation in the construction industry. Further, there is no difference between designers and builders in their perceived levels of digital maturity although medium and large designers and builders are more mature than small players, which are more mature than micro players.

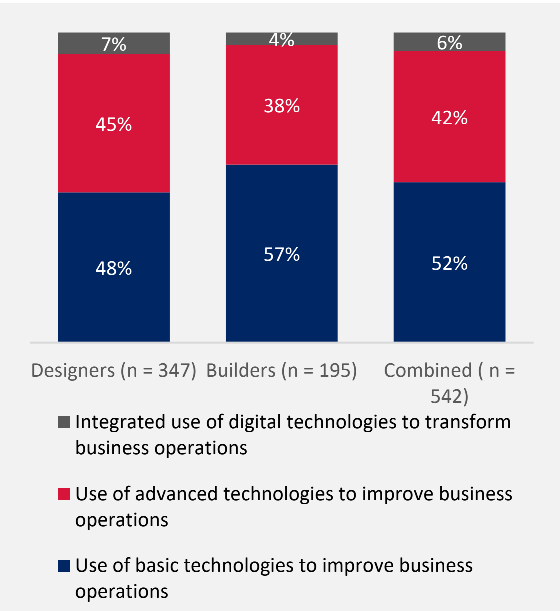

Figure 3.12 - Level of digital maturity of designers and builders

3.4.4 Data storage profiles of organisations

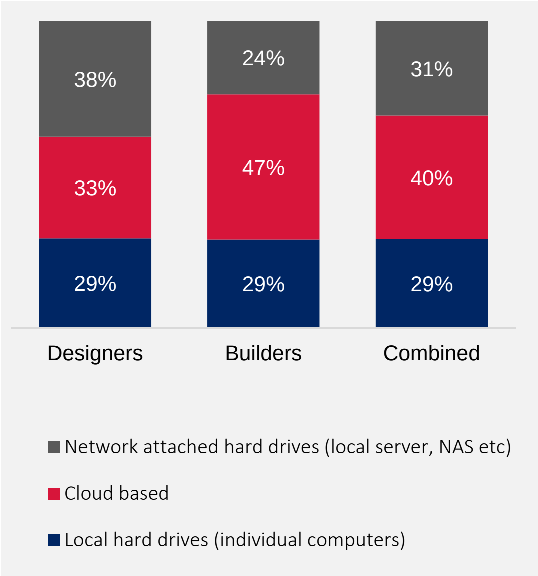

Figure 3.13 - Data storage profile of designers and builders

Figure 3.13 reveals that nearly one third of all data is stored in local hard drives by both builders and designers, with little difference between the two groups. However, micro designers and builders use local hard drives significantly more than other designers and builders.

On average, builders use more cloud-based data storage methods than designers. This may be because of the builders need for onsite access to data on one hand and designers requiring quick access to larger design files that supports rendering. Further, large designers use cloud-based data storage significantly more. 38% of designers' data is stored in local network storage compared to 24% of builders. This indicates there is a greater tendency for better overall locally managed IT and network setup with designers as opposed to builders. Also, micro designers and builders use network attached data storage significantly less than other designers and builders.

3.4.5 Level of outsourcing of IT services

The class 2 building sector seems to prefer outsourced IT management, with both designers (60%) and builders (68%) outsourcing their IT services with or without internal support, (Figure 3.14). This is explained by the fact that most designers and builders are in micro-SME categories and their capabilities do not warrant internally managed IT. This may also indicate that designers have comparatively more capability or need in handling IT services within the organisation than builders. In addition, large designers and builders are in favour of internally managed IT services probably due to economies of scale. It is worth noting that micro-level designers also prefer internally managed IT services. A possible reason is that micro-level designers do not demand complex IT services and it is economical for them to manage internally.

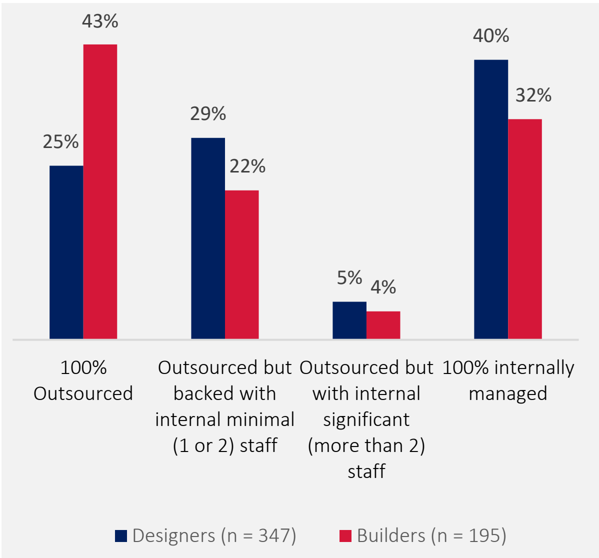

Figure 3.14 - Level of outsourcing of IT services

3.4.6 Average annual spending on IT

Designers and builders have significantly different profiles in IT investment as a percentage of their turnover (see Figure 3.15). Designers tend to invest more than builders with over 53% compared to 16% investing more than 3% of the turnover on IT budget. This validates the previous finding that designers have greater levels of locally managed IT. It can be explained by the fact that designers use more software than builders. In addition, there is significant correlation between organisation size and IT investment. That is, the smaller the organisation, the smaller the percentage of investment. In comparison to other sectors of the economy, construction has the lowest IT investment and the NSW figures are reflective of even lesser than comparative figures for the US. However, as average builders' turnover is higher than designers', the absolute value of investments might present a different picture.

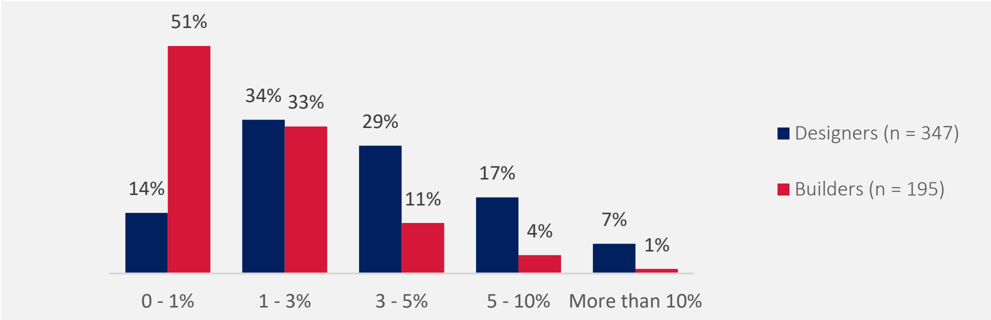

Figure 3.15 - Average annual budget for IT

3.4.7 Time horizon for achieving different levels of digitalisation

Figure 3.16 reveals the self-assessed capability of designers and builders in achieving set milestones of digitalisation. An overwhelming majority (87%) of the respondents already use CAD based PDFs. Two thirds (68%) of them already have 2D CAD capability while nearly half (46%) have 3D CAD capability and a further quarter (24%) indicated that they can achieve this by 2022. This indicates that moving towards 3D CAD by 2022 is much more feasible. It will only push 30% of the population harder than what they naturally expect to achieve.

Designers are leading builders in achieving the five levels of digitalisation. Further, medium and large designers and builders are leading micro and small players in achieving the five levels of digitalization. In particular, micro players are behind all the other players in achieving the highest level of digitalization (i.e. digital twins). This provides solid evidence that much greater efforts are needed for lifting the digitalisation capacity of builders, particularly the smaller ones, if NSW is to realise greater digitalisation across the industry.

