BRANZ

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Connecting consenting systems and third party technology tools to improve performance and productivity

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Project LR12093
Third Bearing Ltd / Simpli, funded by the Building Research Levy

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Connecting consenting systems and third party technology tools to improve performance and productivity

What will it take to get connected?

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third bearing

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Contents

1. Introduction

Appointment and Terms of Reference

Simpli together with Third Bearing Limited were commissioned by BRANZ to address the question of:

> *How connections between consenting systems and third-party technology tools can help improve performance and productivity in the building and construction sector.*

This research was funded by the Building Research Levy.

Purpose

The main intended outcome of this research focuses on finding ways to improve the integration of third-party technology as part of the building consent process, improving both the efficiency of the process but also improving information and knowledge about the quality of buildings. This will give Councils and third-party technology providers a common understanding of the improvement potential from creating connections across systems, and how-to best factor this need for future connection as part of the investments Councils are making in online consenting systems.

Scope

This research project addresses the key priority of the BRANZ Research Levy Prospectus – applying technology to drive change with a focus on the use of new technology in the building and construction sector to improve productivity, level of output and performance of buildings. Specifically, it addresses these questions:

- What are the existing technologies that would enhance the consenting process if seamless connection was available?
- What is the 10 to 20-year development picture of these technologies, and what impact are these likely to have for the consenting system?
- How could these technologies enhance the outcomes of the building consent process? Which of these enhancements are the most important for (a) efficiency of process, (b) understanding quality of buildings, and (c) overall productivity and performance of the building and construction sector?
- What are the technical issues around connecting the Council online services to the third-party technology providers?
  - i. Is it an infrastructure or system-design issue, from either the Council online service-side or third-party technology-side?
  - ii. Is it a case of defining data sharing standards?

Work programme and reporting

The assignment was commissioned in November 2019 with a draft report delivered March 2020. Interviews and desktop research were undertaken between November 2019 – April 2020. A final report was delivered on 30 June 2020.

Our work was carried out by Tyson Schmidt, Peter Askey, Sonia Griffin of Third Bearing Limited and Ross McCarthy and Kate Fox of Simpli.

Methodology

Our research methods consisted of:

- Desk-based research on the existing range of online consenting and building information systems currently available.
- Reviewed both domestic and international jurisdictions encompassing published material from third-party providers and Councils, policy papers from local authorities and central governments, industry body news and position papers and research undertaken by industry groups and academic institutes.
- Engagement with third-party providers to map existing capabilities and determine any future plans for connecting and leveraging systems. This was achieved with individual interviews.
- Develop a map of existing capabilities and test this with Councils to ensure accuracy of representation and to determine awareness and future plans for connecting and leveraging third-party providers. This was completed with individual interviews.

A full list of interview questions is in Appendix A & B.

Abbreviations, tables and currency units

The following abbreviations are used throughout the text:

2D - Two dimension
3D - Three dimension
AEC - Architecture, Engineering, and Construction
BAC - BIM Acceleration Committee
BCA - Building Consent Authority
BIM - Building Information Modelling
BIS - Building Information Systems
CAD - Computer Aided Design
CDE - Common Data Environment
CEBC - Consortium of European Building Control
CSIRO - Commonwealth Scientific and Industrial Research Organisation
EDRMS - Electronic Document and Record Management Systems
GIS - Geographic Information System
GPS - Global Positioning System
GSA - General Services Administration
GTIN - Global Trade Item Number
HKBIM - Hong Kong Institute of Building Information Modelling
LGOIMA - Local Government Official Information and Meetings Act 1987
LINZ - Land Information New Zealand
MBIE - Ministry of Business, Innovation and Employment
NSC11 - National Science Challenge 11: Building Better Homes Towns and Cities
NPC - National Product Catalogue
PUB - Singapore's Public Utilities Board
TA - Territorial Authorities
TPP - Third-Party Providers
UK - United Kingdom
USA - United States of America

Probity

In accordance with our agreement for accessing data and information we gave an understanding not to identify any individual third-party provider, building information systems or Building Consent Authority as part of our reporting where this may reveal any commercially sensitive position or development plan.

Acknowledgements

We would like to thank the teams from:

BUILDING CONSENT AUTHORITIES

Manawatū District Council – Karel Boakes

Palmerston North City Council – Leigh Sage

Horowhenua District Council – Megan Leyland

Kāinga Ora Consentium – Anna McCrossan, Stephen Choy, Katerina Solomona

Auckland City Council – Andrew Minturn

Waitaki District Council – Lichelle Guyan, Roger Cook and Brent Cunningham

Timaru District Council - Jayson Ellis

Carterton District Council – Dave Gittings

Christchurch City Council – Mark Urlich and Donna Grice

THIRD-PARTY TECHNOLOGY PROVIDERS

Top Notch Construction - Thomas Heppleston-Tait

MasterSpec – Mark Fairbairn, Alex Shaw and Russell Turner

ProductSpec – Ian Watt

Conqa – Daniel O'Dononghue

BIM Acceleration Committee – Andrew Reding

Artisan – Sunil Surujpal

CadPro – Hans Grootegoed

EBOSS – Matthew Duder

Objective – Nigel Paxton

Compliance Audit Systems Limited - Dr Johannes Dimyadi

OTHER ORGANISATIONS:

LINZ – Chris Kane

University of Auckland – Professor Robert Amor

GS1– Nick Allison and Gary Hartley

Presentation to Simpli User Group

2. Our report on a page

The New Zealand construction industry will see increased adoption of technology alongside a maturing of digital consenting systems. We found five main areas where third party technology could enhance the consenting process – use of BIM, automated code checking, digital product specification information, adoption of quality assurance tools, and data sharing across BCAs and external agencies.

Enabling interaction between these technology and consenting systems will lead to quicker and smarter consent processing. It will also create a richer set of information that the industry, BCAs and Government agencies can draw on to analyse productivity, quality and performance.

Technology is not the main barrier to achieving interaction. Key issues raised were time & effort required (sustained effort needed to go digital and associated change in ways of working), battles with IT (two camps – BCAs who had support of their IT department or those that had to 'fight' to secure the mandate and resource), and deciding between enterprise systems (Council-wide) or a specialist system focussed on consenting.

Benefits of technology interaction were seen to be higher for industry than for BCAs. Areas where benefits were seen to be higher for BCAs were adoption of inspection tools and data sharing with other BCAs & agencies.

Continued adoption of BIM is a key enabler as it is a vehicle for much of the information that would be exchanged between systems. Uptake of BIM by residential designers is important due to the volume of residential consents that BCAs deal with.

Addressing trust & liability issues early on as part of technology development will also help reduce barriers to interactions with consenting systems – especially for automated code checking and digital product specification information.

Now...

Industry now...

NZ construction industry is in the early stages of technology transformation. The Construction Sector Accord highlights increased adoption and better use of technology as necessary to improve productivity. The limited uptake of technology by industry has influenced adoption rate by BCAs as well.

Consenting systems now...

There is still a fair way to go on digital consenting adoption by BCAs. Nearly a third of BCAs have advanced consenting systems (covering nearly 60% of consents), but there is a range of systems with varying capabilities. This range presents a number of issues for connecting with third party technology providers – increased number of connection points increasing the complexity and cost to link, and a lack of standardisation which limits sharing across different systems. Nearly all systems are based on PDF submission, limiting design information that can be extracted.

Short-term focus for BCAs

- Need to raise awareness of technology developments and their benefits
- Get 100% of BCAs with digital consenting systems and able to share data
- Adopt tools for remote inspections (incl. real-time video capture)

Medium-term focus

Interactions between industry technology and consenting systems will be underpinned by:

- Increased adoption by BIM, especially for residential consents
- Sufficiently addressing any trust & liability issues early on

Key initial steps will include:

- Establishing live library of product specification info
- Ability to draw info from BIM submissions
- Adoption of automated code-checking pre-submission

Key concept: how far to lag?

Commercial drivers and size of productivity prize means industry will lead in technology adoption, so key question is how far should BCAs lag? Too far and they act as a drag on the system overall, but too close and it risks over-investment.

In 10-15 years time...

Future of construction

The entire way of working will be rethought as new technologies are adopted by NZ construction firms. These technologies will drive increasing amounts of data, requiring better tools to share information and derive value from analysis.

- 3D printed buildings
- 6D BIM
- IoT sensor-driven data leveraged for site and asset management
- Real-time project visibility driven by 3D data capture and data analysis

Future of consenting

All consenting will be digital-based, helping to streamline effort by building officers. It will also increasingly be seen as just one part of the whole building process starting from demand analysis, through digital resource consenting, and easily-accessed digital property information.

Dynamic consenting

- Draws directly from 6D BIM submissions
- Automated & trusted code-checking within systems
- Automatic sharing of information to system stakeholders

Golden thread

- Digital twin held by Councils as part of Building Act requirements
- Twin updated throughout building lifecycle, kept 'live'
- Easy access for operations and management of buildings

3. Overview of building consenting in New Zealand

1. The construction sector in New Zealand is adopting innovations and technologies that are changing the process of building. While technology was primarily used at the front end of the construction process (i.e. for the design of buildings), it is now increasingly being applied throughout the full construction process – from design, through the building process, and during the life of the building post-construction. This is resulting in increasing amounts of data and information flows from the sector and increasing demands to connect across technology solutions.
2. This section provides an overview of the consenting systems used by Building Consent Authorities (BCAs) in New Zealand as well as technology being used across the building and construction sector that relates to consenting.

Overview of consenting in New Zealand

3. Almost every building constructed in New Zealand requires a building consent.[1] A Government guide states that a building consent:
"is the foundation document for any significant building project. The building consent allows the owner, or owner's agent, to carry out building work in accordance with the plans and specifications approved by the building consent authority. The building consent also provides formal recognition that the plans and specifications meet the requirements of the New Zealand Building Code. Building work carried out in accordance with the approved plans and specifications will meet minimum performance standards."[2]
4. BCAs are responsible for issuing building consents under the Building Act 2004. They also inspect the building work for which the consent has been granted, and issue notices confirming that the completed building complies with the Building Code. Currently there are 72 BCAs in New Zealand, with the majority of these being local authorities. The only non-local authority BCA is Consentium which was established in 2019 by Kāinga Ora/Housing New Zealand to be responsible for the consenting of all Housing New Zealand related building projects.
5. Each BCA operates largely independently, running their own software solutions and operational structure. There are some shared services arrangements in existence, although these tend to be limited to sharing of staff resources for consenting of high-end buildings (where smaller BCAs may not possess the assessment skillsets required) or for inspections duties. A number of BCAs also utilise external contractors to undertake consent processing or other consent-related functions.
6. An efficient and effective consenting process is an important part of the construction process. While consent costs are a small part of the total costs associated with development,[3] the process can cause delays due to information missing from submitted designs, processing delays by BCAs, or failed inspections requiring rework and reinspection. Reducing these delays through the consenting process can save between $1,000 to $1,600 a week per house according to a 2012 BRANZ report – not insignificant when total profits per house were estimated between $10,000 and $20,000 at that time.[4]
7. The number of new dwellings consented in the year ended December 2019 was 37,538, up 14 percent from the December 2018 year.[5] The total value of all buildings consented in the same period was just under $24 billion, with $7.5 billion of this being non-residential and $13.9 billion related to new residential dwellings.
8. Auckland saw the biggest rise in new residential dwelling consents issued (18%) through to the year ended December 2019, and also consented the highest total number of consents at 15,154. The next highest number of consents was in Canterbury with 5,308 in the same period.

1 Section 41 of the Building Act 2004 sets out the cases where a building consent is not required.
2 Department of Building & Housing, "*Guide to applying for a building consent (residential buildings), Second Edition October 2010*" - https://www.building.govt.nz/assets/Uploads/projects-and-consents/guide-to-applying-for-a-building-consent.pdf - accessed 18 May 2020.
3 See for example, Deloitte Access Economics (2018) "*Cost of residential housing development: A focus on building materials*" - https://www2.deloitte.com/content/dam/Deloitte/nz/Documents/Economics/nz-en-DAE-Fletcher-cost-of-residential-housing-development.pdf, accessed 18 May 2020.
4 Ian Page (2012) "*Value of time savings in new housing*" BRANZ report SR259 - https://bit.ly/2Yeel1a - accessed Dec 2019.
5 Stats NZ https://www.stats.govt.nz/information-releases/building-consents-issued-december-2019 - accessed Feb 2020.

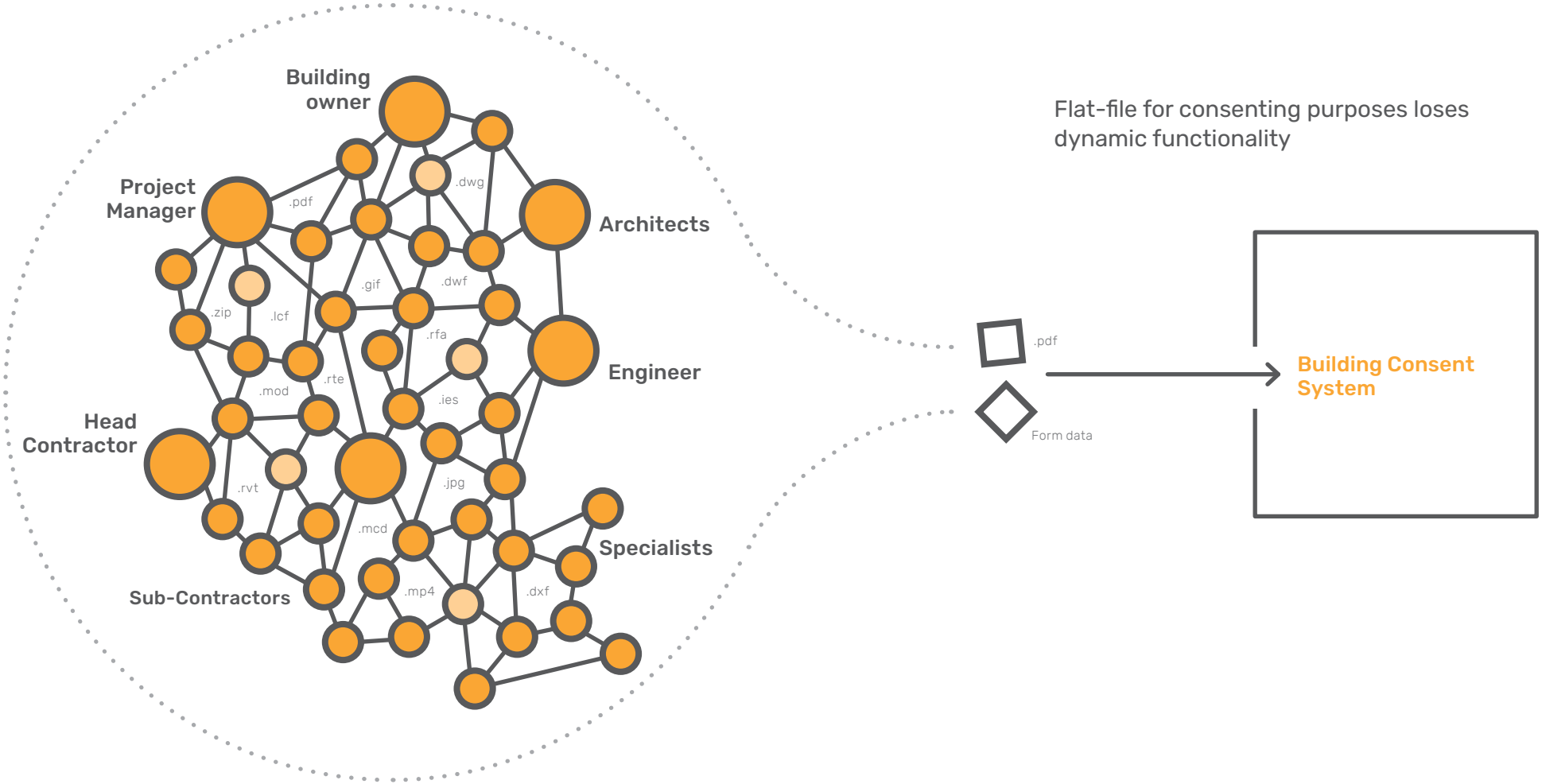
9. Almost all building designs are created using digital design and modelling software. Even basic residential dwellings will have a full set of design drawings completed in some form of computer-aided design software (CAD), with other design elements such as engineering calculations and services designs also completed using a variety of digital tools. As building complexity increases so does the number of people involved at the design and build stages – all sharing and exchanging a variety of digital files as part of communicating their contributions to the development.
10. This richness of information and file-type exchange at the design stage of a building is then flat-filed to PDF format for consent submission. The only additional information submitted is done as part of basic data collection through electronic or hardcopy forms. Diagram One illustrates how any dynamic functionality is lost as part of the consent submission process.
11. The Construction Sector Accord report released in April 2019 was a collaboration between construction sector leaders and government and called for a new building consenting model.[6] The Accord noted that the current process is inefficient and inconsistent across regions, contributing to reduced productivity. Part of the solutions to be explored is better "use of digital technology to promote speed and accuracy in the consenting process". The Accord's Transformation Plan notes a deadline of June 2021 for a new building consenting model to be designed.

6 Construction Sector Accord https://www.constructionaccord.nz/transformation-plan/regulatory-environment/ - accessed Feb 2020

Diagram One.

Digital design data

Richness of digital data design and information from many different sources within the construction process



Flat-file for consenting purposes loses dynamic functionality

Case Study - **The future of construction**

The future will be a continuation of the construction sector shedding its slow adopter image.[7] The next generation of contractors will be on the leading edge of innovation. They will have to be forward thinkers to transform their companies, driving more productivity and faster projects with less risk and stronger profit margins. They will carefully select which technologies to implement based on specific outcomes and relative risks for adoption and use.[8]

Suppliers will be expected to provide the tools needed to dig deeper into their data to see results in real time and allow the operation of smarter projects and facilitate better forecasting and planning for future ones.

While BIM has been readily embraced, it will continue to develop due to the diverse range in size and priority of users. The global BIM industry will continue to develop with millennial workers considered key to widespread adoption.[9] It is thought the requirement of millennials to be enabled to embrace the big picture of projects will help older workers overcome hesitance to adopt BIM and other technologies.

"Whether it's drones, robotic systems and automation or even mobile apps, companies need to have the right people and processes in place for technology to be successful," says Fred Ode, CEO and chairman of Foundation Software.

Three international studies all conclude that given the sheer size of the Engineering and Construction industry and its slow adoption of technological innovations, the construction sector is ripe for disruption.

Two of the studies identify the lack of investment in digital technologies as a contributor to the sector not embracing technology.[10] The studies conclude that current sector investment in digital technology is around 1% of sector revenues. This is significantly lower than other industry sectors that needed to adopt digital technologies to address productivity and efficiency – to achieve transformation they needed to invest an average of 3.5% of revenues.

Neither study determines what the appropriate investment might be but signal the gap as a significant opportunity for disruptive innovation. While each study varies on what their respective disruptive innovations might include, they all agree on the role of 5-D BIM and importance of its contribution.

Projects underway including digitisation of the building code, automated code checking, digitisation of specifications and the digitisation of objects by manufacturers all facilitate New Zealand's future 3-D BIM progression. These projects support development of the design and engineering phase of the value chain and carry over into the construction phase. Other digital information that will be embedded in 3-D BIM include geometry, spatial data from GIS systems, aesthetics, thermal properties, and acoustic properties.[11]

Further innovation to incorporate BIM with cloud technology creates an opportunity to shift to Generative design. This replaces the one human – one computer – multiple design options with one human – many computers – many design options. The expected outcomes from this design approach include improved design, improved selection and use of materials, better prefabrication functionality and better build output quality.[12] This is consistent with one of the innovations identified by Boston Consulting Group for digital technologies and big data along the value chain.[13]

7 Marla McIntyre (February 5 2018) "*Technology Solutions Drive Productivity and Ease Labor Shortage Concerns*" Construction Executive Journal, Jan/Feb 2018, p. 44-54 https://bit.ly/31bMqky – accessed April 2020 (Quote Matthew Harris, CPO, Viewpoint)

8 Marla McIntyre (February 5 2018) "*Technology Solutions Drive Productivity and Ease Labor Shortage Concerns*" Construction Executive Journal, Jan/Feb 2018, p. 44-54 https://bit.ly/31bMqky – accessed April 2020 (Quote Frederic Guitton, CRO, Red Team Software

9 Marla McIntyre (February 5 2018) "*Technology Solutions Drive Productivity and Ease Labor Shortage Concerns*" Construction Executive Journal, Jan/Feb 2018, p. 44-54 https://bit.ly/31bMqky – accessed April 2020 (Allied Market Research)

10 McKinsey & Company (June 2016) "*Capital Projects and Infrastructure*" https://mck.co/30SdZz7 - accessed May 2020 and Deloitte (2016) "*Point of View on Digital Construction, The business case of incorporating digital technologies into the construction industry*" https://bit.ly/3eguEQu - accessed May 2020

11 McKinsey & Company (June 2016) "*Capital Projects and Infrastructure*" https://mck.co/30SdZz7 - accessed April 2020

12 Michael Molitch-Hou (November 2017) "*Generative Design Meets BIM for Smart Urban Planning, Dutch construction firm Van Wijnen uses BIM to invent entirely new ways of designing and constructing*" https://bit.ly/2UYD9ly - accessed May 2020

13 World Economic Forum and Boston Consulting Group (2016) "*Shaping the Future of Construction A Breakthrough in Mindset and Technology*" https://bit.ly/3ejMMZW - accessed May 2020

Table One. Three international studies conclusions on the Engineering and Construction industry adoption of technological innovations

World Economic Forum (by BCG)[14]	McKinsey & Company[15]	Deloitte[16]
> Advanced building and finishing materials > Standardised, modularised, and prefabricated components > (Semi-)automated construction equipment > New construction technologies (e.g. 3D printing) > Smart and life-cycle-optimising equipment > Digital technologies and big data along the value chain	> Higher-definition surveying and geolocation > Next-generation 5D building information modelling > Digital collaboration and mobility > The Internet of Things and advanced analytics > Future-proof design and construction	> Connected assets (use of sensors) > Dynamic work planning (tracking materials and resources) > Worker safety (technology to reduce hazards) > Real-time project visibility (driven by 3D data) > Collaboration driven by cloud technology > Data analytics

Other industry views supporting generative design is the belief it provides a design leveraging opportunity to solve targeted problems[17] and counter to this is the view that while it's trivial to show that generative design is possible, it's much harder to take the next step and show that generative design is useful. In fact, it rarely happens. This is the real challenge of generative design: going from the plausible to the practical.[18]

Given the scale of the New Zealand market it is reasonable to expect that the development of digital technologies will follow similar patterns experienced internationally where new entrants to the sector create a foothold for their disruptive technologies by presenting focused solutions around a single technology solving a specific but industry wide problem (opportunity) i.e. Conqa, Masterspec or the use of virtual/augmented reality. Internationally the shift is expected to be towards rethinking the entire way of working and using a mix of technology solutions for one specific big problem. For this to happen will require an increase in scale and entrants investing in a business model that stretches beyond simple product development and sales and a strategy that shifts from cost savings and improved efficiency to value creation.

From our interviews with third party providers we learned that digital transformation would continue to create opportunities. These opportunities include remote collaboration platforms and digitisation of processes. The digitisation of the building construction site will continue to evolve, integrated mobile technology will increasingly improve communication and site collaboration and there will be greater use of remote control.

"The construction industry is still in the early stages of tech disruption, and despite the new technologies already available, you can only expect these to continue to increase in number, and advance in capability. Technology will continue to make building processes faster, simpler and safer as machines get smarter and more proficient at processing data and taking action".[19]

14 World Economic Forum and Boston Consulting Group (2016) "Shaping the Future of Construction A Breakthrough in Mindset and Technology" https://bit.ly/3ejMMZW - accessed May 2020
15 McKinsey & Company (June 2016) "Capital Projects and Infrastructure" https://mck.co/30SdZz7 - accessed May 2020
16 Deloitte (2016) "Point of View on Digital Construction, The business case of incorporating digital technologies into the construction industry" https://bit.ly/3eguEQu - accessed May 2020
17 Daniel Davis (20 February 2020) "*Generative Design is Doomed to Fail*" https://bit.ly/30YB0Ai - accessed April 2020
18 Daniel Davis (20 February 2020) "Generative Design is Doomed to Fail" https://bit.ly/30YB0Ai - accessed April 2020
19 Conqa "How technology is disrupting the technology sector" https://www.conqahq.com/post/how-technology-is-disrupting-the-construction-industry - accessed 18 June 2020

BCA building consent systems

12. The last decade has seen an increasing number of BCAs adopt digital consent processing systems. Currently around 90% of BCAs have some form of digital capability relating to consenting – from the ability to receive a submission electronically through to the processing and issuing of consents. A small number of BCAs have full end-to-end digital capability where an application can be received, processed, issued, inspections managed, and a certificate of code compliance issued completely digitally and online. Prior to the adoption of digital consenting systems all building consents in New Zealand were submitted and processed in hardcopy.

13. Digital consenting systems have a number of benefits for users. Assessments completed by ConsultingWhere Ltd and Third Bearing Limited in 2015 identified savings to users from reduced lodgement effort and removal of printing charges, through to reductions in processing delays.[20] For Palmerston North City Council, Third Bearing Limited found that the different charging approach meant applicants would save an average $323 per consent on printing charges alone. Third Bearing Limited's work for Palmerston North City Council and the GoShift initiative estimated that 70% of total benefits from implementing a digital consenting system accrued to the users. These findings were similar in scale to those identified by ConsultingWhere Ltd for Selwyn District Council.

14. Where digital submission is available uptake has generally been high, with more than 95% of consents coming in digitally (either submission via an online portal, emailed files, or through USB). In some areas, such as Auckland City Council, the uptake has been lower with around 70% digital submission.[21] Even when building consents are submitted in hardcopy they are predominantly still designed in computer-aided design software, with Councils we interviewed telling us that only 1-2% of submitted consents are written applications with hand-drawn plans.

15. Digital consenting systems can be generally categorised in two ways: specialist standalone systems that focus purely on consenting, or enterprise systems that have consent processing functionality as part of wider capabilities (see Diagram Two). AlphaOne, GoGet and the Simpli portal are examples of specialist systems that were designed primarily for the building consent systems. Enterprise system providers such as Datacom, SAP, and TechOne are examples of where building consents have been included as part of general online services systems.

16. Both the enterprise and specialist systems vary in their approach and depth of capabilities. Simpli is a specialist system and is a portal only, feeding submission information through to other processing systems. GoGet has a range of modules that cover the consenting and inspection process and is designed to work with the Simpli portal or other submission system. AlphaOne is a more contained 'end-to-end' specialist system that can also operate with the Simpli portal. All of the specialist systems have the ability to interact with a range of enterprise systems for finance or document management purposes.[22]

17. Where building consents are handled by enterprise systems they tend to use a smart forms approach to capture submission and processing information, with varying capabilities to manage workflow and decisions.

20 Third Bearing Limited (Dec 2015) "*PNCC Online Consenting System Feasibility Study*" Third Bearing Limited (Dec 2015), "*PNCC Online Consenting System Economic Impact Analysis*" ConsultingWhere Ltd (May 2015) "*Selwyn Council Building Consent System Cost-Benefit Analysis Final Report*"

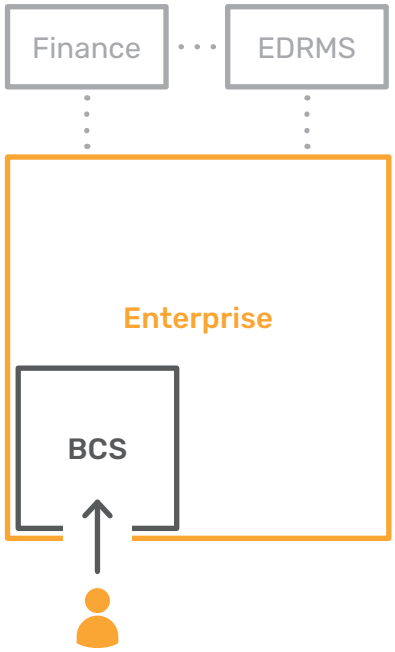
21 Interview with Andrew Minturn (18 Feb 2020) at Auckland City Council

22 A number of other Council systems are also used as part of digital consent processing. Electronic document and record management systems (EDRMS') generally connect to consenting systems to manage the consent and property files, and finance systems are used to invoice and process consent fees.

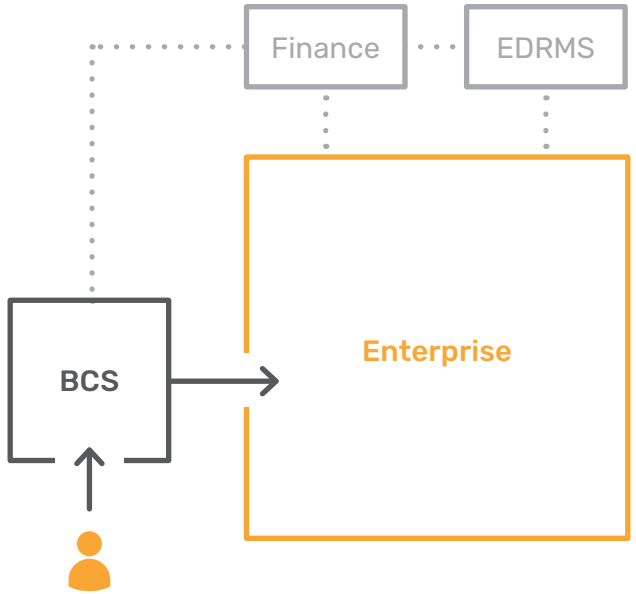
Diagram Two.

Digital consenting systems connection with enterprise systems

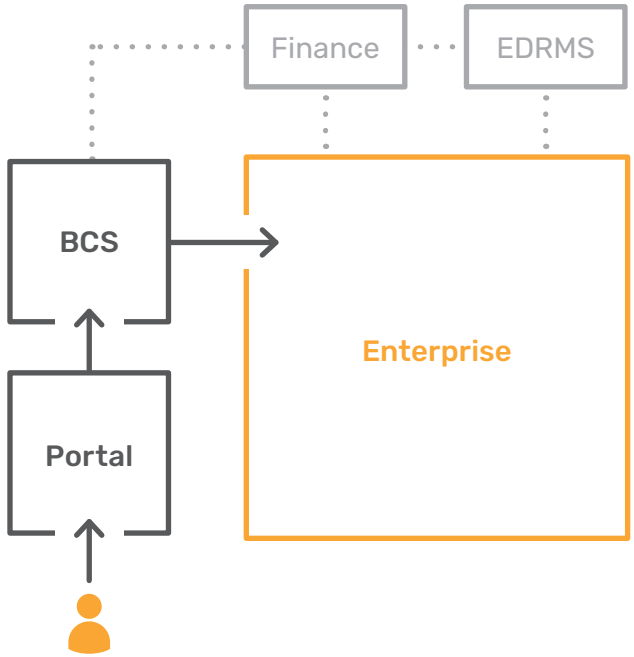
Digital consenting systems are generally catergorised in two ways: specialist consenting systems or enterprise systems that have consent processing functionality. Here we have three examples of how these interact with one another:



The building consenting system (BCS) is within the enterprise system. These tend to use a smart forms approach to capture submission and processing information with varying capabilities to manage workflow and decisions. Examples are Datacom, SAP and TechOne. A portal can be added at the front of this.



Submission, processing and inspection management functions are managed within the BCS and directly interacts with enterprise and related systems. An example of this type is AlphaOne.



Specialist submission portal feeds submission information through to the BCS which manages the processing and inspection management functions. Directly interacts with document, financial and record management systems. Examples of this type of system is Simpli/GoGet or Simpli/AlphaOne.

18. The development and evolution of digital consenting systems can be categorised as having gone through three main stages over the last decade (see Table Two).

19. A fourth stage is now emerging since the purchase of the AlphaOne and GoGet systems by the Australian firm Objective. While AlphaOne and GoGet currently remain separate, there is the potential for them to be combined into a single product.

Table Two. Overview of consenting system development.

2010-2015	Early beginnings	Genesis of standalone systems: > GoGet initial modules focus on mobile inspections and processing. > AlphaOne created in collaboration with Selwyn District Council, adopted by Kaipara District Council. > Adaptation of enterprise systems: > Datacom incorporates LIMs & inspections as part of existing online services. > The likes of TechOne and Authority offer varying online service capabilities for consenting Standardisation collaboration efforts: > GoShift collaboration begins standardising consent forms across Councils > Shared services arrangements between BCAs emerge (e.g. Manawatū District Council & Palmerston North City Council).
2015-2017	Ramping up of capabilities	Standalone systems grow: > GoGet suite expands to cover key consenting stages (including submission via Simpli portal) > AlphaOne secures additional clients for end-to-end product > Enterprise systems expand: > SAP in place at Auckland – consent process part of wider enterprise system. > Datacom customers able to submit consent applications > Collaboration goes digital: > GoShift/Simpli submission portal developed and piloted with 8 BCAs.
2017-2019	Maturing of products	Grows to 30+ BCAs using at least one module. AlphaOne in use by over 12 BCAs users. Simpli portal in use by 20 BCAs.
2020		Objective purchases AlphaOne and GoGet.