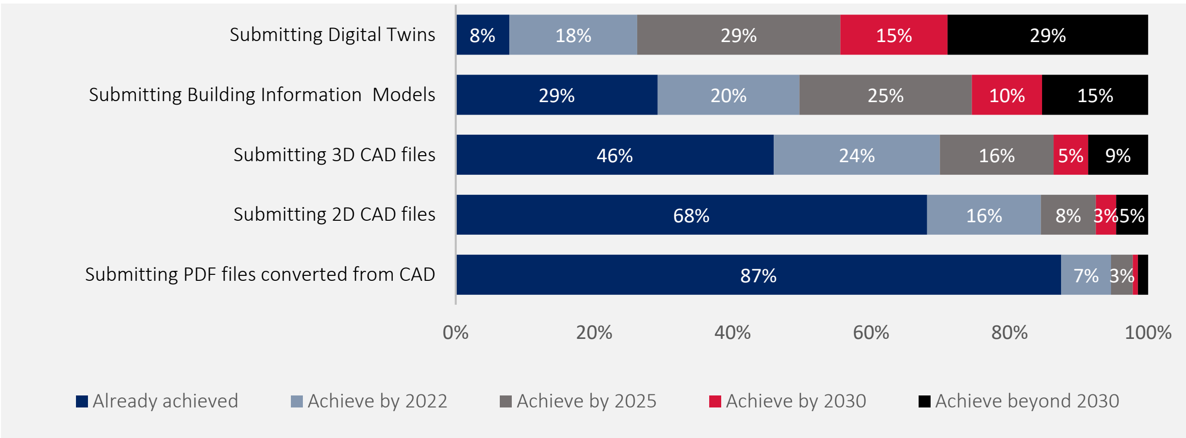

Figure 3.16 - Ability to achieve the following milestones in digitalisation

3.4.8 Perceptions on technologies that may drive change in the near future

Designers and builders believe that BIM is the technology driving major changes in the coming 3 to 5 years, according to Figure 3.17. 3D printing, AR/VR, integrated construction management tools are the main technology trends after BIM. However, these responses should be understood in the context of level of knowledge possessed by respondents on advancement of technologies and their capabilities as it is likely that more people are much more aware of BIM, Integrated Cost Management, CNC, 3D printing and drones as technologies.

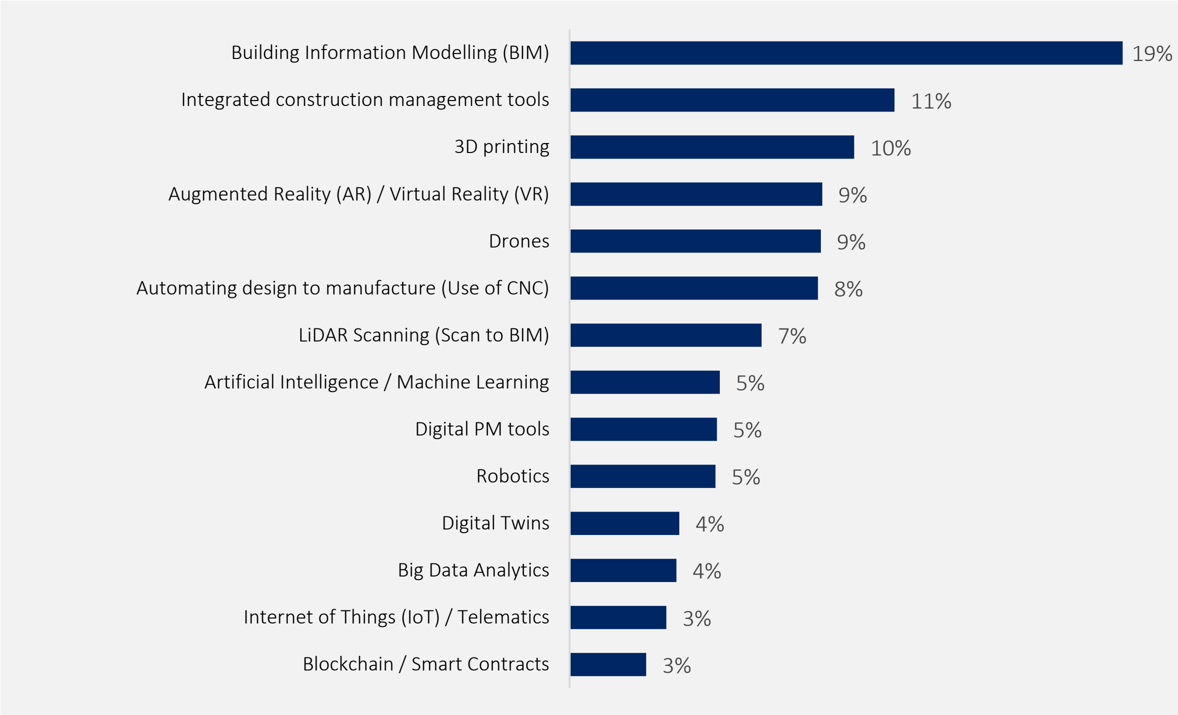

Figure 3.17 - Respondent perception of technologies driving change

3.4.9 Digitalisation of construction management activities

Use of specialist software for construction management tasks are limited while use of general office software is indicated at significantly high levels (see Figure 3.18). More than 10% of builders currently use cloud-based applications for cost control, safety and site activity records. Delivery management, site activity records, waste minimisation and environmental compliance related work are the activities that use highest paper-based processes. Unsurprisingly, more than half of all listed activities are carried out using standard MS Office software. Estimating and pricing, and cost control have highest usage of specialist software/ cloud (43%).

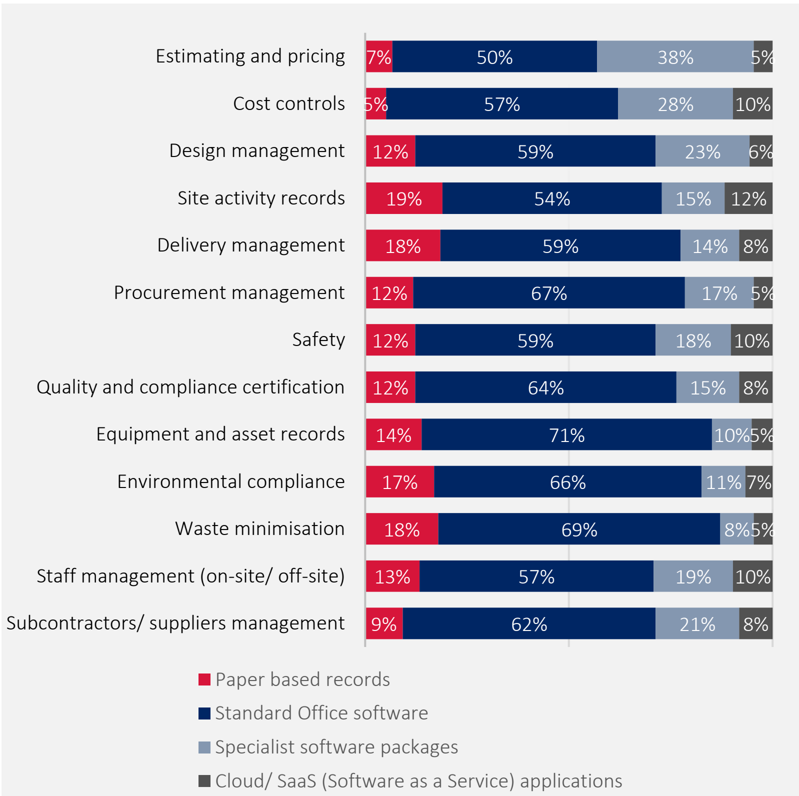

Figure 3.18 - Level of digitalisation of construction management activities

3.5 Section 4 - Subcontractors and Suppliers

3.5.1 Methods used by builders for obtaining quotations from suppliers

The methods used to obtain quotations from the supply chain indicate the level of digitalisation with respect to supply chain management. There is a very low level of advanced quotation processes in construction supply chains, as indicated in Figure 3.19.

Only 24% of builders use more advanced systems to obtain quotations. However, 50% use internet to obtain quotations and further 24% using telephone based quotations indicates a low level of digitalisation in procurement. Further, large builders are significantly less in favour of telephone-based manually-analysed quotations, and large and medium builders are ahead of small and micro builders in e-portal-based procurement and full e-procurement. These findings indicate significant scope for development of e-procurement methods for sourcing materials, components, subcontractors and suppliers.

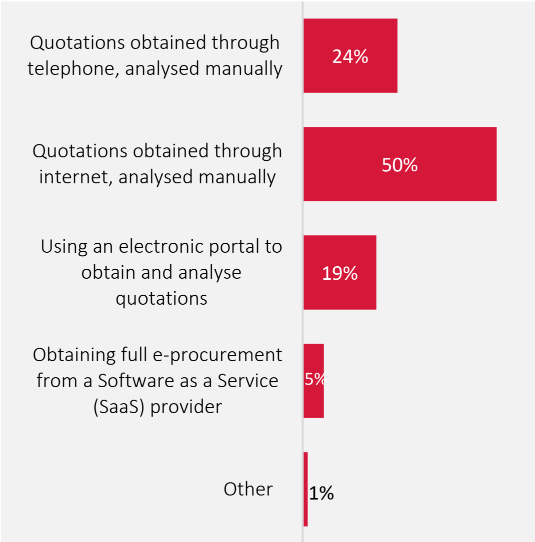

Figure 3.19 - Methods for obtaining quotations from suppliers

3.6 Section 5 - Training, Research and Development

3.6.1 Staff training in obtaining new digital capabilities

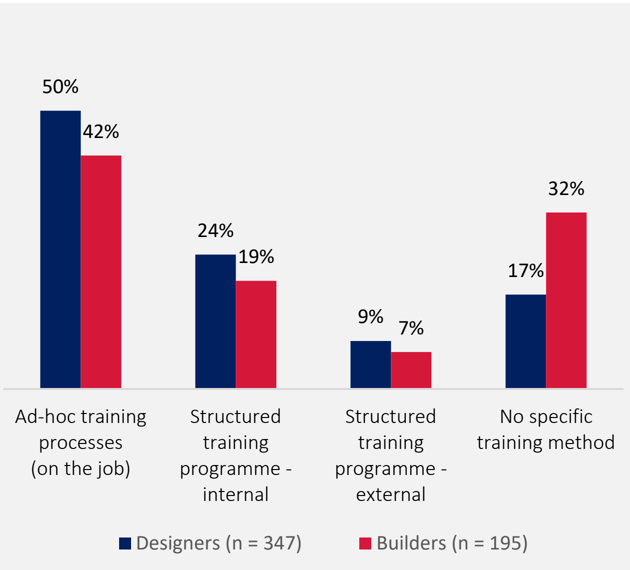

Figure 3.20 - Staff training approaches utilised

There are very low levels of planned training provided by both designers and builders (8%), as shown in Figure 3.20. Ad-hoc training accounts for half (47%) of training approaches expressed by both designers and builders. It is also important to note that there was no training provided by 22% of respondents with the figure further deteriorating to 32% for builders alone.

Training aspects are very weak for builders as nearly 75% do not have internal or external structured training processes. This indicates that in most construction companies learning predominantly happens by way of on-the-job personal experience and not through an organised formal process. The above observation arose irrespective of organisational size.

3.6.2 Builders employing personnel with digital capabilities

Builders were equally split regarding the ease of finding personnel with digital capabilities for producing as-built drawings. Implication of this is that half of the builders are unaware of personnel with digital capabilities in design. That indicates a need for assimilation and dissemination of such information in the industry.

3.6.3 Average annual budget for research & development

There are significantly low R&D investment profiles for both designers and builders, as indicated in Figure 3.21. On average 15% do not invest at all while further 39% invest less than 1% of their turnover on R&D activities. These confirm the poor level of investment of R&D in construction sector, as indicated from many other sources such as the McKinsey Global Institute Report (Manyika et al. 2017). In addition, it is found that builders and designers have different profiles in R&D investments with designers investing more in R&D in terms of a percentage of turnover than builders. In absolute dollar value, this may not be the case because designers' turnover is less than builders'.

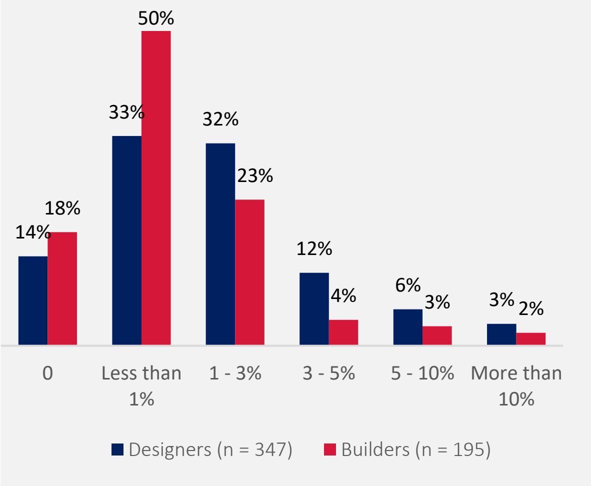

Figure 3.21 - R&D investment profile

3.7 Section 6 - Drivers of Digitalisation

There is a broad agreement (over 60%) that all the listed drivers are important (see Figure 3.22). 'Greater level of accuracy and trustworthiness' and 'improve quality and standards in construction' were the top two most highly rated drivers of digitalisation. These indicate the importance of digitalisation in improving trust and standards in the construction industry.

There is no significant difference between builders and designers in their acknowledgement of the top two drivers. However, large, medium and small designers and builders hold stronger belief in the top two drivers than micro designers and builders do. This indicates that more communication and training is necessary for micro players to understand and benefit from improvement to digitalisation capability. The least rated driver was 'incentivising/ providing tax benefits to organisations moving towards digitalisation'. It indicates that financial incentives are not considered a great influential factor in driving digitalisation. Also, designers do not believe that digitalisation will support building certification significantly. This likely arises as there is lower literacy about technologies such as blockchain and smart contracts.