4. International approach to building consenting

Use of electronic systems and online platforms

20. In 2018 the Consortium of European Building Control (CEBC) surveyed 30-member countries and reported on the status and plans for the electronic authorisation and control of construction works (e-delivery) in Europe.[23] The report established the extent e-delivery was being used across all members in the planning, issuing of permits, design, construction and building control disciplines. The report also determined what future steps each country is preparing to take in this field. Conclusions from the report included:
    - Doing business electronically in building control is already becoming the mainstream method for obtaining a building permit among CEBC members organisations/countries. The majority of member organisations (22-25 respondents) are well developed in some areas of e-Delivery with most other areas being developed in some shape or form.
    - As the processes are being digitalised so are the possibilities to undertake enquiries and building identification electronically. As these systems develop it is a natural progression to use the same systems to also store the data.
    - Of the thirty (30) respondents, five members were noted as having well advanced systems of e-Delivery and they are all seeking to further advance these systems towards full IT solutions in the building control discipline. These are City of Vantaa, Finland, Derby City Council, England, General Council of Technical Architecture of Spain, Technical Regulatory Authority, Estonia and "Vereniging Beow-en Woningtoezicht, Nederland.
    - For the time being computers are not used to provide full compliance checking of building regulations. Technologies are being developed which will enable building proposals to be fully checked for building regulation compliance solely by electronic means.
    - Legal frameworks and legislation will have to adapt for the procedures and communications involved in obtaining building permits to become fully electronic.
    - Most countries/member organisations have or are implementing methods of working electronically on site during the construction phase. The most advanced solutions can be found in Finland, Scotland, Estonia, Norway and Spain.
    - Electronic systems are widely used to archive documents and data related to the building control process. Being able to track through the lifetime of a building (or "Timeline") showing the various alterations, extensions, demolitions and building uses etc. is an important feature that is used almost everywhere and is recognised as adding value to the life of a building. Finland, England, Estonia, Netherland and Spain are the countries with leading experience in this respect.
    - Use of BIM is relatively less known and not yet broadly adopted in building control processes. No-one among CEBC members has a fully developed system that would integrate BIM as a part of the control processes, and many do not propose to. Most advanced in the use of BIM in building control are Finland, Estonia and parts of UK.
21. In the USA there are approximately 20,000 state, county, city or municipality building permit issuing places.[24] Due to the large number of authorities and the countries federal and state structure it is difficult to get an accurate overall assessment, and we were unable to find research that addressed the entire USA in terms of the use of online platforms for the processing of building permits.
22. Sampling individual authorities revealed common use of such platforms as ePLAN, eBUILD and Evolve by authorities indicating that electronic processing of permits was well established. Most of the authorities sampled have electronic systems for the receipt of building permit applications. Many of the authorities up until February 2020 also took over the counter paper-based applications, but the COVID 19 event has forced authorities to accept electronic submissions only.

23 Consortium of European Building Control (2018) "*E-Delivery in Europe*" https://www.cebc.eu/public-current-reports/ - accessed February 2020

24 Moody Analytics, https://www.moodysanalytics.com – accessed March 2020

23. Examples of some large USA municipalities include:
    - New York City launched The Development Hub, a digital platform that enabled online submission of plan review applications along with required forms and payments. New York's system allows plan examiners to review applications in their technologically advanced offices with large television screens and smart boards. Webcams and video conferencing tools were used to facilitate communication between plan examiners and applicants.[25] However, the system currently only accepts drawings in PDF format, which limits the capabilities of the system.
    - City of Boston started using a similar system in 2014 and was able to process 21% more applications in 18% less time in their first year.[26]
24. Use of BIM in the USA is well established with 72% of construction firms in the US believed to be using BIM technologies for significant cost savings on projects.[27] USA was an early adopter and it is not just the government that has been pushing for the power of visualization, coordination, simulation, and optimization in the construction, several US states, universities and private organizations are supporting the adoption of higher BIM standards.
25. In 2003 the US General Services Administration (GSA) formulated the National 3D-4D-BIM Program. This program established policy mandating BIM adoption for all Public Buildings Service projects. GSA also actively partners with BIM vendors, federal agencies, professional associations, open standard organizations, and academic/research institutions to develop a community of BIM leaders within GSA.
26. In 2010, Wisconsin became the first US state to require all public projects with a budget of $5 million or more and all new construction with a budget of $2.5 million or more to incorporate BIM. Meanwhile, through the NBIMS-US Project, the National Institute of Building Sciences buildingSMART alliance has curated consensus-based open BIM standards to foster innovation in processes and infrastructure.
27. A 2012 study by China Construction Industry Association found that less than 15% of a total of 388 surveyed companies were using BIM. According to industry players, this slow rate of adoption can typically be associated with resistance toward new management processes. The popular sentiment regarding BIM in China is that the government provides encouragement to use the technology, but leadership is missing. Even though the Ministry of Housing and Urban-Rural Development chalked out a role for BIM processes in industrialization, urbanization and agricultural modernization in its 12th Five-Year Plan, it is not mandatory to use BIM. The Ministry of Science and Technology has also approved the China BIM Union to develop the national standard of practices.[28]
28. The Hong Kong Institute of Building Information Modelling (HKIBIM) was established in 2009, and the roadmap for BIM implementation was formulated by the Housing Authority in 2014. The contractors are leading the BIM agenda in Taiwan, where hiring a third party to model the design is the norm.[29] Hong Kong has indicated plans to use BIM-only permitting but the process will take five to 10 years.[30]
29. One of the early adopters of BIM processes, the South Korean government has been working systematically to increase the scope of BIM-mandated projects in the country since 2010. The South Korean Ministry of Land, Infrastructure and Transport even provided $5.8 million over a period of three years to build open BIM-based building design standards and information technology. Since 2016, the Public Procurement Service has made BIM compulsory for all public sector projects over $50 million.[31] South Korea saved $1.6 billion (U.S.) through e-permitting from 2004-2016. By working with industry to standardize the permit process, the government also reduced the permit approval period from 60 to 15 days.[32]

25 New York City (Oct 3, 2017). "*The HUB Enrollment*" https://www1.nyc.gov/site/buildings/industry/the-hub.page - accessed Feb 2020

26 Lawerence, A. (2015). "*How Boston Is Making Permitting and Licensing Easier | Data-Smart City Solutions*" https://bit.ly/2YSb46l - accessed Feb 2020

27 Geospatial World (May 2017) "*BIM adoption and implementation around the world: Initiatives by major nations*" https://www.geospatialworld.net/blogs/bim-adoption-around-the-world/ (2017) - accessed May 2020 and McGraw Hill 2014
McGraw Hill Construction (2014) "*The Business Value of BIM for Construction in Major Global Markets: How Contractors around the world are driving innovation with building information modelling*" Smart MarketReport (pp. 1–60). Bedford: McGraw Hill Construction. Retrieved from https://bit.ly/37VAEvK - accessed 9 Feb 2020

28 Geospatial World (May 2017) "*BIM adoption and implementation around the world: Initiatives by major nations*" https://www.geospatialworld.net/blogs/bim-adoption-around-the-world/ (2017) - accessed May 2020

29 Geospatial World (May 2017) "*BIM adoption and implementation around the world: Initiatives by major nations*" https://www.geospatialworld.net/blogs/bim-adoption-around-the-world/ (2017) - accessed May 2020

30 Daily Construction News, D Proctor (July 2, 2019) "*Electronic permitting can deliver efficiencies*" - https://canada.constructconnect.com/dcn/news/government/2019/07/electronic-permitting-can-deliver-efficiencies-says-expert - accessed May 2020

31 Geospatial World (May 2017) "*BIM adoption and implementation around the world: Initiatives by major nations*" https://www.geospatialworld.net/blogs/bim-adoption-around-the-world/ (2017) - accessed May 2020

32 D Proctor (July 2, 2019) "*Electronic permitting can deliver efficiencies*" Daily Construction News https://canada.constructconnect.com/dcn/news/government/2019/07/electronic-permitting-can-deliver-efficiencies-says-expert - accessed May 2020

30. Singapore with the benefit of being a small market has leveraged this to its advantage. The government has created a central repository for building codes, regulations and circulars published by various building and construction regulatory agencies in Singapore. Through this Construction and Real Estate Network, or CORENET, the Building & Construction Authority (BCA) set out to implement the world's first BIM electronic submission. Since 2015, BIM e-submissions have been mandated for all projects greater than 5,000 sqm. To facilitate information sharing, BCA and buildingSMART Singapore have developed a library of building and design objects, as well as project collaboration guidelines. BCA will also lead the development of automated model checking for BIM e-submission.[33] Singapore has invested more than $250 million on development but it will take time for the automated code checking system to be fully operational.[34]

31. Electronic submission and permitting is adopted widely throughout Australia. You can get a building approval from either local government or a building certifier (or surveyor depending on the terminology of the state). Applications for building, demolition or occupancy permits or for building approval certificates can be submitted in a variety of ways, including in person, by post or electronic lodgement depending on the systems the relevant permit authority has in place. Under the Building Act, permit authorities have a fixed amount of time to grant or refuse a permit application. The point at which a permit authority's timeframe for assessing an application starts is referred to as 'starting the clock'. The point at which the clock starts depends on the method of application.

32. Australia recognised from an early stage how complex the assessment of designs correctly against building codes was and the high long-term costs from human failure in getting this task wrong. From 1991 until 2006 the Commonwealth Scientific and Industrial Research Organisation (CSIRO) had developed and released an automated code compliance checking system commercially available for use by the construction industry to check building designs for compliance against numerous building codes. The system has not been used commercially since 2006 and there is no plan for further development.[35]

33 Geospatial World (May 2017) "*BIM adoption and implementation around the world: Initiatives by major nations*" https://www.geospatialworld.net/blogs/bim-adoption-around-the-world/ (2017) - accessed May 2020

34 D Proctor (July 2, 2019) "*Electronic permitting can deliver efficiencies*" Daily Construction News https://canada.constructconnect.com/dcn/news/government/2019/07/electronic-permitting-can-deliver-efficiencies-says-expert - accessed May 2020

35 J Dimyadi, R Amor (2013) "*Automated Building Code Compliance Checking – Where is it at?*" Conference Paper presented at the 19th International CIB World Building Congress pp.172-185

Implementation of model based e-permitting systems

33. There have been numerous research attempts over the last half of the century to automate compliance audit processes in the domain, but there are only a handful of successful implementations reported to date and most of them only have limited applications. The main challenge remains with accessing and processing the right information efficiently and effectively.[36]

34. Building design review is the procedure of checking a design against codes and standard provisions to satisfy the accuracy of the design and identify non-compliances before construction begins. The current approaches for conducting the design review process in an automatic or semi-automatic manner are either based on proprietary, domain-specific or hard-coded rule-based mechanisms.[37]

35. Several government agencies and municipal jurisdictions around the world have started to implement code compliance checking in their systems, which have mostly focused on building code compliance. These systems are all judged partially complete as they don't provide a fully automated code compliance checking platform capable of analysing a building model against all relevant building, fire, and energy codes simultaneously and require intervention to assess those components of the building permit process that are not rule based and require judgement based decisions.

36. For distribution of world acceptance of BIM please refer to Diagram Three.[38]

36 J Dimyadi and R Amor (2016) "*Automating Conventional Compliance Audit Processes*" Conference Paper presented at the IFIP 14th International Conference on Product Lifecycle Management

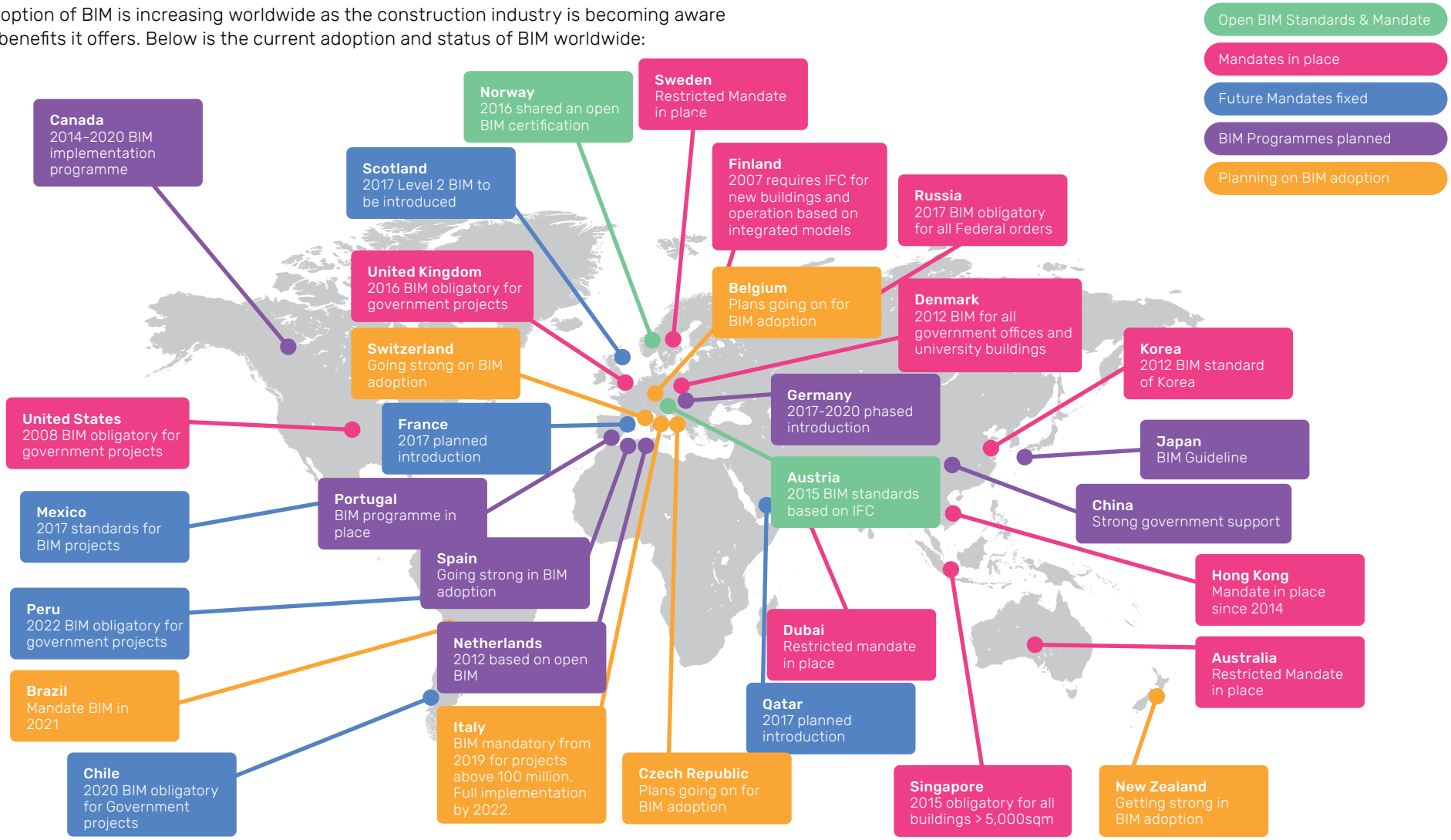
37 Nawari O. Nawari (16 April 2019) "*A Generalised Adaptive Framework (GAP) For Automating Code Compliance Checking*" Buildings. 9. 86. 10.3390/buildings9040086.

38 https://www.geospatialworld.net/article/bim-adoption-around-the-world-how-good-are-we/ Global BIM Regulation Evolution (15 Dec 2018)

Diagram Three.

Overview of BIM adoption worldwide

The adoption of BIM is increasing worldwide as the construction industry is becoming aware of the benefits it offers. Below is the current adoption and status of BIM worldwide:



Source: McAuley, B., Hore, A. and West, R. (2017) "*BICP Global BIM Study - Lessons for Ireland's BIM Programme*" Construction IT Alliance (CitA) Limited (Creative Commons Attribution-Noncommercial-Share Alike 3.0 License)

37. The table below summarizes the automated code compliance checking systems, what they check, and the jurisdictions for which they were originally developed.[39]

Table Three. State of Automated Code Compliance Checking in International Jurisdictions

Code Checking System	Code			Initially Developed For
	Energy Code	Fire Code	Building Code	
FORNAX		✔	Partial	Singapore
Solibri Model Checker		Partial	Partial	Finland
EDModelChecker			Partial	Norway
Design Check			Partial	Australia
ComCheck/ ResCheck	✔			United States
SMARTCodes			Partial	International

38. FORNAX is an electronic plan check checking systems software that automates the process of checking and approving building plans for compliance with building regulations, codes of practice and planning guidelines owned by novaCITYNETS Pte Ltd. It also an electronic approval management software which aims to enhance productivity in local authority by automating the process of examining and approving applications for development controls, building control and other infrastructure development activities.