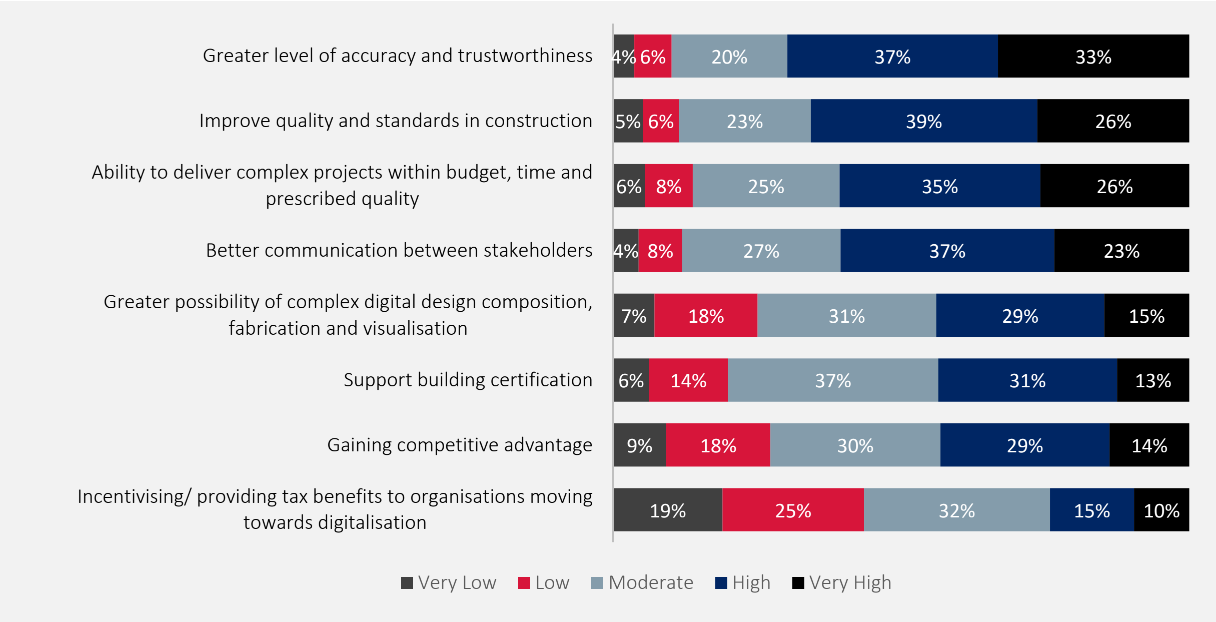

Figure 3.22 - Drivers of digitalisation

3.8 Section 7 – Barriers for Digitalisation

The top three barriers for digitalisation were 'high cost of software purchase/ licensing', 'high cost of digital tools and setting up equipment', and 'inadequate design fee to support digital innovation', as shown in Figure 3.23. Both designers and builders felt that the cost of software and hardware seem to make digitalisation more difficult. In particular, no matter how intensively (or not) they utilised the most commonly used software such as AutoCAD, Revit, Sketch-up and Microsoft Project and Buildsoft, they consistently agreed that high cost of software and licencing is the biggest barrier to digitalisation. Inadequate design fee to support digital innovation is the third most rated barrier for digitalisation mainly because it was deemed by designers as the second biggest barrier although only ranked sixth by builders. High cost of IT specialists was rated the fourth biggest barrier as it has been ranked as the fourth and the second biggest barrier by designers and builders respectively.

Furthermore, there is no significant difference in builders' concern about the top three barriers across different organisational sizes. However, medium and large designers do not share the same strong concern about high cost of software, hardware, and IT specialists as micro and small designers do. This may be because medium and large designers have managed to achieve economies of scale and thus are less concerned about these high costs. Nonetheless, designers, big or small, shared a same level of strong concern about inadequate design fee.

Anecdotal advice during survey interviews indicated that the high cost of switching is also an impediment to the industry increasing its future digital capability. The OBC has referred this observation to the Australian Competition and Consumer Commission (ACCC) for their consideration. There may be options to enhance the degree of competition or the conditions on which digital services are offered to constructors. There is also a role for industry associations to raise this matter with major suppliers on behalf of their members.

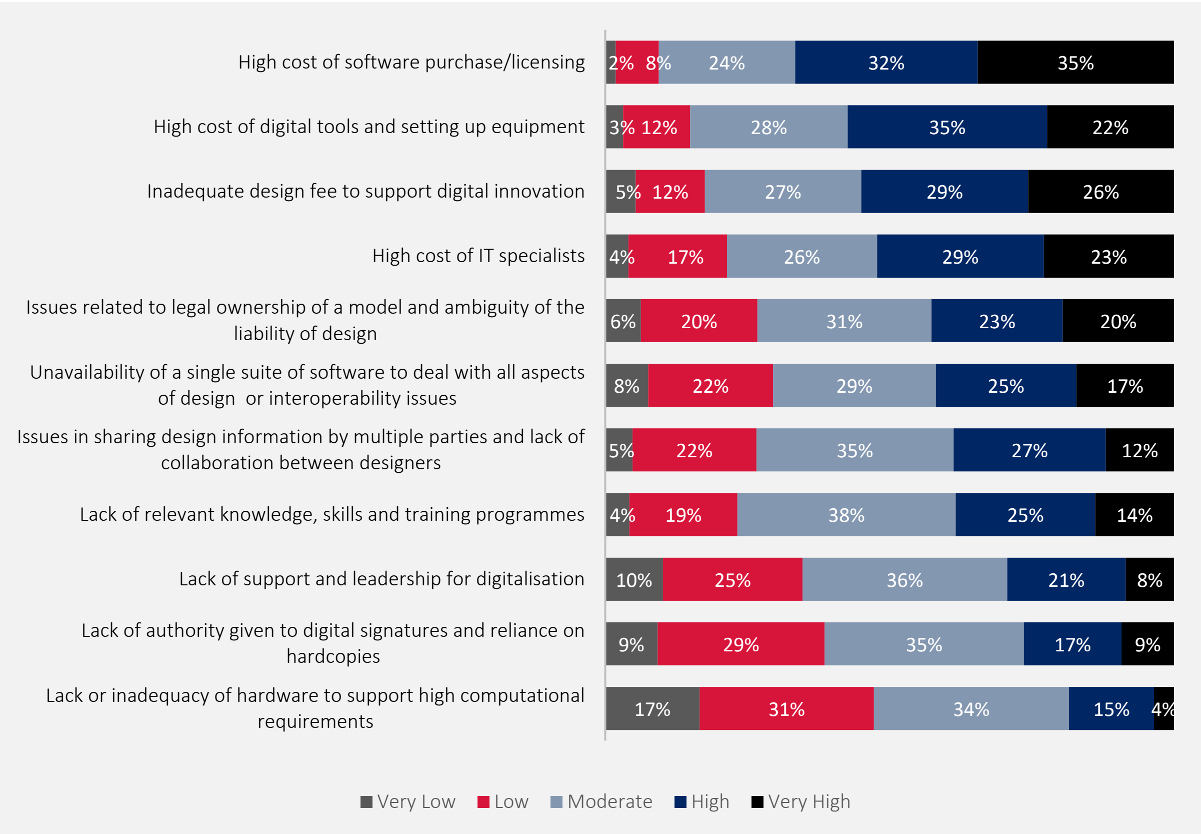

Figure 3.23 - Analysis of Barriers for Digitalisation

4 INTERVIEW FINDINGS

4.1 Introduction

Nine semi-structured interviews were carried out with designers, builders, and software service providers (SSP) to seek further detailed explanation of the findings of the surveys (Figure 4.1). Three organisations were selected from each category representing micro/small, medium and large organisations.

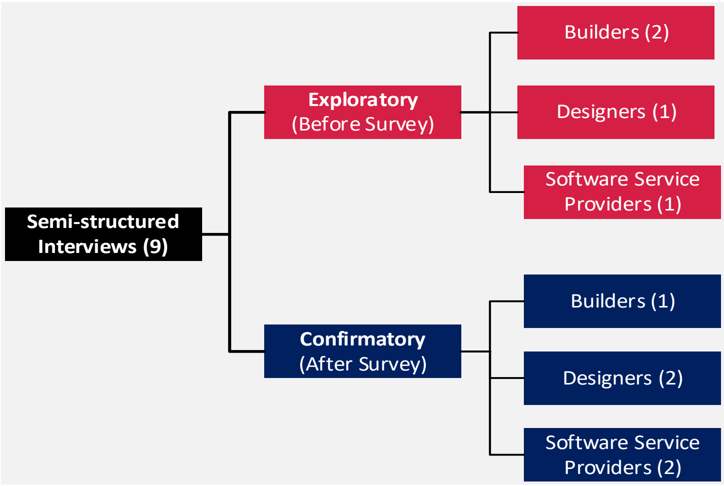

Figure 4.1 - Interview categories and implementation process

4.2 Key Findings

A systematic content analysis of interviews with the three types of construction stakeholders that operate at the fringes of the industry was carried out. It provided valuable insights on not only the current and feasible levels of digitalisation, but also on drivers and barriers for digitalisation. These interview findings substantiate the findings of the survey on digitalisation of construction that were presented in the previous section.

Views Captured via Interviews:

Designers

1. Designers stated that hard copy submissions are still required by many councils.
2. Designers already produce 3D drawings, that are converted to 2D to suit the local Councils' submission requirements.
3. Designers stated that they are capable to adapt to any digital advancements suggested by the DBP Act.
4. Barriers for digitalisation identified by designers are: different levels of digital capabilities among staff members and stakeholders, disconnect between different age brackets in terms of technology competencies, lack of common data environment, interoperability of software, difficulties in migrating to alternative software, and high cost of software licensing.

Builders

1. As-built drawing (ABD) practices were not prevalent with builders. They perceived that ABD is not a current mandatory requirement and it is not a standardised practice in the industry.
2. While only the large builder indicated the use of sophisticated software such as Aconex for tendering and post-contract administration, all other builders favoured Microsoft office suit including Microsoft Project for document management.
3. Builders indicated that they can easily adapt to any transformations in terms of digitalisation if mandated by legislation.
4. It was widely perceived that digitalisation is associated with efficiency, productivity, and safety, which drives many builders to adapt new technologies.

Software Service Providers (SSP)

1. SSP have observed that architectural practices in Sydney are digitally more advance than manufacturers, engineers, or builders.
2. SSP have witnessed a sharp increase of digitalisation and stated that lot of automation already happens in designing class 2 buildings.
3. SSP anticipate that mandating PDF submissions may not mitigate class 2 building defects or quality issues or improve the process because they do not provide any additional information that is not already given by hardcopies.
4. As barriers, SSP have observed that software cost has drastically increased 60 to 70% over the last five years forcing people out of their perpetual licenses into a subscription model.

In conclusion, all interviewees that operate at the fringes of the industry indicated strong views towards the necessity of digitalisation and standardisation of construction practices in NSW. They expressed positive views towards the anticipated changes that the DBP Act would bring and firmly believed that current digital capabilities of the industry are sufficient to adapt quickly.

Image Source: Kasun Gunasekara

5 CONCLUSIONS

5.1 Overview

This research set out to review the state of digitalisation of the class 2 building sector in NSW with specific reference to the production of design drawings and as-built drawings. The research involved a detailed worldwide literature review followed by gathering data through a survey of class 2 building designers and builders (including developers). The survey resulted in 542 valid responses from 347 designers and 195 builders. The survey findings were verified and expanded through a series of nine interviews involving three designers, three builders and three software service providers each representing small, medium, and large companies.

5.2 The Current State of Digitalisation

The key highlights of the survey findings indicate:

- Sector consists of 54% micro, 26% small, 15% medium and only 5% large design and building practices (Figure 5.1). This means the sector is characteristically driven by micro-small enterprises accounting to 80% of the industry. It also indicated that 95% of class 2 designers and builders are micro-small-medium organisations with their experience in the sector spreading over 10 years for 60% of respondents while only a quarter with less than 5 years of experience.
- Over 80% of documentations are already submitted in PDF format. Whilst this indicates a primitive level of digitalisation as it is the least common denominator in transacting documents online, it paves the way for greater levels of digitalisation moving forward.
- Over 23% do not submit as-built drawings (ABDs) at all. At least 35% use PDF format and up to 36% use more advance formats such as CAD, 3D models and BIM considering architectural, structural and services implementations. The interviews with builders supported this finding and indicated that ABD is not a standard practice in the industry and most submit annotated PDFs of service layouts to clients for reference purposes.

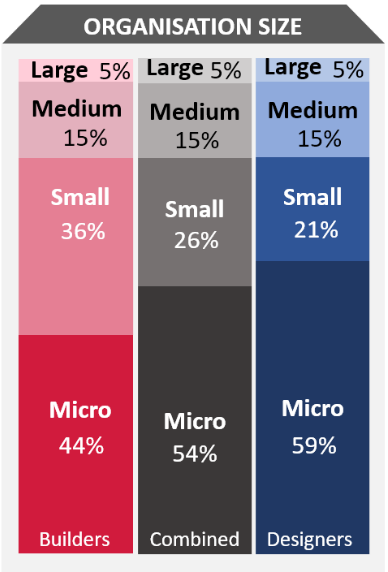

Figure 5.1 - Organisation size

5.2.1 IT infrastructure & digital capability

The main findings related to IT infrastructure and digital capability are:

- The three most popular software used by organisations for Class 2 building designs development and ABDs were AutoCAD, Revit and Sketch-up, each indicating around 30-40% medium to high usage for both Designers and Builders.
- Rhino, 3D Studio Max and Grasshopper were the most used software for rendering and 3D modelling.
- MS Project, Aconex, Procore were the most used software for document management, cost and schedule management.
- Navisworks was more popular with designers in this category while Buildsoft is more popular with builders for cost management.

These findings stated above were clearly supported by the interviews that affirmed the industry-wide usage on MS Project predominantly by small and medium builders and the usage on advanced software such as Aconex only by large builders.

NSW building designers indicated that they have digitalised processes for DA (87%), declared design (90%) and ABD (72%) processes. This shows significant level of digitalisation. Although encouraging, it does not indicate the exact level of digitalisation of these processes within organisations but is only reflected as a basic level at least that have been achieved.

5.2.2 Digital maturity of organisations

In analysing the level of digital maturity of these organisations based on the Office of Chief Economist digital maturity classification, 52% are still at basic level of maturity with further 42% leaning towards mid-level of maturity using advanced technologies. It indicates that the construction sector requires a significant effort in bringing the whole sector to greater levels of digital maturity.

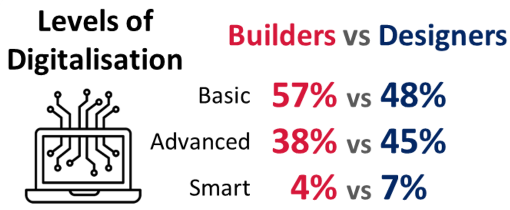

Figure 5.2 - Levels of digital maturity of organisations

Majority of designers and builders are in state of basic level of digital maturity (Figure 5.2). It is encouraging that 38% builders and 45% designers are at the Advanced level of digitalisation.

These findings were further exemplified in analysing the state of IT infrastructure in these organisations. Around 30% use local hard drives for storage of data with further 30% using internally networked systems, followed by 40% using cloud-based systems. Builders tend to prefer cloud-based systems compared to designers preferring locally managed network-based systems. This directly corresponds with the nature of work undertaken by these two categories with builders requiring more onsite and, on-the-go, access to data while designers requiring much more data rich design files effectively and conveniently stored locally.

5.2.3 Training, research and development

The class 2 building sector is predominantly reliant on ad-hoc training of their workforce on IT related aspects (47%). 32% of builders and 17% of designers do not have training in developing digital capabilities of their workforce. This itself is an indicator of low adoption of innovative digital technologies as training becomes imperative in case of adoption of new technologies. Investment in research and development (R&D) is endemically low in this sector with 15% at zero investments and further 39% investing less than 1% of their annual average turnover.

There was a relatively low level of awareness towards the DBP Act with 44% of respondents have little or no knowledge of it. This necessitates a significant effort in communication of the implication of the legislation to both designers and builders.

5.3 Drivers and Barriers for Digitalisation

The research reviewed the key drivers and barriers for digitalisation of the NSW class 2 building sector. These findings are highlighted in Figure 5.3 and discussed below.

5.3.1 Drivers

Achieving ***greater level of accuracy and trustworthiness*** is the highest rated driver selected by respondents. This symbolises two of the most impactful factors that hinders performance and function of the construction industry. It is expected that digitalisation will improve these deficiencies significantly.

The second most highly rated driver is ***improving quality and standards in construction***. Digitalisation helps eliminate errors and improve quality and standards. It is closely followed up by ***ability to deliver complex projects within budget, time and prescribed quality*** and ***better communication between stakeholders***. It is interesting to note that, although still considered a driver, *Incentivising/ providing tax benefits to organisations moving towards digitalisation* is deemed to be the least important driver for digitalisation.