39. In 2017 novaCITYNETS PTE Ltd was awarded a $NZ30 million contract over six years by the government of Singapore to its CORENET ePlanCheck System. Commissioned by the Building and Construction Authority for the Singapore Government, ePlanCheck performs automated conformance checks on digital plans submitted by architects and engineers against building and related codes and regulations.[40]

40. In 2018 Singapore's Public Utilities Board (PUB) awarded a $NZ4 million contract to novaCITYNETS Pte Ltd, to supply, deliver and implement a Building Information Modelling (BIM) Checking System for Building Plan Submission for about 20 months and thereafter maintain the project for the next 20 months. The contract involves the translation of PUB's sewerage, drainage and water design regulations and combine that with Subject Matter Expert knowledge into the computable software checking program FORNAX to perform automated checking against "Electronic Building Models" for any non-compliance against regulatory requirements. It will also help to reduce ambiguities and subjectivity in code interpretation by different individuals.[41]

41. By re-engineering 16 Government Agencies from 9 different Ministries, CORENET has consolidated fragmented business processes of the real estate and construction industry into a unified Many Agencies, One Government platform. The project delivered the following strategic competitiveness for the Singapore Government:[42]

> 80 percent reduction in total time to secure construction related permits/ licenses
> 73 percent reduction in number of application forms from 845 (physical) to 231 (electronic)
> US$150 million per year in hard cost savings on operational expenses
> US$1 billion per year estimated savings in investor risk and capital financing cost
> E-Government Excellence Distinguished Award 2013 for Shared Systems and Services bestowed by Singapore Ministry of Finance and Infocomm Development Authority of Singapore
> World Bank Citation 2009 of CORENET as instrumental to Singapore's No. 1 ranking in its Doing Business Survey.

42. A potential issue for the Singaporean government agencies is what happens when these contracts expire. Without an understanding of the terms of the contracts it is unclear how the ownership and future use of the systems funded by government will be managed.

39 Kamellia Shahi (2018) "*Evaluation of Current Construction Permitting Process in City of Toronto and Future of Permitting in the Global Construction Industry*" https://bit.ly/2YMy2fD - accessed May 2020
40 Nova MSC Group Annual Report (2017) http://www.nova-hub.com/wp-content/uploads/annualreport/NOVA-MSCAR2017.pdf - accessed March 2020
41 Nova MSC Group Annual Report (2018) http://www.nova-hub.com/wp-content/uploads/annualreport/NOVA-MSCAR2018.pdf - accessed Feb 2020
42 E-Government, Nova-hub.com (2020) http://www.nova-hub.com/e-government/ - accessed March 2020

Managing liabilities

43. The Consortium of European Building Control survey (2018) determined for the time being computers are not used to provide full compliance checking of building regulations. Technologies are being developed which will enable building proposals to be fully checked for building regulation compliance solely by electronic means. The survey concluded "perhaps legal frameworks and legislation will have to adapt for the procedures and communications involved in obtaining building permits to become fully electronic".[43]

44. In a report to the European Commission if found building permits procedures must operate as simply as possible.[44] Nation-wide validity for building permits is only an issue for non-site specific aspects of service performance. Germany and the United Kingdom have put in place a nationwide approval process for building designs that are non-site specific.

45. The World Bank 2020 says "it is important that the responsible party for defects be held liable not only by contract but also by law for an adequate period after the completion of construction. Moreover, the parties involved in the building design, supervision and construction should be required to obtain insurance to cover the costs of any latent defects. To date, more than 131 economies have introduced provisions to protect building owners against latent defects, but only 29 of them mandate that the parties involved in the building construction obtain insurance to cover such costs."[45]

46. Ensuring open access to relevant regulations can act as a powerful tool to strengthen accountability in both the private and public sectors while the corruption and abusive practices prevalent in opaque business environments. According to a case-study published in Doing Business 2013,[46] economies with a greater access to regulatory information tend to have more efficient regulatory processes and lower regulatory compliance costs. In today's digital age it is even more important, and much easier, to disseminate information quickly and on a wide scale.

43 Consortium of European Building Control (2018) "E-Delivery in Europe" https://www.cebc.eu/public-current-reports/ - accessed Feb 2020

44 ECORYS Nederland B.V., in association with Delft, University of Technology (Nov 2015) "*Simplification and mutual recognition in the construction sector under the Services Directive*" https://bit.ly/30WKFaw - accessed March 2020

45 World Bank (2020) "*Doing Business 2020*", p.40. https://bit.ly/3dcml7e - accessed April 2020

46 World Bank (2013) "*Doing Business 2013*" http://documents.worldbank.org/curated/en/399811468157505743/Doing-business-2013-smarter-regulations-for-small-and-medium-size-enterprises - accessed April 2020

47. Gary Dunger sees three major challenges.[47] First, automation requires rigor on the part of the architect to consistently categorize elements within the digital building model so that the software will recognize it correctly. Next, as mentioned previously, building codes are often intentionally vague to allow for performance-based solutions that meet the code's intent, but maybe not the letter of the code. "It's hard to build that vagueness into the software," he says. Lastly, building codes are constantly changing and the software companies will need to keep up to speed with the latest editions to stay accurate.

"Getting a Building Permit" rankings

48. The World Bank annually investigates 190 economies worldwide to understand the regulations within those economies that enhance business activity and constrain it. Economies are ranked on their ease of doing business, from 1–190. A high ease of doing business ranking means the regulatory environment is more conducive to the starting and operation of a local firm. The rankings are determined by sorting the aggregate scores on 10 topics, each consisting of several indicators, giving equal weight to each topic. One of those 10 topics relates to construction – "getting a building permit".

49. This topic tracks the procedures, time and cost to build a warehouse—including obtaining the necessary licenses and permits, submitting all required notifications, requesting and receiving all necessary inspections and obtaining utility connections. In addition, the dealing with construction permits indicator measures the building quality control index, evaluating the quality of building regulations, the strength of quality control and safety mechanisms, liability and insurance regimes and professional certification requirements.

47 G Dunger (27 August 2018) "*Building Review Software Feasible or Far-Fetched*" https://bit.ly/3eiiRkI - accessed April 2020

50. The indicators measured in order to determine an economy's "getting a building permit" ranking include:
    - Reduced the time taken for processing permit applications
    - Streamlined procedures
    - Adopted new building regulations
    - Improved transparency
    - Introduced or improved "one stop shop" capability
    - Introduced or improved electronic platforms or online services.
51. The measures are then scored against four elements – procedures, time, cost and quality assurance. The ranking achieved is based on the average of the four element scores. To rank highly it is important to not only score well but also be consistent across all measures. One poor element score can impact significantly on the average. This contributes to why perceived lesser or emerging economies rank ahead of the established or high-income economies.
52. Construction permitting is considered important because good construction regulation matters for public safety, but also for the health of the building sector and the economy as a whole. Economies that score well on the ease of dealing with construction permits tend to have rigorous yet expeditious and transparent permitting processes.
53. Globally reforms in the areas of dealing with construction permits have risen sharply in recent years, peaking in 2018/19 at 37. Twenty-one of the 37 economies reforming aspects of dealing with construction permits simplified the permitting processes by streamlining interactions with agencies for preapprovals and inspections. Another 16 reformed their building quality control systems. In addition, 12 economies either set up or improved online platforms for processing building permits, and 3 economies launched one-stop shops.
54. In the Doing Business 2020 study New Zealand's economy ranked 1 overall for ease of doing business and 7 for the "getting a building permit" topic. All economies ranked in the top 10 for the "getting a building permit" topic provided online services for permit applications and processing. Those economies in order of ranking are:

Table Four. World Bank rankings of ease to get a building permit 2020

Topic – "getting a building permit"	**Rank**
Hong Kong	1
Malaysia	2
United Arab Emirates	3
Denmark	4
Singapore	5
Taiwan	6
New Zealand[48]	**7**
Mauritius	8
Serbia	9
Lithuania	10

55. Among the 10 economies that advanced the most across all 190 countries ranked, efforts were focused on the areas of starting a business, dealing with construction permits, and trading across borders. In general, economies that score the highest share several features, including the widespread use of electronic systems and online platforms to comply with regulatory requirements.
56. All of the top 20 ranked economies in the World Bank 2020 including New Zealand have electronic systems and online platforms for the processing building permits. When the high-income economy countries not in the top 20 are considered it is reasonable to assume that this trend will continue to include potentially the top 60 (Portugal ranked 60) ranked economies.

48 World Bank assessment indicators are based on Auckland City Council building consent requirements only.

5. Third-party providers that impact building consenting

57. Several reports and research papers have identified the need for increased technology uptake by New Zealand's building & construction sector. These reports are underpinned by a long-identified need to improve productivity in the sector, and also the recognition of global 'megatrends' that will inevitably have significant impact on the sector in New Zealand (such as increased manufacturing, prefabrication and modularization).[49]

58. The use of digital tools within the construction process is increasing and there is continued investment in third-party technology solutions for the construction process. Cloud-based systems, mobile apps and smartphones have made communication, collaboration and accessibility to information a core component of building processes. The Construction Sector Accord Transformation Plan update from January 2020 highlights the need for improved building regulatory systems and consenting processes, including better use of digital technology to promote speed and accuracy.

59. We looked at five main third-party technology areas to assess the potential for connecting to consenting systems:
    - Building Information Modelling (BIM)
    - Automated code checking
    - Product specification
    - Quality assurance tools (including inspection)
    - Data connections and sharing with public agencies.

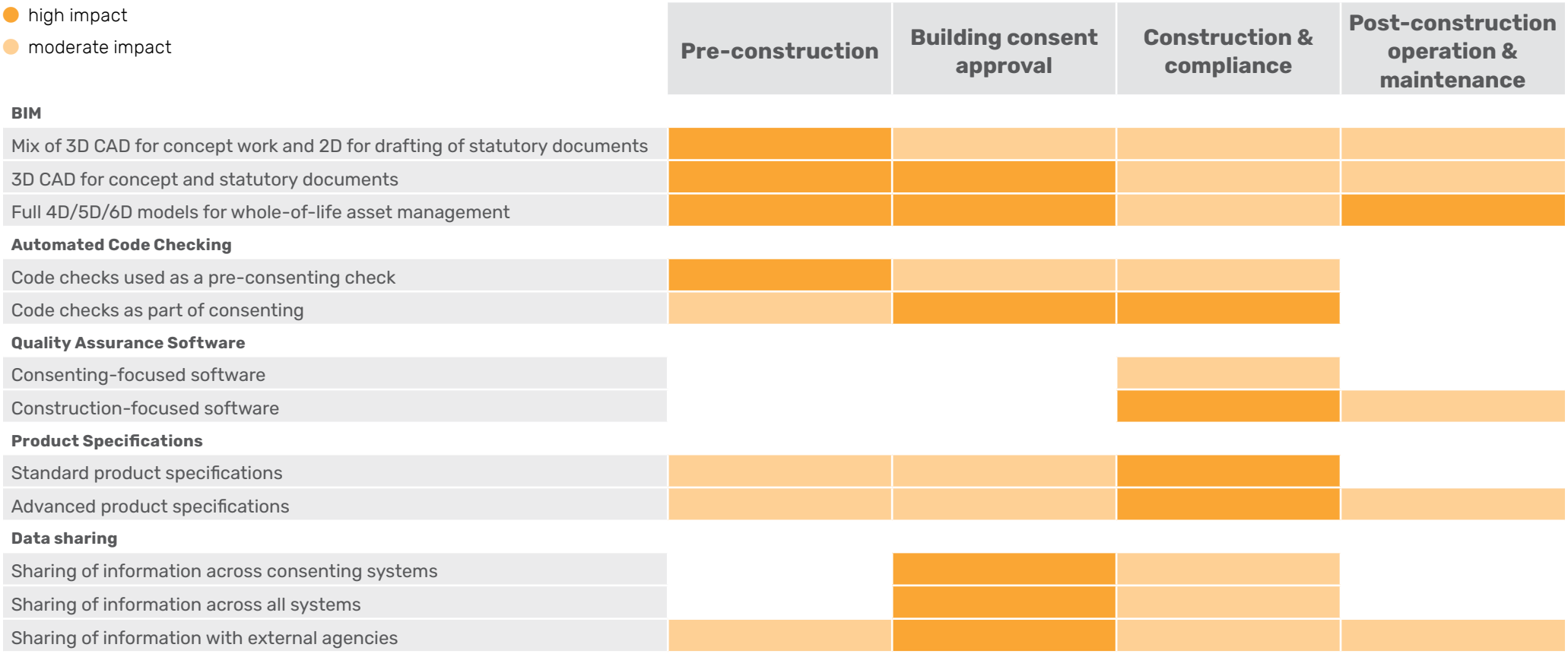
60. Each of these areas are at a different stage of development and offer different benefits if connected to the consenting process. We talked to third party providers to understand where they currently saw their technology in relation to consenting, where they saw their future development heading, and what the 'ideal' future state looks like for them in relation to consenting. This section provides an outline of where each of the technology areas are currently at and a sample of key third-party technology providers involved.

61. The current and potential future impact on the construction process by the five key areas assessed is shown in the Diagram Four. Shaded areas show the stages of construction that the various third-party technologies impact on.

49 See for example Anne Duncan, Kingi, V. & Brunsdon N. (2018) "*Adopting new ways in the building and construction industry*" *BRANZ Study Report SR406*. Judgeford, New Zealand: BRANZ Ltd.

Diagram Four.

Potential impact points of third-party providers on the construction/ consenting process



Building Information Modelling (BIM)

62. BIM is a coordinated set of technology-supported processes that adds value through the sharing of structured information for building and infrastructure assets.[50] BIM typically includes information on design, construction, logistics, operation, maintenance, budgets, schedules, and much more, providing a richer data environment than traditional approaches. Information created in one phase of the construction process can be passed to the next phase for further development and reuse.

63. BIM use within New Zealand is being driven by the BIM Acceleration Committee (BAC) who were established in 2014 to actively promote the use of BIM, complete regular analysis of industry to review opportunities and barriers of use and provide guidance for BIM projects. An alliance between industry and government, the BAC was initially co-funded by private industry ($2.1 million), MBIE and BRANZ ($973,000) for the first three years and subsequently supported by BRANZ and industry.

64. BAC has been involved in a number of large-scale BIM research projects:
    - Asset Metadata Standards Handbook – the Committee have agreed to support the University of Canterbury in developing a guide to the NZ Asset Metadata Standards. The business case for AMS is due to be completed in June 2020.
    - Translation of the building code into digitalised code being completed as part of the National Science Challenge 11 – Building Better Homes, Towns and Cities (NSC11).
    - NZ BIM Handbook – currently in its third edition (released in 2019) the handbook documents a consistent approach, using common language, to BIM in New Zealand.
    - Regular monitoring of the construction sector with regular survey and analysis of BIM use, barriers to use and type of use.

65. There are some indications that use of BIM has plateaued recently, with the proportion of industry projects staying level at 59% after a small increase in 2018.[51] Barriers to the continued growth of BIM have been considered by the BAC and also in a 2016 BRANZ report.[52] These identified uptake issues such as:
    - Capability of consultants' knowledge and understanding of BIM
    - Client capability and understanding BIM can be used in construction delivery
    - Changing sector culture and attitudes
    - Financially seen as a cost rather than an investment
    - Need for knowledge sharing.

66. Our assessment of the status of BIM across the construction process both current and future is shown in the Diagram Five.

67. The majority of residential and commercial buildings in New Zealand are currently designed using some form of computer-aided design. For example, BCAs with digital consenting systems noted that fewer than 1-2%[53] of consent applications are submitted in hand-drawn or similar format, with the remainder using 2D or 3D digital drawing tools. This usage of 3D digital design tools provides a strong base for further growth of BIM in the industry, but requires additional information to be added to the 3D models (non-graphical information such as operational and financial data) and arrangements to allow for collaborative working on common design models to progress further along the BIM definition.