5.3.2 Barriers

Understanding how the industry players feel about barriers for digitalisation of their organisations provides a crucial insight in developing a strategy for digitisation. ***High cost of software purchase/licensing*** is considered the most important barrier, including price and non-price conditions that create impediments to switching. This is followed by ***high cost of digital tools and setting up equipment***. Both designers and builders feel that cost of software and hardware seem to make digitalisation more difficult. ***Inadequate design fee to support digital innovation*** is the third most rated barrier for digitalisation mainly because it was deemed as the second biggest barrier by Designers although it was only ranked sixth by Builders. ***High cost of IT specialists*** was rated the fourth biggest barrier as it has been ranked as the fourth and the second biggest barrier by designers and builders respectively.

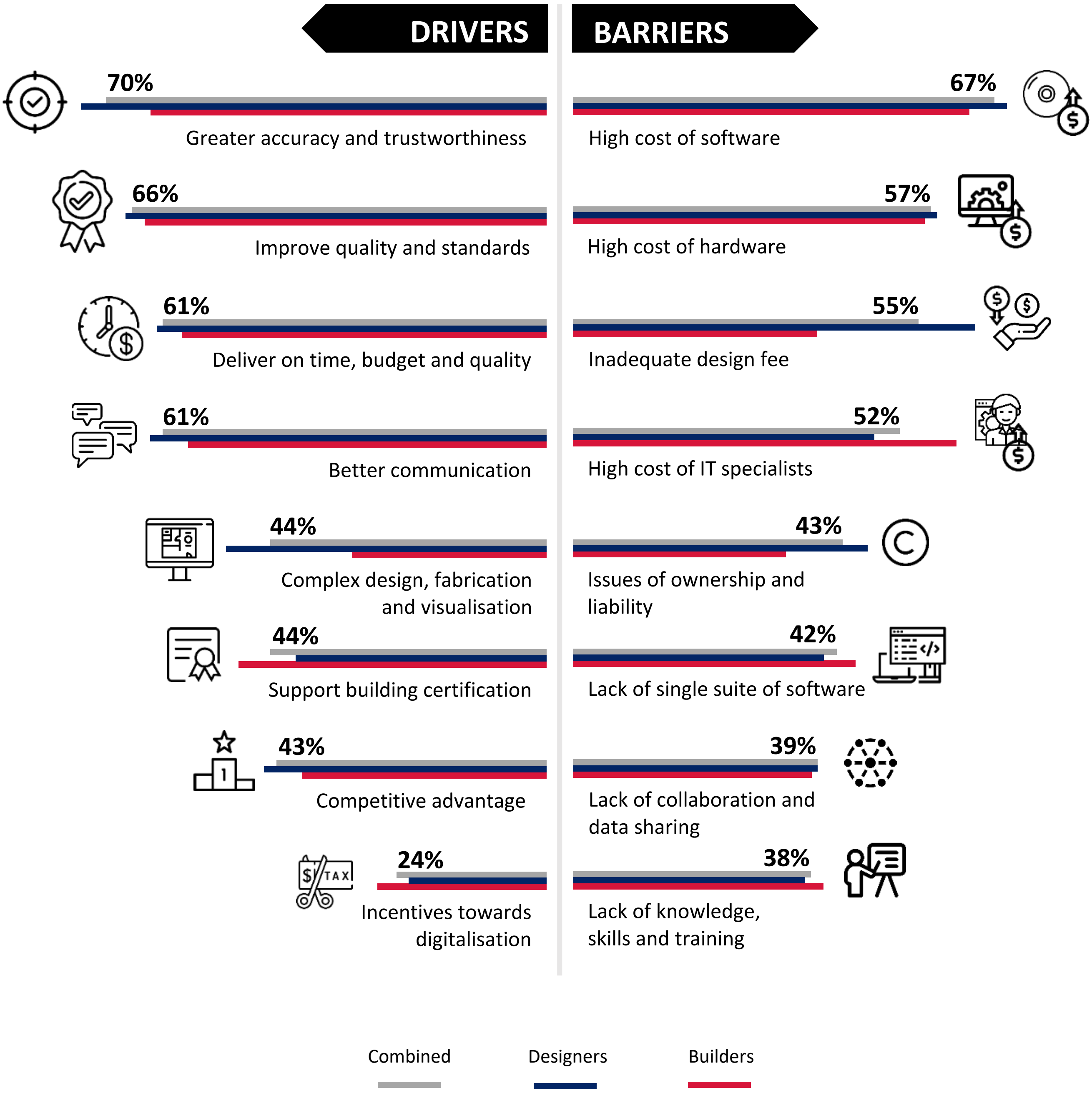

Figure 5.3 - Drivers and barriers for digitalisation

5.4 The Strategic Framework for Digitalisation of Design & Construction

5.4.1 Feasibility levels of digitalisation

The class 2 building sector has achieved the basic level of digitalisation to the level of use of PDF files to submit design and ABD drawings (87%) with further 7% being able to achieve it by 2022 (see Figure 5.4). 84% and 70% of respondents indicated that they have either already been using 2D CAD and 3D CAD respectively or will achieve it by 2022. This figure almost reaches 50% for use of BIM and 26% for use of digital twin technology by 2022.

The state of digitalisation of design and construction suggested by the designers and builders are depicted in Figure 5.5 and Figure 5.6 respectively. These indicate significant potential for mandated capability advancement in the short term for the industry.

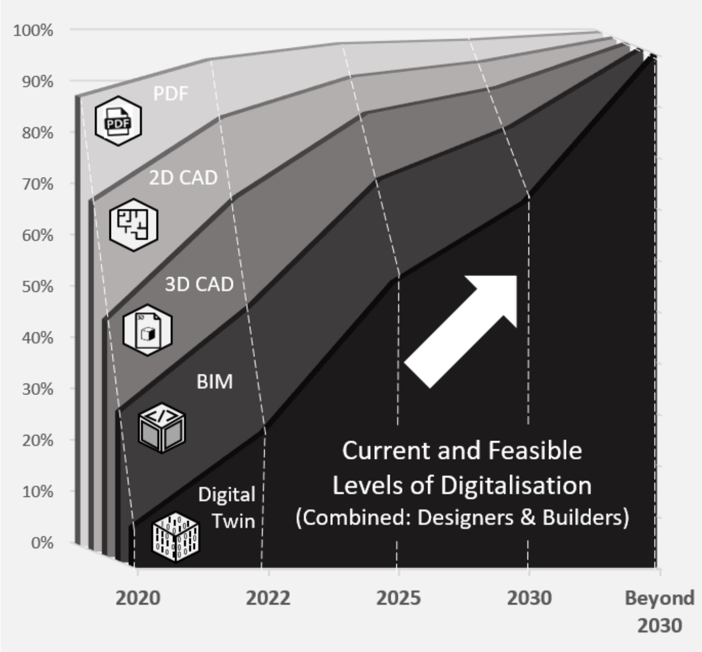

Figure 5.4 – Current and feasible levels of digitalisation (Designers & Builders)

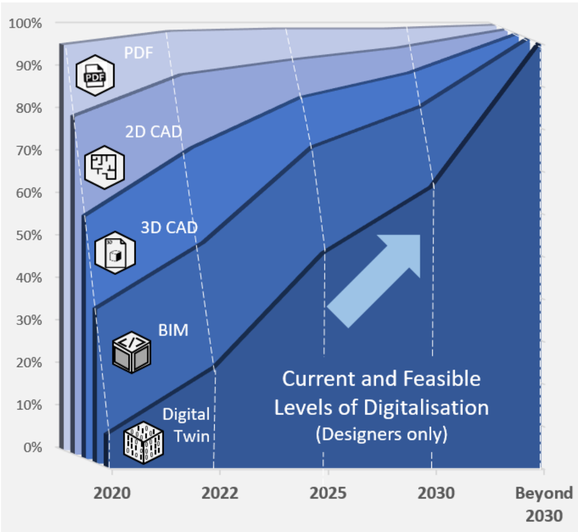

Figure 5.5 - Current and feasible levels of digitalisation (Designers)

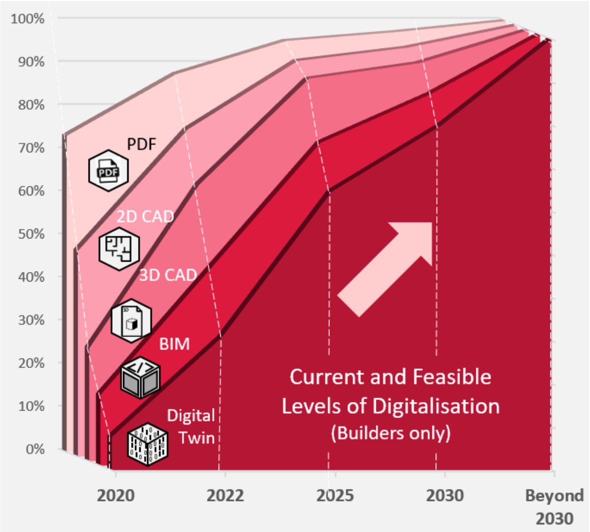

Figure 5.6 - Current and feasible levels of digitalisation (Builders)

5.4.2 The Strategic Framework

The proposed Strategic Framework for Digitalisation of Design and Construction (SFDDC) is presented in Figure 5.7[1]. It was developed based on the findings of the report considering feasible levels of digitalisation of design and is applied to a series of time horizons for implementation in stages that reflect the Chief Economist's digital maturity stages (Figure 1.1). It is a decadal plan that require further development for implementation. Stages 1 to 4 move from basic, advanced, smart to transformative levels of digitisation. The top half of the Figure 5.7 is characterised by the baseline technologies that need to be adopted at each stage. The bottom half presents the minimum targets that needs to be achieved at each stage.

Note 1 - Larger scale version of Figure 5.7 is available in Appendix 1

It denotes the state of digitalisation of design drawings and Issued-for-Construction (IFC)[2] drawing submissions and ABDs for time horizon periods of Stage 1 (up to 2022), Stage 2 (2022 to 2025), Stage 3 (2025 to 2030) and Stage 4 (beyond 2030). Given that the sector is dominated by micro and small enterprises (80%), achieving greater levels of digitalisation across industry will require extra care taken in uplifting their capabilities. Industry wide coordinated training is a crucial aspect of the proposed strategic frameworks across all four stages.

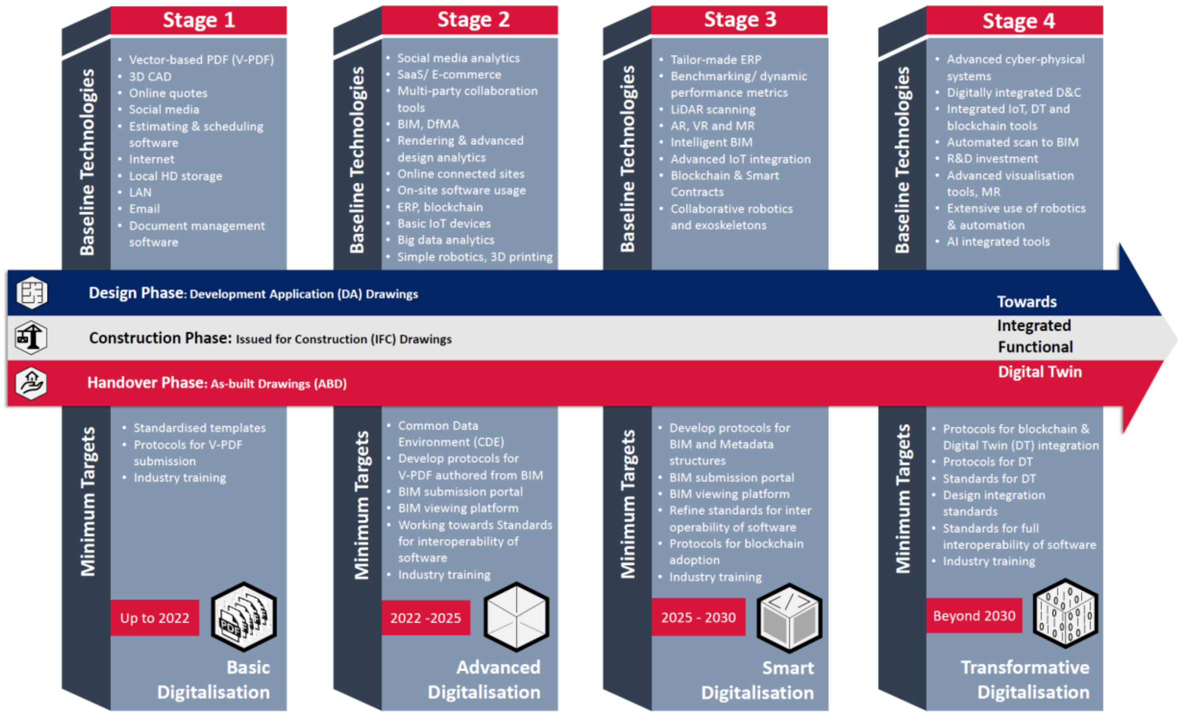

Figure 5.7 - Proposed Strategic framework for digitalisation of design and construction (SFDDC)

Stage 1: Basic Digitalisation (up to 2022)

Stage 1 indicates the basic level of digitalisation that needs to be achieved by 2022. It is characterised by the use of basic technologies such as connectivity to the internet, having a website, using email to improve business operations and the use of vector-based PDF or 3D-CAD. This stage involves the achievement of standardised templates and protocols for V-PDF and 3D-CAD submissions.

It is evident that the whole sector could achieve use of PDF by 2022 without it being an overwhelming burden to the industry, in particular, to micro and small enterprises. To achieve 3D CAD by 2022, only 30% of organisations would be pushed harder than their normal trajectory of advancement. Therefore, it is recommended that all designs, IFC and ABD submissions be in Vector-based PDF format on a standard template implemented across all jurisdictions in NSW.

There are implications for the public sector drawing evaluation authorities (and NSW Planning portal). These organisations would also need to develop not only capabilities to accept Vector-based PDF formats but fluency and capacity to effectively use them to evaluate submitted drawings. However, this should not be overwhelmingly burdensome as the required IT capability enhancement would be minimal. The main aspect would be to train staff to be able to effectively use the 3D Vector-based PDF drawings.

Note 2 - IFC generally implies drawings issued for construction to the builder and in this instance includes drawings approved for construction

Stage 2: Advanced Digitalisation (2022 to 2025)

Stage 2 indicates an advance level of digitalisation that needs to be achieved by 2025. It is characterised by the use of technology in advanced ways to improve their operations both as a design and/or construction organisation. This stage envisages the use of technologies such as SaaS and cloud-based software, data analytics, BIM, DfMA processes, rendering and advanced design analytics, ERP systems, basic IoT devices, basic blockchain systems, 3D printing, simple robotics, among others. Stage 2 also indicates the targets of achieving a common data environment (CDE), BIM submission portals, BIM viewing platforms and working towards interoperability of software.

The next stage of natural technological advancement is for the industry to move towards BIM capability. The data indicates that 74% of the industry would have achieved BIM capability in their natural course of progression by 2025. Therefore, this would push the balance 26% of the industry much harder than they would have naturally progressed. This appears achievable with good regulation, training and a strategic approach to development.

Designs being authored through BIM software would help to enable greater consistency and coordination. IFC submission in a Common Data Environment will need to be in BIM format. It is also expected that BIM format will be used for ABD certification and submissions to client. The development of standards for interoperability of software and achieving a Common Data Environment is vital for success at this stage. As such it will require skill enhancement of the workforce to evaluate BIM submissions as well as enhancing the portal capacity to accept BIM format submissions. Adopting this strategy will eliminate the need for the 76% of the industry to downgrade their already BIM enabled designs.