68. BCAs currently believe that BIM is not at a stage or used widely enough where it can add value to a consent application. It is recognised that this will change and there will be a requirement for a BCAs to be able to receive and view BIM consent applications.[54]

50 As defined by BIM Acceleration Committee (https://www.biminnz.co.nz) – accessed May 2020

51 EBOSS, BAC, MBIE, BRANZ, (Nov 2019) *BIM in New Zealand – an industry-wide view 2019* - https://www.eboss.co.nz/bim-in-nz/overview - accessed February 2020

52 Peter Cunningham (2016) "*Government as Client: Challenges using Building Information Modelling on NZ Construction Projects*" BRANZ Project LR0498 https://bit.ly/30QMmq6 - accessed April 2020

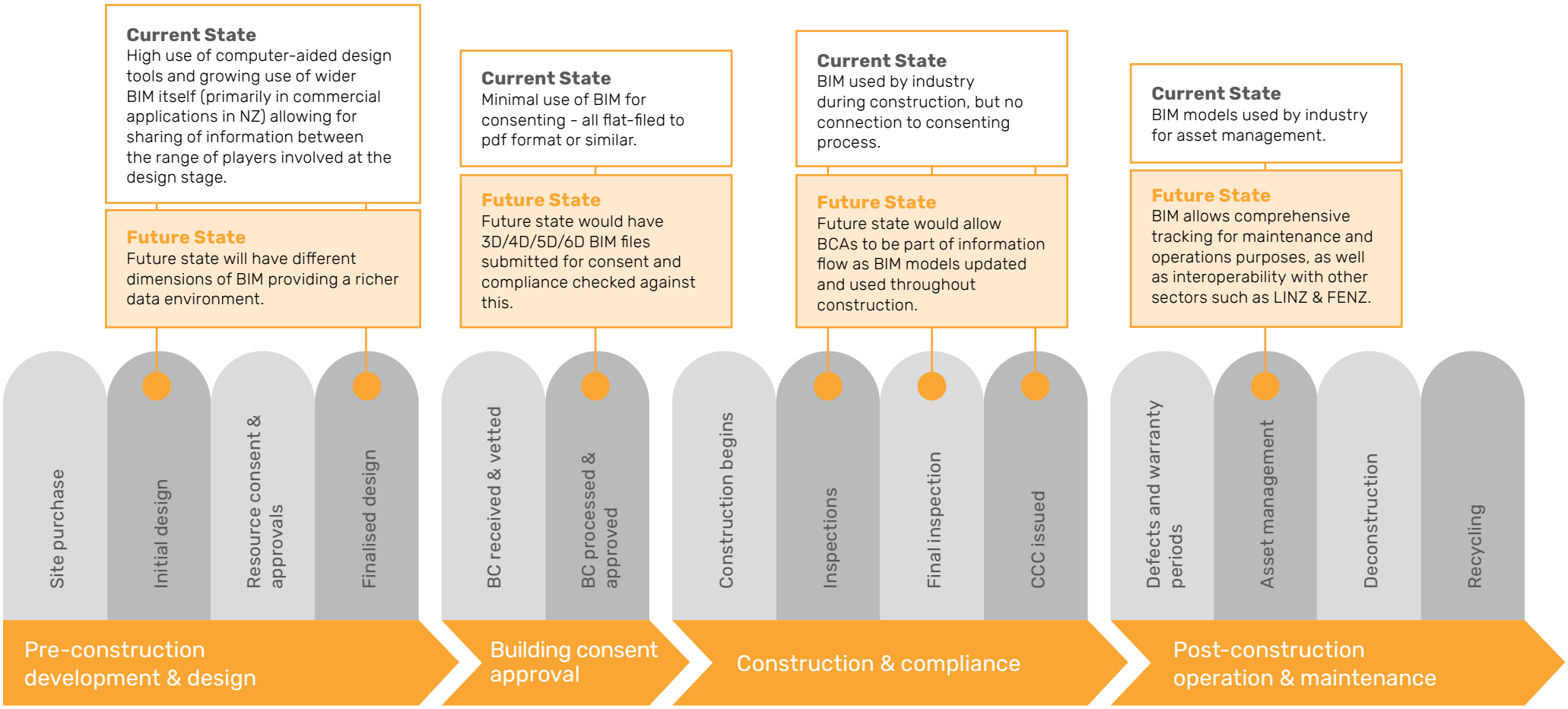
53 Obtained from sample of BCAs interviewed

54 Obtained from sample of BCAs interviewed

Diagram Five.

Building Information Modelling (BIM)

BIM typically includes information on design, construction, logistics, operation, maintenance, budgets, schedules, and much more, providing a richer data environment than traditional approaches in it's fullest sense.



Automated code checking

69. Checking whether a building design conforms with the New Zealand Building Code currently remains a largely manual process. A BCA officer may use digital tools to assist in verifying a design against code (such as using digital tools to measure elements on a pdf plan, or at an advanced level using tools to compare versions of plans for any variation), but there is currently no tool to allow for extensive verification without officer input.

70. The New Zealand BIM Handbook notes that code validation (another term for automated code checking) will become more prevalent in the future.[55] Benefits are seen as reducing the chance of code design errors, omissions or oversights (saving money and time in corrections) and reducing turnaround time for review by BCAs (throughout all stages of consent processing). For a BCA there are also productivity benefits from applying officer efforts to higher-value verification aspects, with automated code checks covering the basic elements or providing the first cut checks.

71. Automated code checking is reliant on three key components:
    - Interpretation of the building code into a logical, verifiable, digital representation
    - An agreed audit process to apply the digital code to the digital representation of a building (the process a BCA utilises to interpret a code and perform its checks)
    - An appropriately formatted digital design model that contains sufficient information to allow digital interpretation against the code.

72. The ability to automatically check a design against building codes took a big step forward with the increased usage of tools such as Revit, ArchiCAD and AutoCAD from the late 1980s and the increased adoption of BIM from its advent in the 1990s.[56] As noted earlier in this report, the majority of building designs are currently completed in some form of 2D or 3D digital design tool, which is then 'flattened' to 2D pdf or paper-based format for consent submission. Ensuring that these digital design models contain sufficient standardised information to allow them to be 'code-checked' automatically will be an important future step.

73. The NSC11 Building Better Homes Towns and Cities funded the University of Auckland to translate 15 codes into a computable form for automated code checking.[57] The 15 codes form part of what stakeholders have proposed that MBIE own and maintain as an official repository of a complete digital building code and standards to provide a single source of truth for all software systems.[58] Compliance Audit Systems Limited[59] has a research and development programme supported by Callaghan Innovation funding which may contribute to further translation. There is also a 3-year research project, led by Yang Zou at University of Auckland, as part of the MBIE-funded Building Innovation Program which is exploring Natural Language Processing approaches to automated translation of codes and standards into their digital and computable equivalent.[60]

74. It is estimated, based on the 15 codes translated to date, that approximately 70% of each of the currently published 600 plus compliance documents (all the 'Acceptable Solutions' documents of the Building Code and relevant normative Standards) can be translated into a computable form for automated code checking. Based on the 15 codes (focussing first on the most commonly used standards) completed to date it is difficult to establish accurately the cost of translation of the remainder with indicative costs suggested to be in the order of between $6 million to $12 million,[61] with ongoing costs also needed to maintain the software and update it for changes in the Building Code.

55 BAC, *The New Zealand BIM Handbook*, Version 3, April 2019, p.16.

56 See, for example, C.S. Han, J.C. Kunz, and K.H. Law, *A hybrid prescriptive-/performance-based approach to automated building code checking*, 5th Congress on Computing in Civil Engineering, pp.1-12, 1998, and J. Dimyadi and R. Amor, *Automated building code compliance checking – where is it at?* Proceedings of the 19th World Building Congress Construction and Society, pp.172-185, 2013, and H.Narayanswamy, H.Liu, and M.Al-Hussein, *BIM-based Automated Design Checking for Building Permit in the Light-Frame Building Industry*, 36th International Symposium on Automation and Robotics in Construction (ISARC), pp.1042-1049, 2019.

57 As referenced in an email from Ruth Berry, BRANZ, 28 May 2020

58 National Science Challenge: CASE STUDY: Automating compliance audits

59 Automated code checking research was conducted at the University of Auckland between 2013 and 2015. A commercial entity – Compliance Audit System Limited, which is 21% owned by a commercialisation subsidiary of the University of Auckland – has been established to implement a code checking tool (known as ACABIM).

60 As referenced in an email from Robert Amor, Auckland University 18 June 2020

61 As referenced in interview with Andrew Reding, BAC, 18 February 2020

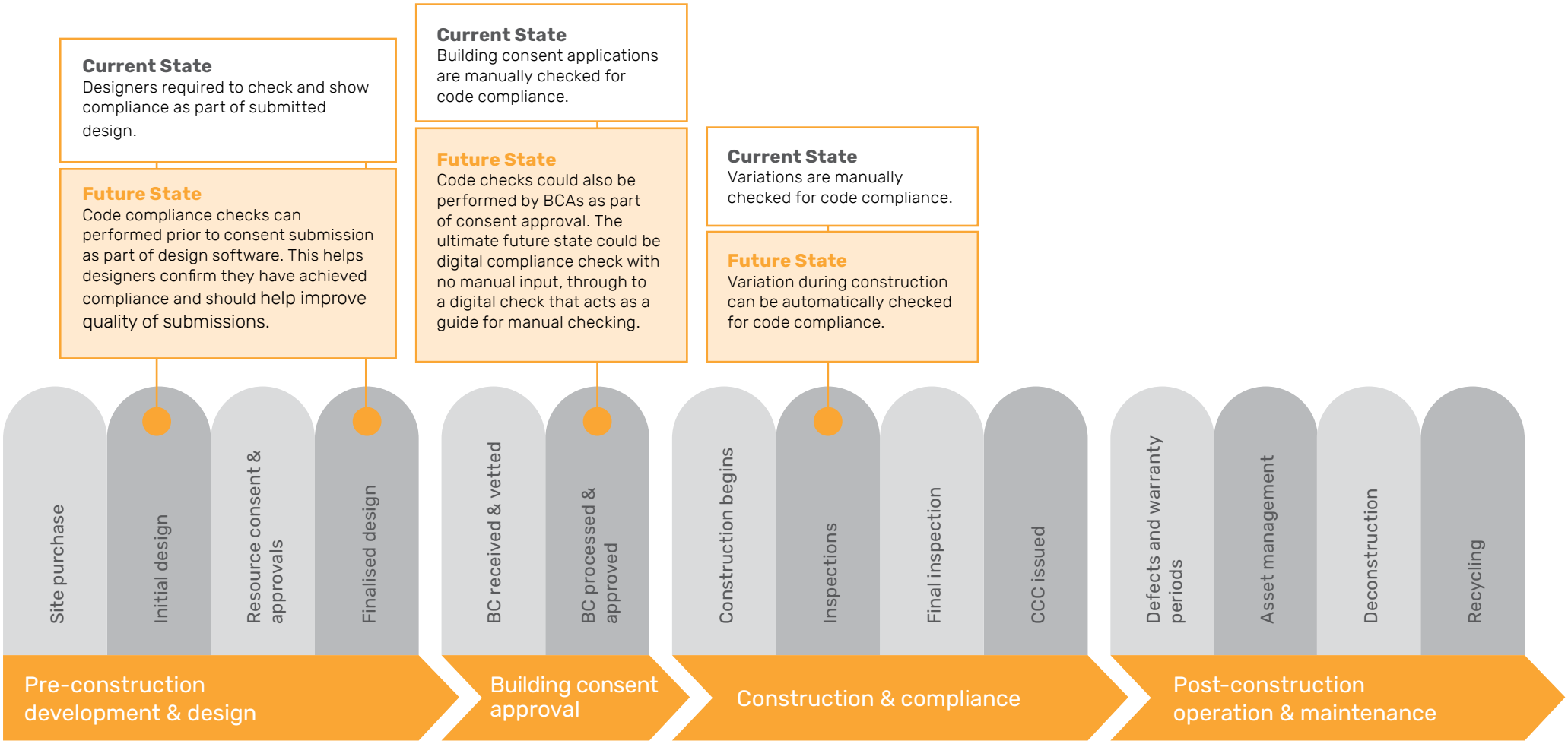
75. There are two main ways that automated code checking can be used:
    - Used prior to consent submission – designers and applicants test their design models before submission to BCAs. This would be done throughout the design stage and the results of the check could also be sent in as part of the consent application submission.
    - Used by BCAs as part of consent application processing – BCAs would receive a BIM model as part of a consent application and test this using an automated code checking tool. An alternative approach is for BCAs to require hardcopy results of a automated code check to be submitted as part of a flat-file consent application.
76. ACABIM is currently being marketed to those commercial players, using BIM tools who potentially need automated code checking.[62] An initial trial with Christchurch City Council is currently underway to evaluate how automated code checking could be used by BCAs. Using a parallel approach by processing BIM format building consent submissions through the automated code checking system while simultaneously processing the same consents through its incumbent system, Christchurch City Council has been able to compare performance to ascertain the benefits and constraints of the technology to date. The trial has confirmed code checking software achieves time-saving and staffing resource benefits in processing of building consent applications.
77. The trial to date is limited to BIM building consent submissions for commercial design builds only. There would be increased benefit to BCAs to have residential group builders using the technology but there is little incentive for change due to "multi proof" provisions and the current fast-tracking of applications service available to this group.[63]
78. There are likely to be a number of issues that need to be resolved before wider uptake of automated code-checking by BCAs:
    - Of the firms surveyed by EBOSS in the BIM Use in New Zealand 2019 report, 59% report using BIM in some way on projects. This survey covers use of BIM at various stages of the construction cycle, including asset management once a building is in place. For consenting purposes, however, the key usage of BIM is for design and construction management across both commercial and residential projects. BCAs we spoke to did not see sufficient uptake of BIM at these points and across all building types they deal with. Uptake needs to reach a 'tipping point' so that worthwhile investing in the tools to use BIM becomes worthwhile – if only used for a handful of larger commercial consents then BIM may stay 'niche' and BCAs won't invest.[64]
    - Applying the digital codes to building consenting models will require BCAs to have confidence the system is built to enable a true and reliable reflection of the Building Code. This may require some form of audit or verification by an independent body.
    - Funding the continued maintenance of the checking software as the Building Code changes. Needs to demonstrate a benefit to industry and BCAs so that any costs of using the checking software can be successfully on-charged.
    - Clarity over who has ownership of the decision-making. BCAs unlikely to cede decision-making to the digital tool wholly unless liability clearly delineated. Also, the inability for all of the building code to be covered means manual intervention and judgements is still needed.
79. Current building code compliance checking processes and our assessment of a potential future state using automated code-checking is shown in the diagram on the following page.

62 As referenced in interview with J. Dimyadi, ACABIM interview on 13/03/20
63 As referenced in interview with Mark Urlich, Christchurch City Council, 16 June 2020
64 Feedback from BCA interviews May 2020

Diagram Six

Automated code compliance checks

Checking how a design complies with the Building Code is currently a manual process undertaken by Building Consent Officers. There are three ways this could be done digitally:



Product specifications

80. There are currently over 600,000 building products available on the New Zealand market.[65] The Building Act 2004 provides for a wide range of products and systems to be used to meet the performance standards of the Building Code, meaning that designers and BCAs need sufficient information to understand how products can achieve the standards required.

81. Building clients are expected by BCAs to submit product specification information as part of the building consent application. This information is additional to construction specifications specifically required by the Building Act 2004. At the most basic level this may be object information (i.e. the design elements of the product) and more technical information is provided externally or appended to the consent application in 2D flat-file. More advanced digital design tools allow product information to be embedded as part of the digital model (i.e. BIM). Product specifications are also used throughout other stages of the building life cycle, providing important reference information during construction and inspections. They are also useful post-construction for maintenance and warranty of products through to deconstruction and recycling of a building.

82. A number of companies currently compile digital libraries of building products and specifications available in New Zealand.[66] These libraries list technical information on each of the products such as the standards they meet, instructions and procedures for use, design object information, recommended environmental application, maintenance and warranty information. These products can be 'attached' to a design model in a variety of formats to be compatible with 2D & 3D models or in printed format.

83. There is currently no "real time" direct digital connection between product specification providers and BCAs. Some consenting systems are able to access a 'static' library of product specifications – effectively a library of PDF documents that can be appended to a building consent file.

84. None of the current consenting systems offer a 'live' library of products through direct link to the product specification providers. The most common practice is for flat-file versions (usually pdf) of product specifications to be appended to consent applications and then compiled as part of final inspection documentation. For BCAs these documents then form part of the property file, and for building owners they form part of their as-built records.

85. Product specification data format is currently not standardised, with different product platforms offering different levels and types of information. This can cause issues such as delays in consenting processes due to the need for BCAs to ask for additional information, and difficulties assessing whether product substitutions will perform to the same standard as those originally specified. The technical information tends to not be available in digital forms that can be transferred to other systems along with object information. For example, products will often have object information downloadable in digital form (as files compatible with digital design tools), but warranty and other technical information will not transfer with it digitally for use in BIM or other digital platforms.

86. In 2017 a BRANZ report looked into the feasibility of establishing a system to electronically trace the use of construction products in New Zealand.[67] It looked at using an existing National Product Catalogue (NPC) to capture information on building products, and having barcodes (or other forms of Global Trade Item Number (GTIN)) to track the use of products throughout their lifetime. Scanning of the barcode would link the user to the product technical information, helping BCAs easily access information to determine performance. It would also allow tracking of whether specified products are used in construction, and post-construction allow easy identification of product issues across multiple buildings (which currently is largely a manual task if a BCA needs to).

65 See MBIE (2019) "*Building system legislative reform. Build products and methods summary*" https://bit.ly/3dca3vl - accessed February 2020

66 For example Masterspec, Productspec, and EBOSS.

67 David Dowdell, Ian Page and Matthew Curtis (2017) "*Electronic traceability of New Zealand construction products: feasibility and opportunities*" BRANZ report SR365 https://bit.ly/3fEGVyl - accessed Feb 2020

87. MBIE also recently consulted on proposed changes to the Building Act 2004 to improve information requirements for building products.[68] This was driven by several issues relating to quality of building products (including substitution of products during construction stage), necessitating improvements to help designers and builders choose the right products and to install them in the way intended. Manufacturers and suppliers will be required to make a minimum level of information about their products publicly available, including evidence for claims about the product's performance. MBIE expects the proposed changes to speed up consenting by reducing the need for BCAs to request further product information and reduce the number of inspection failures.