Stage 3: Smart Digitalisation (2025-2030)

Stage 3 indicates the smart use of digital technologies across the sector that needs to be achieved by 2030. This stage will see rapid proliferation of technologies across the industry where buildings become smarter and intelligent. It is characterised by online platforms and automated supply chain management systems and the use of technologies such as advanced ERP systems, LiDAR scanning technologies, AR, VR and MR visualisation technologies, intelligent BIM, collaborative robotics, advanced blockchain and smart contracts-based systems. Minimum targets to achieve includes the development of BIM and metadata structures, BIM submission portals, Blockchain adoption protocols and more refined standards for interoperability of software.

The last half of this decade will see the boundaries of technological advancement further pushed into achieving smarter and intelligent BIM capability. The survey data indicates that 85% industry would have achieved BIM capability by 2030. As such this benchmark will only push the remaining 15% of industry harder than their natural state of progression to achieve this level of digitalisation in building design.

Designers would be required to submit their designs in advanced BIM formats incorporating metadata such as cost, schedule, and environmental evaluation data integrated BIM formats for IFC and project implementation and client evaluation. ABDs would need to be submitted in BIM format for approval purposes, but builders would be encouraged to submit BIM with Facilities Management (FM) data to their clients. This would enable building clients to use it as the basis for the ongoing management of the building. This period will involve consolidation of protocols for use of BIM and development of standards and protocols for used for additional metadata and FM data submissions. It would also involve refinement of standards for interoperability of software. A major drive in training the workforce and certification of capabilities would be needed at this stage.

Stage 4: Transformative Digitalisation (beyond 2030)

Stage 4 indicates rapid and broad transformation of the construction sector to embedded digitally driven processes that will be achieved beyond 2030. This stage will be characterised by the technologies such as advanced cyber-physical systems, automated scan to BIM, digital twins that provide building automation, advanced visualisation tools, extensive use of robotics and automation, AI integrated tools, blockchain based integrated supply chains governed by advanced smart contracts and digital tracking with IoT devices. The development of protocols for DT, blockchain system governance, standards for advanced building management systems, standards for design integration and full interoperability of software will be key minimum targets. This stage warrants the re-think and development of the next decadal plan for the construction sector.

The new decade would involve the proliferation of digital capabilities in the construction industry truly moving into advanced stages of the fourth industrial revolution. It is expected that this stage would involve the evolution of truly smart and intelligent buildings with self-awareness being brought in through incorporation of sensors into buildings. Integration of sensors and IoT devices to buildings will enable digital twin to operate in its full potential. Survey data indicate that the balance 29% of the designers and builders would achieve digital twin capabilities in this period. This period would require the further development of standards for digital twin as IoT and sensor technologies and data exchange and communication technologies mature. Continued training of the workforce and incorporation of new skill sets into building design and management would occur as these technologies get embedded into buildings.

5.5 Suggestions for Further Research

Taking into consideration the findings and observations of this research, it is suggested that the following areas present opportunities for further research:

- High cost of software was seen as the most significant barrier for digitalisation of organisations. Further research could examine true extent of the impact of software across the entire construction industry. Software used in the class 2 building sector is relevant to the whole industry as well.

- There were clear indications that issues of system interoperability and migration to alternative software are major issues. Further research could examine the extent of impact of these issues in order to expedite the process of digitalisation.

- The success of digitalisation of the class 2 building sector in NSW highly depends on uplifting the status of micro and small enterprises involved. These organisations consist of 80% of the sector and do not have training programs and budgetary capacity for IT investment. Further research could review the type of state-wide digitalisation related training programmes that could be implemented to improve awareness and capability in digital technologies.

- A survey on the whole of Australian construction industry could be carried out to clearly map the state of digitalisation and future direction covering all phases of design, construction, and facilities management. It could evaluate IT capabilities both as people, software, and hardware including infrastructure needed and provide a digitalisation strategy for the whole country.

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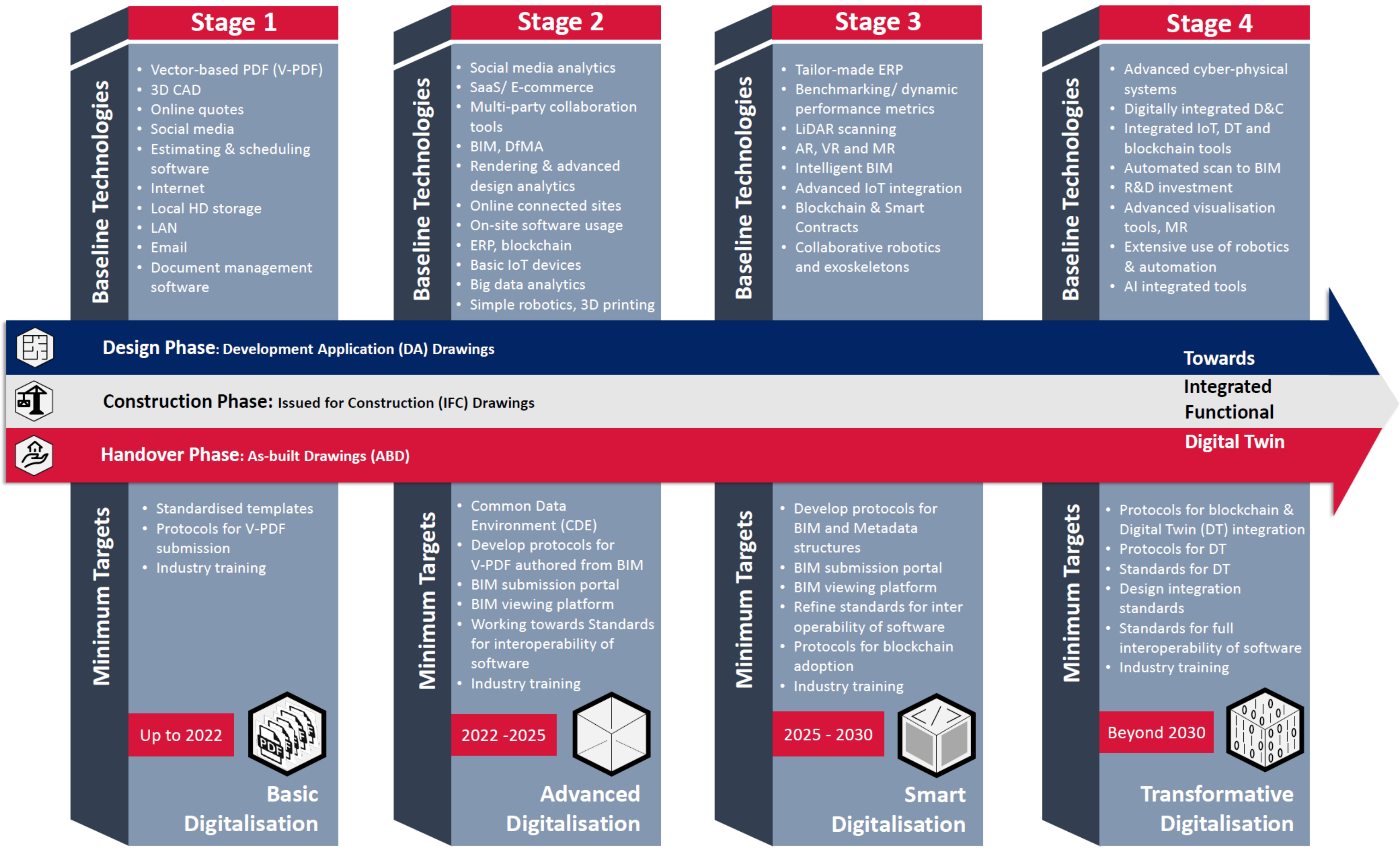
APPENDIX 1



Proposed strategic framework for digitalisation of design and construction

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