88. The proposed Building Act changes stopped short of developing a national register of building products, instead relying on existing product specification providers to evolve their platforms to provide the information required. A number of the major providers – including Masterspec[69], Productspec[70] and EBOSS[71] – are currently working with GS1 New Zealand on projects including the standardisation of information included in product specifications to allow data sharing across systems. This work is likely to achieve the same effect as a national register and also provide the ability for other digital tools (such as BIM and consenting systems) to access the rich technical information that building product specifications need to carry. Current use of product specifications and format for the consent application process and the potential for digital files is shown in the Diagram Seven.

68 MBIE consultation of Building System Legislative Reform Programme public consultation closed on 21 June 2019 with the first set of decisions announced in Oct 2019 (https://www.mbie.govt.nz/have-your-say/building-system-legislative-reform-programme-public-consultation/) – accessed May 2020

69 Construction Information Limited (CIL) operating as Masterspec is a leading product specification system in New Zealand. With seven online specification libraries with more than 1000 work sections covering the entire construction process. (https://masterspec.co.nz) – information accessed Feb 2020

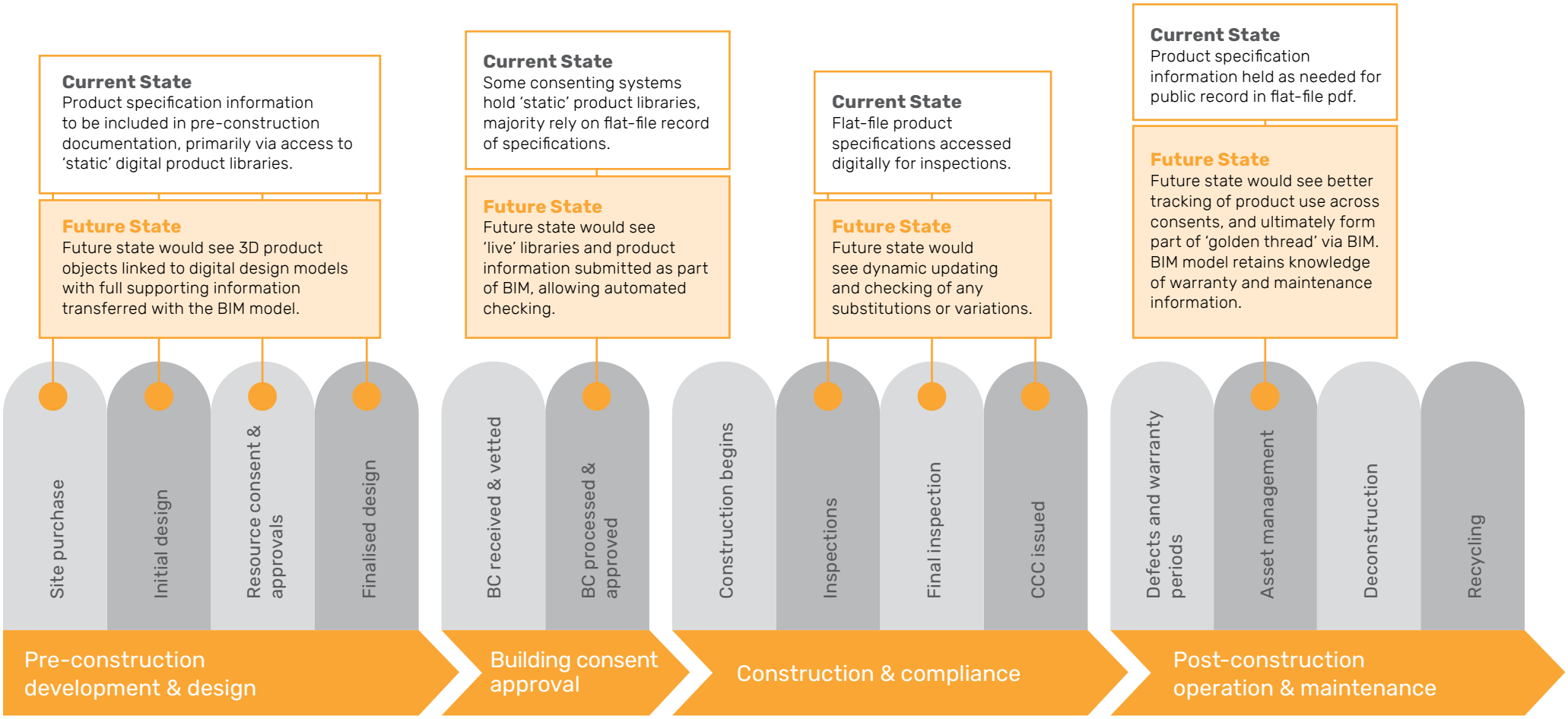
70 Extensive online library of New Zealand building products, including technical files for the development of plans, specifications and quotes. (https://productspec.co.nz) – information accessed May 2020

71 Online product catalogues from 212 of New Zealand's leading architectural product suppliers (https://www.eboss.co.nz) – information accessed May 2020

Diagram Seven.

Product specifications

Digital product specification information used by industry at design and during construction stages, and how digital connection with consenting system could deliver benefits beyond construction through to whole-of-life building management.



Quality assurance and management

89. We have used the term 'quality assurance software' to cover a range of digital tools that are being adopted by industry as part of the construction stage. This includes three main groups of digital tools:
    - Commercial tools whose primary focus is construction and project management, with some potential capability to satisfy consenting tasks (inspections) – such as Conqa[72], asBUILT[73], Acuite[74], CoreCon[75], ZYTE[76], and Procore.[77]
    - Digital tools specifically focused on assisting industry and BCAs manage the inspections process – such as Artisan.[78]
    - Consenting systems, such as GoGet Inspections, that provide an ability to manage inspections, including capturing and recording visual data.
90. All of these tools leverage digital collaboration and mobile solutions to enable users to improve the management and productivity of construction projects. It is one of the fastest growing areas in terms of digital construction, with McKinsey noting that digital collaboration and mobile solutions have attracted close to 60% of all venture funding in the construction-technology sector.[79]
91. The construction industry remains reliant on significant paper flows to manage processes and deliverables (from drawings, tenders, supply-chain, through to payments), often resulting in delays or differences in understandings due to information sharing not being as comprehensive as possible. Shifting toward online, real-time sharing of information is seen as one way to improve "transparency and collaboration, timely progress and risk assessment, quality control, and, eventually, better and more reliable outcomes."
92. Beyond design management, McKinsey & Company have identified seven main areas where digital solutions are needed to provide a seamless, real-time experience when managing construction projects: scheduling (assigning, prioritizing, and tracking tasks), materials management across the entire supply chain, crew tracking, quality control using remote site inspections and tracking, contract management, performance management (across multiple measures of performance), and document management.[80]
93. There appears to be limited interaction between the commercially-driven tools and the consenting system. While construction and project management digital tools will cover the key construction stages, there is little commercial incentive to ensure these systems fit or communicate directly with any consenting systems. Our interviews suggested that this is a result of comparative value being perceived to derive from improving construction management and processes rather than avoiding inspections failures or delays. Technically it is possible to create the links and connections, and this was demonstrated during Covid-19 by Conqa and Auckland Council who used Conqa's cloud based solution to carry out 400 inspections remotely.[81]
94. Artisan is different to other digital tools in this area due to its scope being much more focussed on the needs of BCA inspections. It provides a workflow to capture real-time photographic evidence of the quality of work for critical elements of a build, corresponding to the inspections required by BCAs. It is similar to the likes of Conqa in terms of information capture, but does not place this within a construction or project management tool (this functionality would need to be provided by additional digital tools). In this respect Artisan can be seen as a more specialist tool – creating an accurate record and evidence detailing how each new home is built in the context of BCA requirements.

72 Conqa was formed in 2015 and enables a digitised quality assurance process that is easily accessible by mobile devices. Used on large infrastructure builds such as Ryman Healthcare facilities in Australia and New Zealand (https://www.conqahq.com) – information accessed May 2020

73 asBUILT digital are an experienced BIM consultancy that helps firms manage data and information across construction phases. It collects information through the use of tools such as drones, sensors and 3D cameras as part of managing building information through construction and later stages (https://asbuiltdigital.com/) - information accessed May 2020

74 Acuite provides construction intelligence software that collects and aggregates information from across a project (including health & safety) and presents it on a real-time basis for decision-making during construction projects (https://acuitehq.com) – information accessed May 2020

75 CoreCon is an international system that has been tailored for the New Zealand market, automating the flow of information between estimating, project management and accounting (https://www.corecon.com/new-zealand-construction-software) – information accessed May 2020

76 ZYTE is virtual viewing and smart video calling software

77 Procore is an international system that focuses on financial, productivity, quality assurance and health & safety information from pre-construction through to completed build (https://www.procore.com) – information accessed May 2020

78 Launched in 2018, Artisan software was developed to be used in the building inspection process by BCAs by providing a workflow to create real-time photographic evidence of the quality of work for critical elements of a build. Currently being used by Auckland City Council, Tauranga City Council (see https://www.branzartisan.nz) and being tested by Kāinga Ora

79 Rajat Agarwal, Shankar Chandrasekaran, and Mukund Sridhar (June 2016) "*Imagining construction's digital future*". McKinsey & Company article, p. 8 https://mck.co/30SdZz7 - accessed April 2020

80 McKinsey & Company (June 2016) "*Capital Projects and Infrastructure*", p. 8, https://mck.co/30SdZz7 - accessed May 2020

81 As described in the media release (22 June 2020) supplied by Conqa

95. More advanced consenting systems have in-built capabilities relating to inspections. These include tools to facilitate the booking of inspections (including an element of self-service booking by builders), workflows for ensuring quality compliance against inspection requirements, mobile capability for building inspections officers to conduct checks onsite, and in some cases to receive digital image files (still and video) as part of evidencing quality. Inspection tools were highlighted by BCAs as one of the key areas that they are pursuing future digital improvements (especially offsite capturing of images to reduce the number of inspections visits), but we were also told that this is an area where existing tools are variable in terms of meeting the operational needs of BCAs.[82]

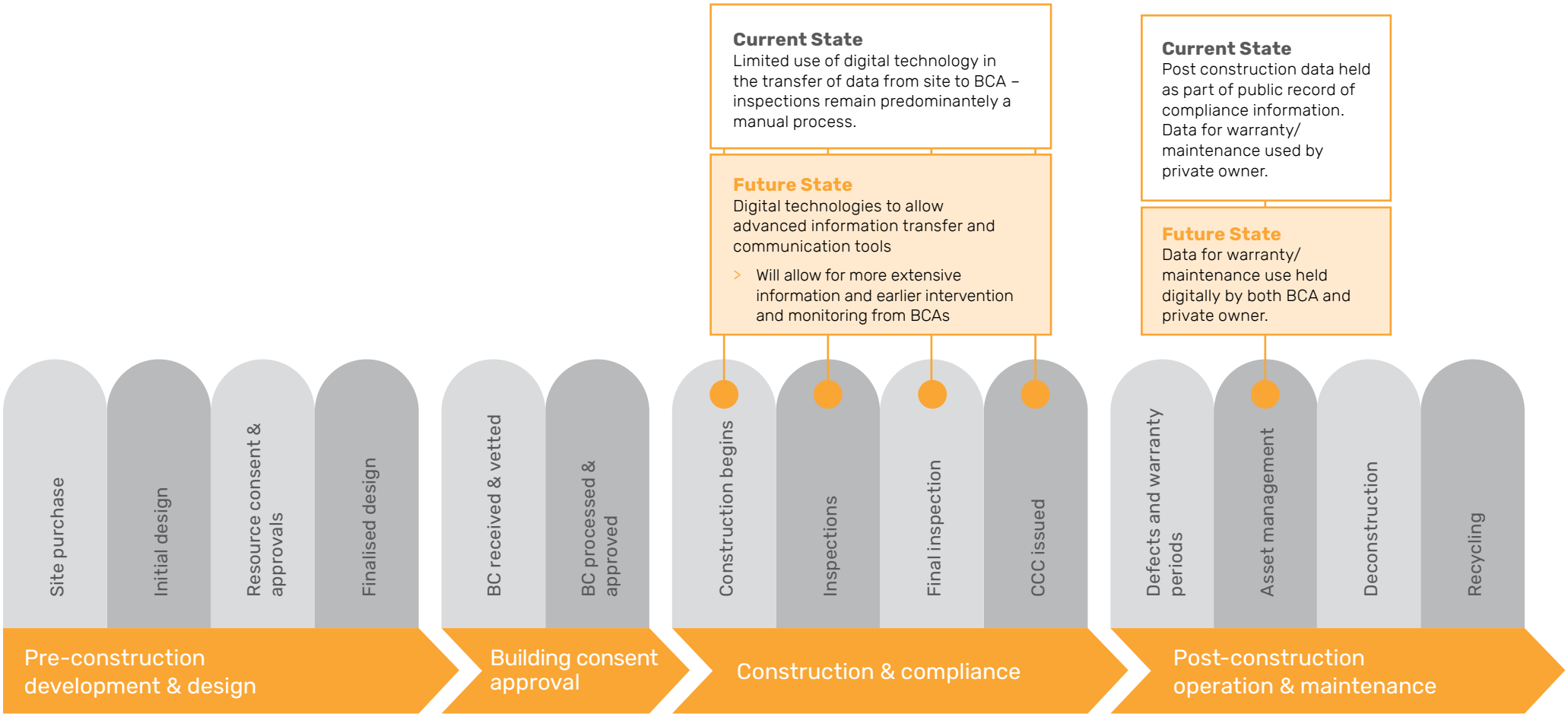
96. Current BCA quality assurance practices and the assessed digital opportunities are shown in Diagram Eight.

82 BCAs we talked to had, to varying degrees, 'turned-off' some inspections capabilities of their consenting systems, primarily relating to booking functionalities.

Diagram Eight.

Quality assurance software

Digital quality assurance software allows for the transfer of real-time build data to be accessed and stored. This has an impact on the inspection stages of the build as below details:



Data sharing from consenting systems

97. A significant amount of data is captured and generated as part of the building consent process. The basis for the majority of this information is the Building (Forms) Regulations 2004 which specifies the information applicants must provide as part of a building consent (and other related applications). Additional information is generated by BCAs themselves as they process the application (e.g. checklists, administrative information relating to the site and applicant).

98. While the Building (Forms) Regulations 2004 specifies what information should be collected, it does not set any standards for the information. Initiatives such as Simpli have created a level of standardisation across member BCAs, and consenting system providers have developed definitions compatible with their systems. This allows for sharing of data and information between BCAs that use similar systems, but is more difficult when using different consenting systems (despite the vast majority of information being very similar in nature).

99. A number of external agencies and organisations collect data relating to building consents. Statistics New Zealand obtains monthly consent information from BCAs as part of providing official data on building and construction activity in New Zealand. It collects information from all BCAs and covers all consents (except those for demolition and for work under $5,000). Only a limited set of information is collected by Statistics New Zealand compared to the amount held by BCAs, in recognition of the specific purpose of official statistics.

100. Commercial groups also collect consent statistics from BCAs as part of either identifying marketing and sales leads or developing other products reliant on understanding building market activity. These requests rely on building consent information being public record, and the regular collections effectively equates to a standing official information request under the LGOIMA 1987. Most of this information is delivered as an extract from BCA consenting systems, or in some cases as a hardcopy. Commercial groups convert the data into formats that suit their purposes (rather than requesting it in that format directly from BCAs).

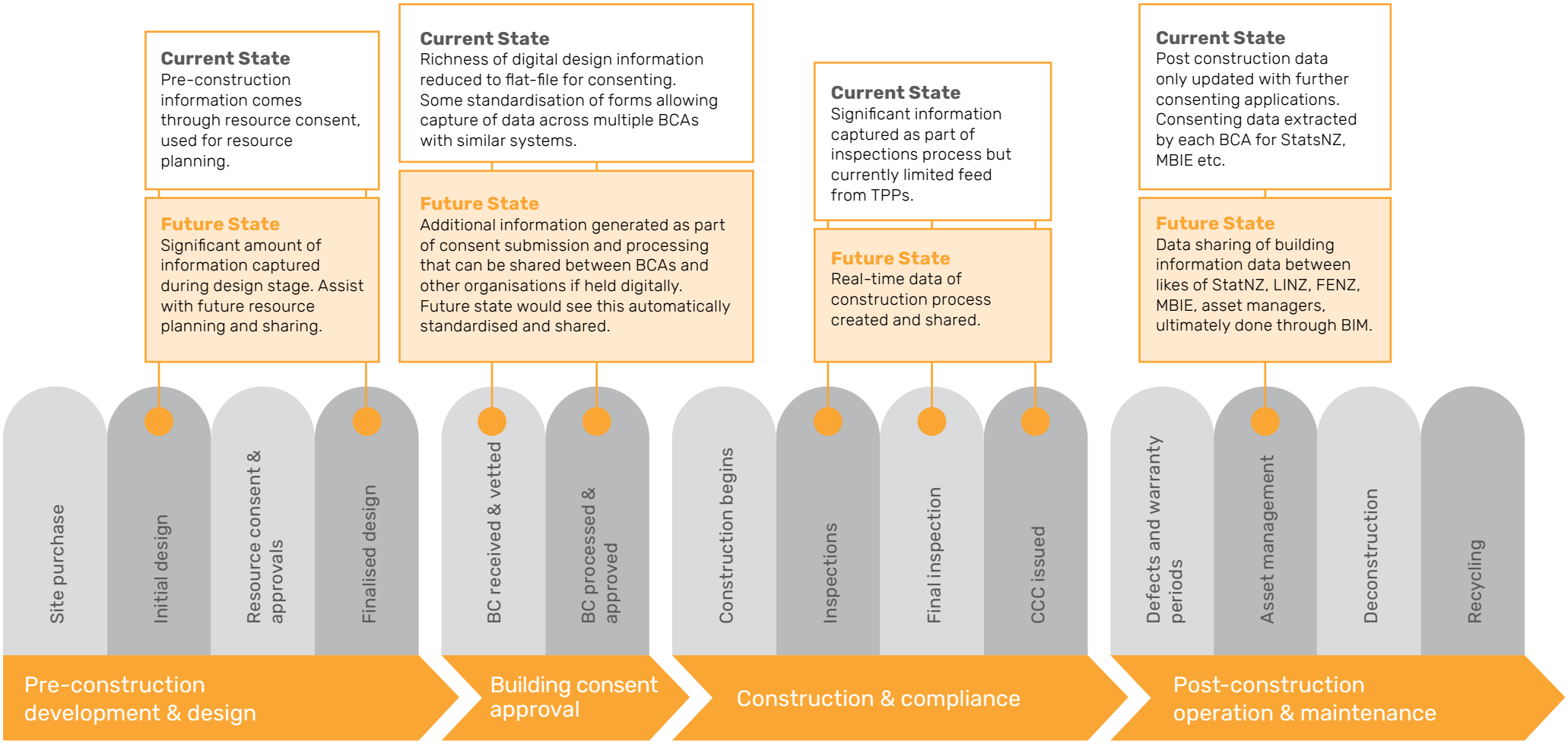
101. Other groups periodically request information like MBIE, BRANZ for economic, research and policy purposes. None of these are standing requests across all BCAs, although previous efforts have been put into working out what these regular requests could look like. They tend to focus on particular interest areas of individual agencies – for example, MBIE's interest in how the building and construction sector is performing, or MBIE & BRANZ interest in the quality of construction – rather than being driven by any cross-agency strategy or view on information requirements. The number of BCAs and range of consenting and enterprise systems makes these type of data requests feasible, but rewards upfront definition of data required so that the various systems can be set up to service the requests. This situation will continue to improve as BCAs increasingly adopt common consenting systems, reducing the scope of any standardisation efforts.

102. The use of data at a BCA level across the construction process and the potential for future sharing of digital data is shown in Diagram Nine.

Diagram Nine.

Data sharing of digital information

Allowing the sharing of digital information between groups will increase accessibility of information that is currently manually extracted and shared. Digital data sharing can occur in real-time and at these points:



6. BCA approach to building consenting

103. In section one of this report we provided an overview of consenting in New Zealand and the digital systems currently used by BCAs. This section builds on that overview by describing where BCAs see the value in third party technology and the role they see consenting playing in the uptake of technology in the wider construction sector.

Still a fair way to go on digital consenting

104. The last decade has seen considerable uptake of digital consenting tools by BCAs, albeit in a reasonably 'organic' way with the market only starting to reach a maturity point in terms of providers. This approach has meant BCAs are at varying stages of digital consenting system capability (see Diagram Ten). Approximately 13% have no digital submission and/or processing capability, but these equate to just over 3% of annual building consents.

105. At the other end, nearly 30% of BCAs have implemented digital consenting with either specialist or enterprise systems (or a mix of these). In most cases these BCAs also have some further additions or developments before being fully 'end-to-end', or choose to have one part of the consenting process done manually in some way (for example, booking of inspections by phone rather than through an online application).

106. In between these two extremes is a range of digital consenting capabilities, with the minimum being a form of online or digital submission and a variety of tools used for some of the tasks after submission. For a number of BCAs the Simpli portal acts as an easy first step into digital consenting, either in addition to some existing basic digital consent processing capability or as a front-end to manual processing.

107. The range of capabilities presents a number of issues for connecting with third party technology providers:

> There remains a number of connection points due to the use of a mix of both specialist consenting, enterprise, and other related systems, increasing the complexity and potentially cost of linking technology

> Where BCAs have similar systems there is an ability to share data and information between each other (and those that have adopted the Simpli system have an ability to share information across other specialist consenting systems due to interoperability)

> Without some form of standardisation (including in the form of adopting intermediary or mid-ware systems like Simpli) it would be costly for BCAs to share with those that do not have similar systems.

Where does third-party technology sit?

108. The overall feedback from our interviews was that there was low awareness of third-party technology developments by BCAs. All of the BCAs we spoke to knew of the developments at a high level, but few had detailed knowledge of their status or potential benefits for consenting. It was clear that any detailed knowledge was due to experience and interest of specific individuals at BCAs, rather than a result of sector-wide education or awareness campaigns.

109. Where there was some awareness of third-party technology developments, we also asked BCAs where they saw the benefits sitting and what they thought the scale of the benefits were. Almost all BCAs we spoke to saw high benefits sitting primarily outside the consenting system (so pre- or post-construction), with most developments only recording medium or low benefit to consenting. Benefits were seen to be higher for industry than for consenting. The only areas that diverted from this theme were inspections tools and data sharing with other BCAs & agencies.

110. A theme that came through the comments from our interviews with BCAs was that in most cases they would be late majority or lag adopters in terms of the technology adoption lifecycle. There was a sense that the technological changes are primarily driven by commercial or industry needs, with only developments relating to inspections seen as being more driven by BCAs.

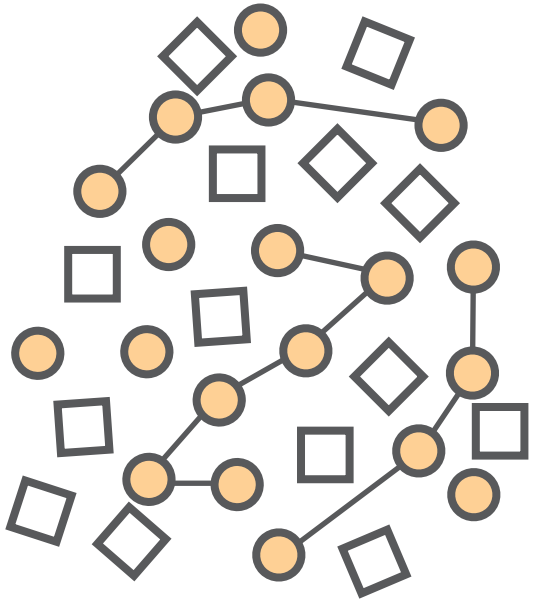
Diagram Ten.

Current BCA digital consenting capability

No digital capacity

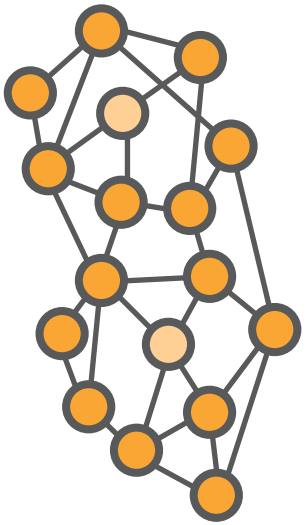
13% of BCAs with no online digital capability process 3% of building consents

Early
Digital submission or part of process



60% of BCAs with digital submission and limited processing capability process 40% of building consents

Advanced
All of process (end-to-end)



27% of BCAs with advanced digital capability process 57% of building consents

Information supplied to Third Bearing from Simpli

Diagram Eleven.

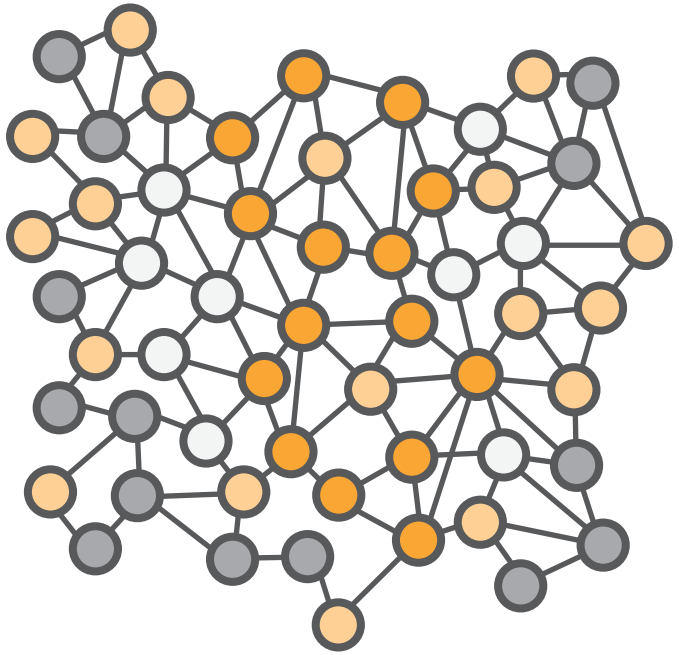
Where we need to get to

Not online

Early
Submission or part of process

Advanced
All of process (end-to-end)

All BCAs adopt digital consenting systems



Enable sharing

Main areas of progress for BCAs in medium-term

111. BCAs highlighted three areas of technology development that they saw as most important in the medium-term:
    - Increased ability to share resources, either with other BCAs or externally with contractors.
    - Standardisation of forms and approaches, continuing to progress the work to date in this area was seen as helping with sharing of resources and also to meet customer concerns around variability across BCAs.
    - Inspections information & tools, with a particular focus on use of still and video images for recording inspections evidence and facilitating remote site visits (with the potential for having some low-risk inspections done remotely).
112. The time horizon for these developments were seen as happening over the next 3 to 5 years. This timing view was based on the time taken to progress digital consenting tools to date, and while the additional improvements were seen as more focussed and contained there were still a number of steps that could not be sped up significantly (such as culture shifts and development pathways of external system providers).
113. We did not hear of any significant push from BCAs for connections to third party technology. In line with the view that these developments were mostly driven from other areas, BCAs saw the timelines for adopting these other technologies as beyond 10 years on the basis that industry needed to adopt the technology first and then BCAs would follow.

Barriers to date

114. The key barriers to adopting consenting technology to date was seen by BCAs to be:
    - Time & effort – technical aspects were seen as relatively straightforward, but the commitment to going digital and to change the way of working to suit a digital environment required sustained effort from a management and culture perspective.
    - Battle with IT – our interviews showed that BCAs tend to fall into one of two camps: those who had the support of their IT department, or those that had to 'fight' with their IT departments to either secure the resource or to have the building 'voice' heard.
    - Enterprise vs specialised system – there was often an almost philosophical debate on whether to use an enterprise system (that provides Council-wide capabilities and connections but does not have particular expertise in building consenting) or specialised system (that are expert in building matters but require connections to other Council systems). Where there was a difference in opinion the BCA either had to delay adoption or adapt its approaches to suit.
115. Expense was not seen as a significant factor. Where enterprise systems were being used there was little additional cost since the wider Council was already paying for the system (and building was either an extension or another module). Specialist systems were not charging significant amounts (if any) upfront, but recovered their costs on a per consent application basis – the savings to industry alone from electronic submission meant passing this charge on was not an issue. Minor capital costs were incurred with a shift to tablet or other mobile devices for inspections, and larger dual screen setups for processing.
116. One area where expense did come into play was the need to connect any consenting system to other Council systems. Specialist systems by now come with the ability to connect to a range of enterprise and other supporting systems (EDRMS, Finance), but if a particular configuration or version is not covered then we were told of how enterprise system vendors can charge significant amounts to accommodate the required integration (and/or place it on a long development pathway, reducing the feasibility).

Barriers to adopting third party technology

117. As noted earlier in this section, BCAs we talked to considered industry uptake and time to be the main drivers in determining when they would adopt third party technology into the consenting process. This was especially the case for BIM, where the general view was that industry adoption needed to increase before it was worthwhile for BCAs to adapt their systems to allow submission of 3D models. This tends to lead to a split between commercial and residential consenting, where the volume of residential consents far outweighs commercial but the uptake of advanced BIM is much more driven by commercial construction developments.

118. Table Five below outlines some of the other barriers or issues for the main technology development groups discussed with BCAs. We expected liability to come through as a strong theme in a number of areas, and while it did come up in interviews it was largely seen as something to be navigated rather than a showstopper. Two main barriers were highlighted:

> Importance of BIM adoption as it underpinned other technology developments (such as automated code checking)

> Trust in the tools where they need to be relied upon for decision-making or to provide evidence to back-up BCA decision-making.

119. Increased BIM adoption by industry was seen as important across a number of the third-party technology areas. As well as needing sufficient uptake before BCAs would look at accepting 4D, 5D or 6D models as part of consent submission, BCAs also saw it as important for automated code checking and product specification. Both of these areas had alternative options, however. BCAs did not need to have BIM-enabled consenting systems to allow industry to use automated code checking themselves (and submitting the results as part of a flat-file consent application). Shifting to a 'live library' of product specifications through consenting systems was seen as a significant and more achievable improvement rather than needing to be BIM-enabled.

120. Trust was raised as an issue in relation to automated code checking, product specification and quality assurance. Rather than focus on liability, BCAs considered trust and verifiability as more important (or more importantly, a precursor). If BCAs trusted a digital tool they would be more likely to adopt it as part of making their judgements and decisions under the Building Act. For example, having an automated code checking tool externally verified as accurate would remove the onus from BCAs in having to make this judgement implicitly as part of their decision-making. Similarly, for product specifications BCAs would need some way of trusting that the information is true and correct before relying on it (and the proposed changes to the Building Act include approaches to address this). Investing in verification is therefore an important part of the technology development process for BCAs.

Table Five. Barriers to third party technology identified by BCAs

Tech group	Issues	Comments
BIM	Wait for industry adoption, then take on	Implications for golden thread and other initiatives such as LINZ
Code checking	BIM adoption by industry, and trust	Ability to do before-BCA check means tech developments not as crucial
Product specification	BIM adoption by industry, and trust	For consenting system providers to provide connection to 'live' library, not BCA-driven
Quality assurance	Trust in tools Fit with BCA way of doing thing (vs. industry needs)	Demand from BCAs for tools in this area, but even existing consenting tools are often 'turned off' as do not fit/match how BCAs work
Data sharing	Ability exists, no issues BCA end	Needs organisation at agency end re needs, and standardisation so can 'draw' from range of systems

7. Future state for consenting

121. Earlier in this report we gave an overview of the development of digital consenting tools and their adoption by BCAs. When placed in the context of industry adoption of digital tools at the design and pre-construction stages, the consenting sector has clearly been part of the late majority rather than toward the innovator end of the technology adoption curve.

122. Our interviews with third party technology providers and BCAs reveal that this situation has not changed and is unlikely to change in relationship to future technology. Third-party technology developers have clear commercial drivers and there is little value for most of them in responding to the consenting sector – instead their target markets are the various parts of the construction industry that are adopting technology to improve productivity and margins.

123. Given the recognition of how far behind the New Zealand construction sector is in terms of technology adoption overall, and the scale of potential productivity improvements that could be realised, there is a high hurdle for arguing to instead invest in turning the consenting sector into an innovator or lead adopter.[83]

124. There may be some signalling benefit to be gained in investing in BCAs to adopt the latest technology for consenting, but real value lies in ensuring industry unlocks the productivity benefits available with technology. As outlined in previous sections, uptake of tools such as BIM by industry will be a precursor for future technology adoption by BCAs. Investing in enabling BCAs to, for example, to accept at least 3D BIM as part of consent submissions in the near term would be less effective than assisting industry to further the level of BIM saturation.

125. In our view the question is therefore one of how far consenting should lag behind lead adopters in the construction sector. The recent situation with adopting digital consenting tools is likely an example where lagging significantly behind is a costly position to change (in terms of time and also resource). The ideal position is to lag but maintain a sufficient capability foundation that it is not costly in either time or resource for BCAs to adopt or connect to key technology changes.

126. Success in this context is that there are not significant delays or costs imposed on the construction sector caused by an inability of the consenting system to connect with key third party technology used by industry players.

127. This is less ambitious than having a fully-automated consenting system with no delays or adverse impacts, but better recognises the position of consenting in relation to sector adoption of technology. It is an attempt to add depth to the online consenting goal set in the Construction Sector Accord, helping to recognise that simply putting digital consenting in place is not sufficient.

128. Based on what BCAs have told us, our view is that the following efforts are needed to ensure an acceptable 'lag' position:

- Raising awareness, both in terms of making BCAs aware of third-party technology capabilities and benefits, and also vice-versa making technology developers aware of consenting issues and requirements, will build a base of understanding that will help inform investment decisions (both in terms of timing and scale).
- Maintain a watching brief on the consolidation and maturation of the consenting system market. To date there has been relatively healthy competition between providers, but as markets mature this can settle and result in slower innovation or improvements. Rich dialogue between BCAs, industry and regulators can help create common understandings and ensure weight of influence on providers (such as provided by the previously MBIE-funded building clusters initiative and by GoShift/Simpli).
- Understanding where the key 'trust' investments need to be made as third-party technologies develop, identifying the regulatory or other interventions that can be made alongside the technology to avoid future liability barriers for BCAs. For example, implementing sufficient verification abilities alongside the development of automated code checking capability will smooth eventual uptake and implementation by BCAs.

83 While no economic analysis has been done on the benefits of improving digital consenting, the accepted estimate is that any improvements in the consent process generate between $1,000 and $1,600 per consent per week saved (based on Ian Page (2012) "Value of time savings in new housing" BRANZ report SR259)

- Improve the capability to share data and information both between BCAs and also with external agencies. One of the reasons digital consenting has taken so long to implement and is still evolving is that there are multiple back-end systems to integrate with, and few tools to easily link across these. Finding a way to share data and information despite this range of systems will not only unlock immediate benefits for BCAs (such as resource sharing) but also builds foundation capability for any future connections to third-party technology.
- Understand how the split between commercial and residential consents is likely to influence consenting uptake of technology. Commercial players are the ones who are leading the uptake of BIM, but in terms of volume they generate fewer consents (though each consent is of greater value). Residential players generate high volumes of consents and are therefore arguably more likely to influence changes in consenting processes (especially for non-metro BCAs), but are generally slower to adopt higher-end technology tools such as BIM. This dynamic will be important in helping determine the 'lag' level for BCAs in terms of technology adoption.

129. These efforts provide a foundation of capability from which future efforts to connect third-party technology to the consenting process can be undertaken. More detailed work could then be undertaken around, for example:
    - Exploratory work on the range of ways that BIM could be used by BCAs, from the basic state of using BIM readers as part of current consenting arrangements through to more fulsome adoption of BIM as part of consent processing and inspections.
    - Building on the work of ACABIM and Christchurch City Council, setting out the ways that automated code checking could be adopted by BCAs, exploring the range of options from pre-checking by applicants through to BCAs using checking tools as part of their assessments of applications. Supporting conversations between GS1 and product specifiers to also take into account how this information could be shared initially as a 'live library' with consenting systems, and in future more fluid exchanges of information as these systems develop.

130. Throughout our work we were also conscious that a lot of the industry technology developments will impact Councils beyond the BCA functions. The future state for construction as set-up by the likes of McKinsey & Company, Boston Consulting Group and Deloitte arguably presents more challenges for Councils in terms of pre-construction (more dynamic sharing and modelling of land and development information, placing pressure on the need for adopting digital tools for resource consenting) and post-construction where maintenance and operations help complete a whole-of-life approach to building.

131. The area where this wider view comes in to play is the concept of the golden thread of information for construction (see case study box). Councils and BCAs could potentially act as the repositories of building information from consenting through to construction and beyond, maintaining a 'live' model that can be drawn on for a range of commercial and non-government purposes (including fire and emergency). There is already a requirement under section 216 of the Building Act 2004 for territorial authorities (Councils) to keep all plans, specifications and other information provided to it in respect of a building and to make this publicly available. Currently this is done through property files, most often paper records but increasingly these are scanned to improve accessibility by BCAs and the public. As the construction sector becomes more digitalised these duties will need to be rethought for a technology-infused approach.

Table Six. Potential implementation staging for connecting third party technology to consenting systems

	Short-term (0-5yrs) **Building the foundations**	**Medium-term (5-10yrs)** **Increased adoption of tools**	**Long-term (10-15yrs)** **Transformation of consenting**
BIM	> Continue to grow industry adoption > Awareness of & understanding use (BCA) > Understand influence of commercial/ residential BIM use on BCA adoption	> BCAs adopt use of BIM readers > Increased skills training by BCAs > Improve capability to draw information from BIM models into digital consenting systems	**Dynamic consenting** > Draws information from commercial systems (BIM 6D) > Automated code-checking within consenting systems > Automatic feed of information to system stakeholders **Golden Thread** > Digital twin held by Councils as property file > Updated throughout building's lifecycle > Easy access for operations and management of buildings > FENZ & Civil Defence able to draw on in emergencies
Automated code checking	> Continued digitalisation of the building code > Build understanding & trust > Define liability angle	> Pre-application code-checking the norm > Advanced BCAs starting to adopt more automated code-checking	
Product specifications	> Determine form of standardisation > Build understanding & trust	> Live library established for use by consenting systems > Increased BIM use captures product use	
Quality assurance software	> Increase awareness of industry and BCA needs across construction phase > Build understanding & trust	> BCAs able to draw from commercial tools > Dynamic information capture allows remote inspections	
Data sharing	> Standardisation of information requirements > Understanding external agency needs	> BCAs more data-driven in decision-making and resource sharing	> System performance informed by real-time consenting data

Case Study - **Golden Thread**

Golden Thread - an idea or feature that is present in all parts of something, holds it together and gives it value.

In construction the golden thread of information is used as a shorthand for an accurate and up-to-date record of building data.[84] Although not standard practice yet, it will detail how a building was designed, built, and maintained. The golden thread is a live document, held digitally. The record will capture the digital fingerprints of people recording their decisions, thus giving a clear accountability trail.

In December 2017, Dame Judith Hackitt said in her interim report following the Grenfell Tower Fire: "There needs to be a golden thread for all complex and high-risk building projects so that the original design intent is preserved and recorded and any changes go through a formal review process involving people who are competent and who understand the key features of the design."[85]

Hackitt's final report set out the duties and accountabilities for those responsible for creating, managing, and storing building information throughout the life cycle of a building. Recommendations included:[86]

- The government should mandate a digital standard of keeping records for the design, construction, and post-construction of high-risk residential buildings.
- These records should also include information about any refurbishments to the building.
- These records should be saved in a format which is "appropriately open and non-proprietary with proportionate security controls"
- The government should work with the industry to decide exactly what information will be held in these records.
- There should be a duty holder who must "hold, transfer and update" information throughout the building's lifecycle.

Information and record-keeping around buildings and construction projects are fragmented, incomplete and often inaccessible. For most buildings, it is unclear if the finished structure is the same as what was designed, potentially impacting on building safety. This also makes it harder for the owner to efficiently and effectively manage the building and complicates renovation/operational maintenance.

BIM is critical to the golden thread – a digital model that all people involved in the project can work on, from the architect to the client. It is the digital description of every aspect of the built asset.[87] BIM draws on information assembled collaboratively and updated at key stages of the project.

While the model is a visual representation of the building, there are other assets linked to it such as technical specifications, construction, and asset management information. This is all hosted in what is called the Common Data Environment (CDE): the place which collects, manages, and disseminates documents.[88] It is where the graphical model and all associated written data (such as specification, installation, maintenance information) is stored.

There are currently gaps around handover, running/maintaining, renovating, and demolishing the building. There are usually no records at these phases, or if there are, they are not joined-up. Since 2016, the BIM mandate has required UK public sector construction projects to use BIM.[89] This has helped speed up the pace and rationale for adopting the process during the design and construction phases.[90]

84 NBS (12 March 2020) "*What is the Golden Thread*" https://www.thenbs.com/knowledge/what-is-the-golden-thread - accessed April 2020
85 Dame Judith Hackitt (December 2017) "Golden Thread: Steps to True Transparency and Accountability (Interim)" https://bit.ly/2Z2F2oX - accessed Feb 2020
86 Dame Judith Hackitt (17 May 2018) "Golden Thread: Steps to True Transparency and Accountability (Final)" https://bit.ly/2Z2F2oX - accessed Feb 2020
87 NBS (12 March 2020) "*What is the Golden Thread*" https://www.thenbs.com/knowledge/what-is-the-golden-thread - accessed May 2020
88 BIM Wiki (20 May 2020) "*Common data environment CDE*" https://www.designingbuildings.co.uk/wiki/Common_data_environment_CDE - accessed May 2020
89 UK Cabinet Office (May 2011) "*Government Construction Strategy – Policy Paper*" https://www.gov.uk/government/publications/government-construction-strategy - accessed May 2020
90 NBS (12 March 2020) "*What is the Golden Thread*" https://www.thenbs.com/knowledge/what-is-the-golden-thread - accessed April 2020

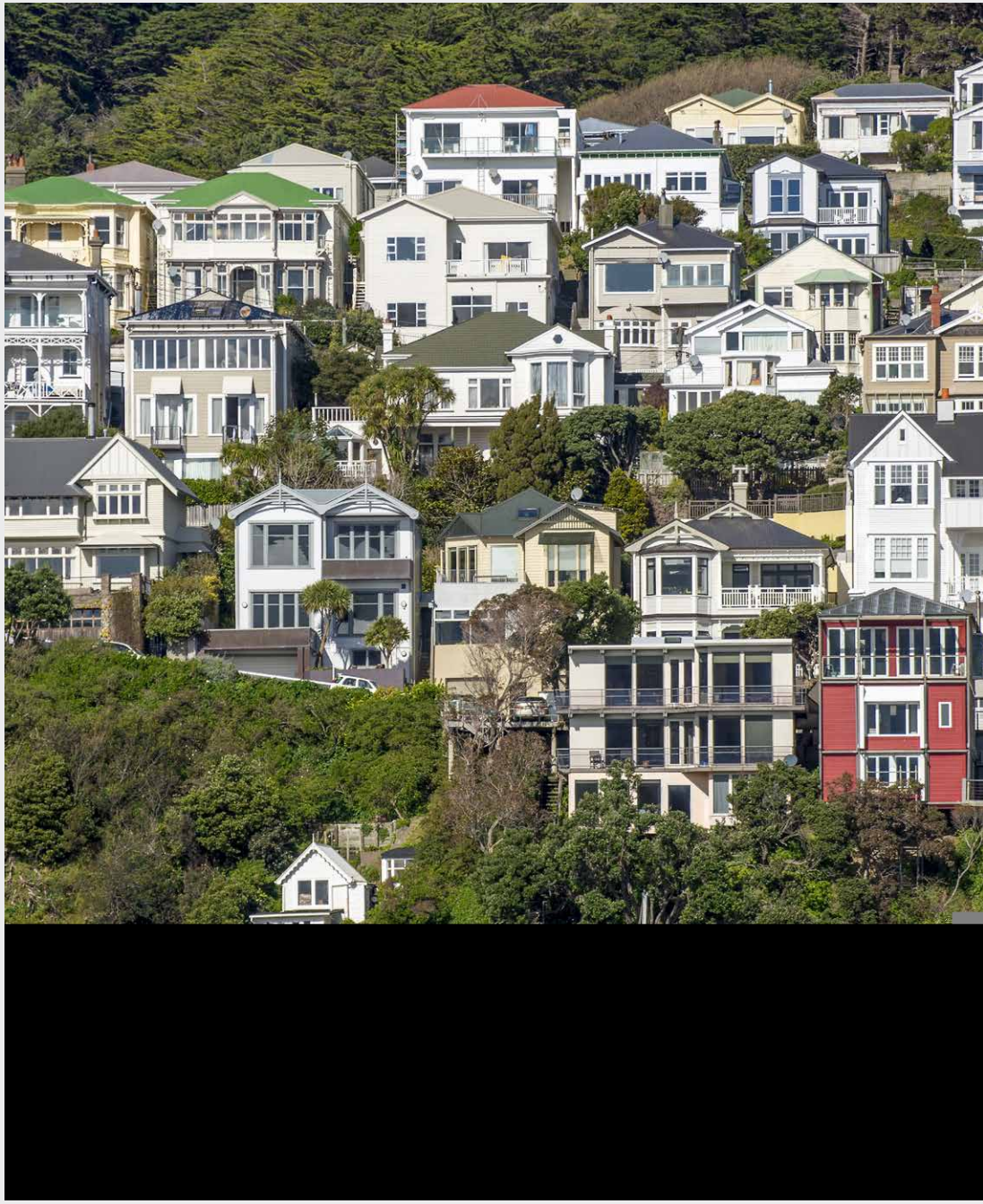
This process will be made much easier with the data available through a digital twin.[91] Having a digital twin will enable the team responsible for the physical asset to see all of the essential information in one place and allow for constant monitoring and maintenance of the asset.

The main threat to data supply to a CDE and the thread of information is insolvency of contractors. There is evidence internationally where a Tier 1 contractor (like Mainzeal) collapses creating a significant data restriction across multiple projects.[92]

On most major projects, the Tier 1 organisation is often the prime and information management lead, provisioning the Common Data Environment (CDE) on behalf of the client, ensuring project information is delivered, assured and approved prior to formal handover. With the financial demise of the Tier 1 contractor comes the clear and present risk of data loss for the client.

If a Tier 1 organisation goes into liquidation, all of the project information they are hosting and managing is locked in and clients and other project parties are locked out from accessing it. Even though fault may lie with the company in liquidation, the onus is on the asset owner (client), and not the contractor, to retrieve and re-procure thousands of datasets from different parties involved in a project. As an alternate to repurchasing the data from the design team or supply chain, the built asset may need to be resurveyed to establish the required data, and these can be significant costs.

To alleviate this occurrence, it is suggested that a clear destination for data drops and information hand over is provided. It is recommended a project and asset management system or CDE be used/provided that enables information to be accessed and shared by all parties throughout an asset's complete lifecycle, enabling all parties to securely communicate and collaborate while simultaneously continuing a robust audit trail.[93]



91 Twinview.com (Feb 2020) "*What is the Golden Thread, Digital Twin for Construction*" https://www.twinview.com/insights/golden-thread-of-data-in-construction - accessed May 2020

92 PBCToday (29 April 2020) "*Insolvency and Data: Severing the Golden Thread*" https://www.pbctoday.co.uk/news/bim-news/insolvency-data-golden-thread/75519/ - accessed May 2020

93 CIOB UK, Andrew De Silva (18 January 2019) "*Using the Golden Thread to Reduce Risk and Improve Project Outcomes in Housing*" https://www.bimplus.co.uk/opinion/using-golden-thread-reduce-risk-and-improve-projec/ - accessed May 2020

Appendix A. Research questions for third-party providers

Our approach to the research interview questions was as follows:

Third-party Providers Current State Assessment (interviewed in person)

- Please outline your current technology capabilities
- What is your current ability in connecting to or sharing information with consenting systems?
- What are the technical issues you face in connecting to consenting systems – is it an infrastructure or system-design issue, from either the Council service side or third-party technology-side?
- What are the benefits of your product in enhancing the understanding of the quality of buildings, overall productivity and performance of the building and construction sector?

Third-Party Providers Future State Assessment (interviewed in person)

- Future state – To the extent you are able to share, what does the future development of your products include?
- Time wise, what does this look like for you - 5/10/20-year plans
- How could the future state impact or enhance current consenting systems, do you have any plans for connecting and leveraging the systems?
- In the future state – what do you anticipate to be opportunities or barriers to connect or leverage consenting systems?
- What are the barriers to you achieving your future state?

Appendix B. Research questions for BCAs

Our approach to the research interview questions was as follows:

Council Interview Current and Future State Assessment (conducted via Zoom meetings)

- What is your current digital consenting ability?
  - No digital functionality
  - Partial digital functionality
  - Full digital functionality
- What are your future plans, how far do you intend to go and how fast do you think you'll get to each point
- What is stopping the future? In getting from where you currently are to where you hope to get to. What are the main barriers to getting there?
- How aware of the following third-party developments are you?
  - Automated Code Checking
  - Product specification sharing & integration
  - Tools to assist with managing inspections or enabling digital connection to construction sites
  - Ability to accept BIM models for consenting
  - Ability to easily share data with MBIE or other groups
  - Others you may know about?
- Where do you see third-party technology adding the most value to Councils and to Customers?
- What are the issues or main barriers to adopting third-party technology alongside consenting systems?
- How far do you think consenting systems will be able to connect with third-party technology in 5-years and in 10-years' time?
  - Stays as is – applications are either paper-based or in PDF form and limited sharing between BCAs

- Connected between BCAs with limited external sharing – Full connectivity between BCAs but limited sharing outside (applications stay paper-based or PDF form, little connection to third-party providers
- Passive external sharing – some sharing with outside but decisions still made within BCA systems, any functions such as code-checking is done outside and submitted as part of application
- Active external sharing – sharing in specific parts of the process only (for example, code checking is part of the BCA process
- Full sharing/linkage – Full sharing with outside (multiple apps are designed to plug-in to consenting system such as code checking and digital product libraries)

> How important a role do you see data standardization in achieving the future state for consenting systems?

> Are you aware of any data standardisation efforts underway in the building sector already?

> Who do you see as best placed to deliver the standardisation needed?

- Councils as customers – require it when purchasing a system
- Technology providers – should do it to be competitive
- National bodies such as MBIE – incentivise or require providers

> Where do you think data standardization would be most valuable if undertaken?

- Consenting process – information coming in/out
- Consenting process – sharing between BCAs
- Wider building sector.

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