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The Home of Property Professionals

Innovation in Construction

CallaghanInnovation
Te Pokapū Auaha o Aotearoa

Thursday 4th August 2022

Sector overview and key market trends

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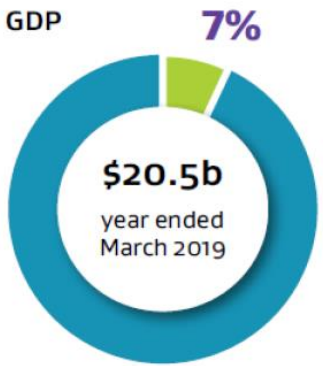
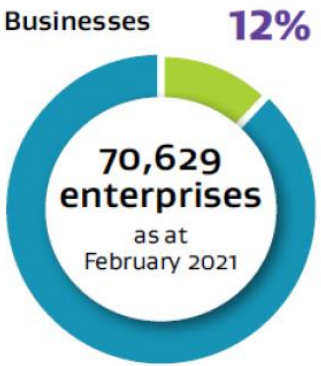
NZ Construction Sector

- **5th largest sector** by employment – 10% of NZ workforce (c.300K FTEs)
- Key driver of economic growth – **7% GDP**
- **Highest job growth of any sector** and **highest growth sector in terms of <u>new businesses</u>**
- One in every five <u>new</u> jobs (20%); **Highest female employment growth**





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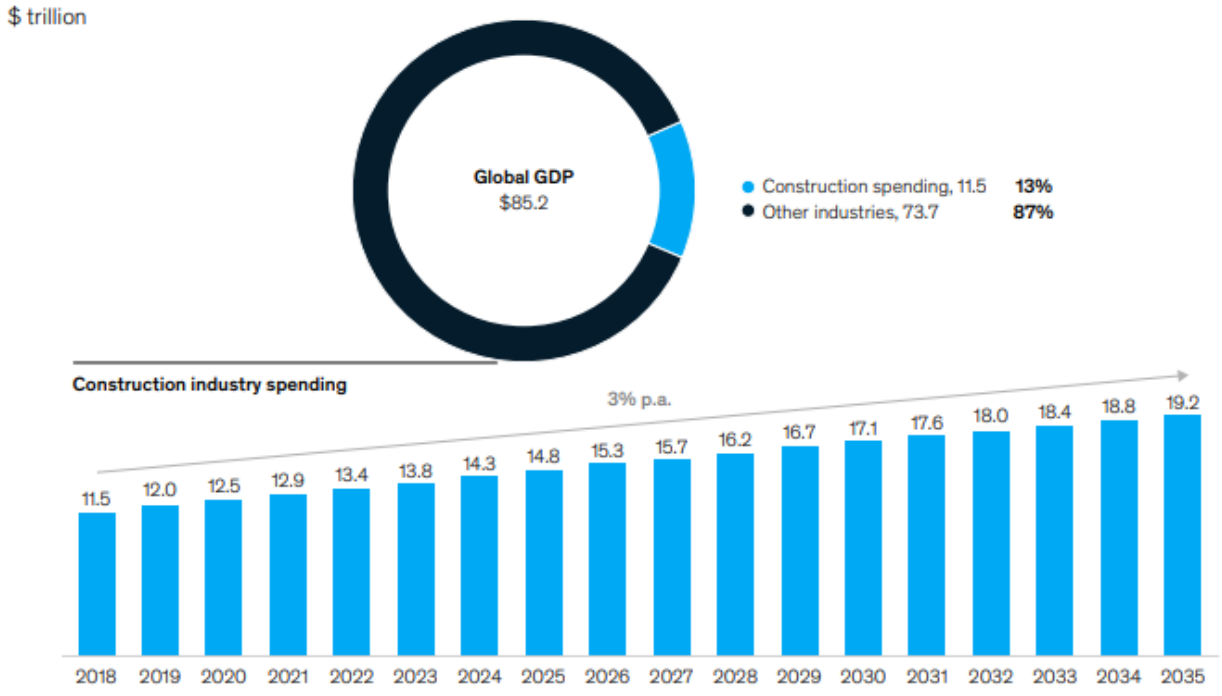
Source: MBIE Construction Sector Accord – May 2022

Global Construction Sector

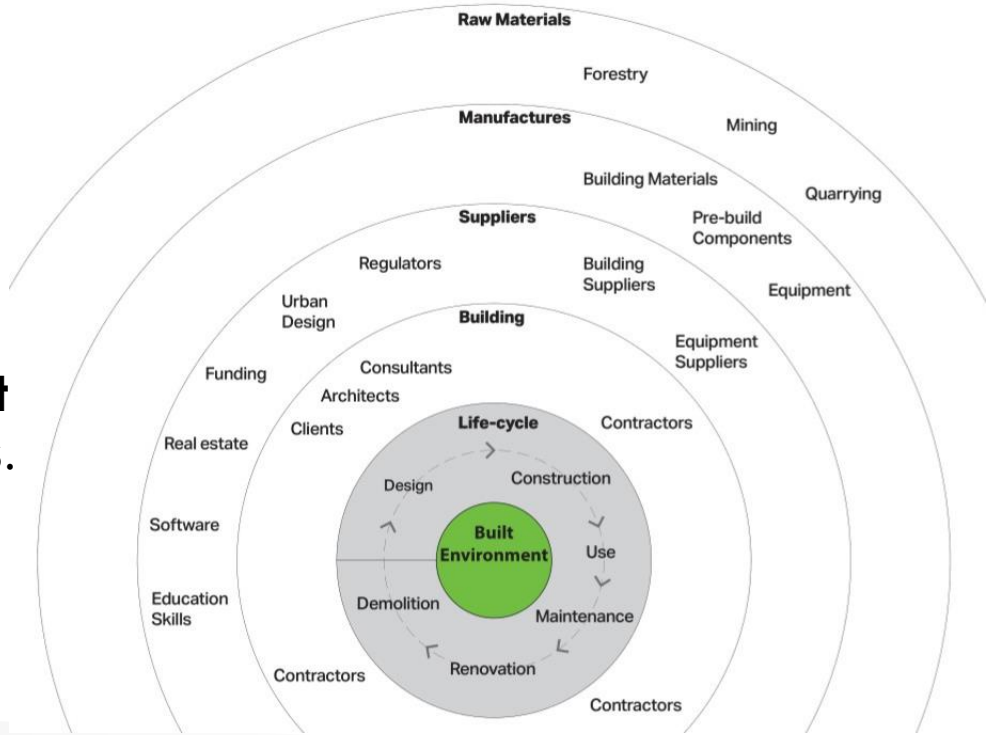
- **The Construction sector globally: 13% of the world's GDP – US$85.2tr**
- NZ Construction businesses exploring international markets as part of their commercialisation strategy



Source: McKinsey – The Next Normal in Construction – Jun 2020

NZ Construction Sector Integrated across our economy

- **Highly-integrated** across multiple sectors.
- Investment in building construction produces the **largest stimulus effect** with **flow-on effects to other sectors**.



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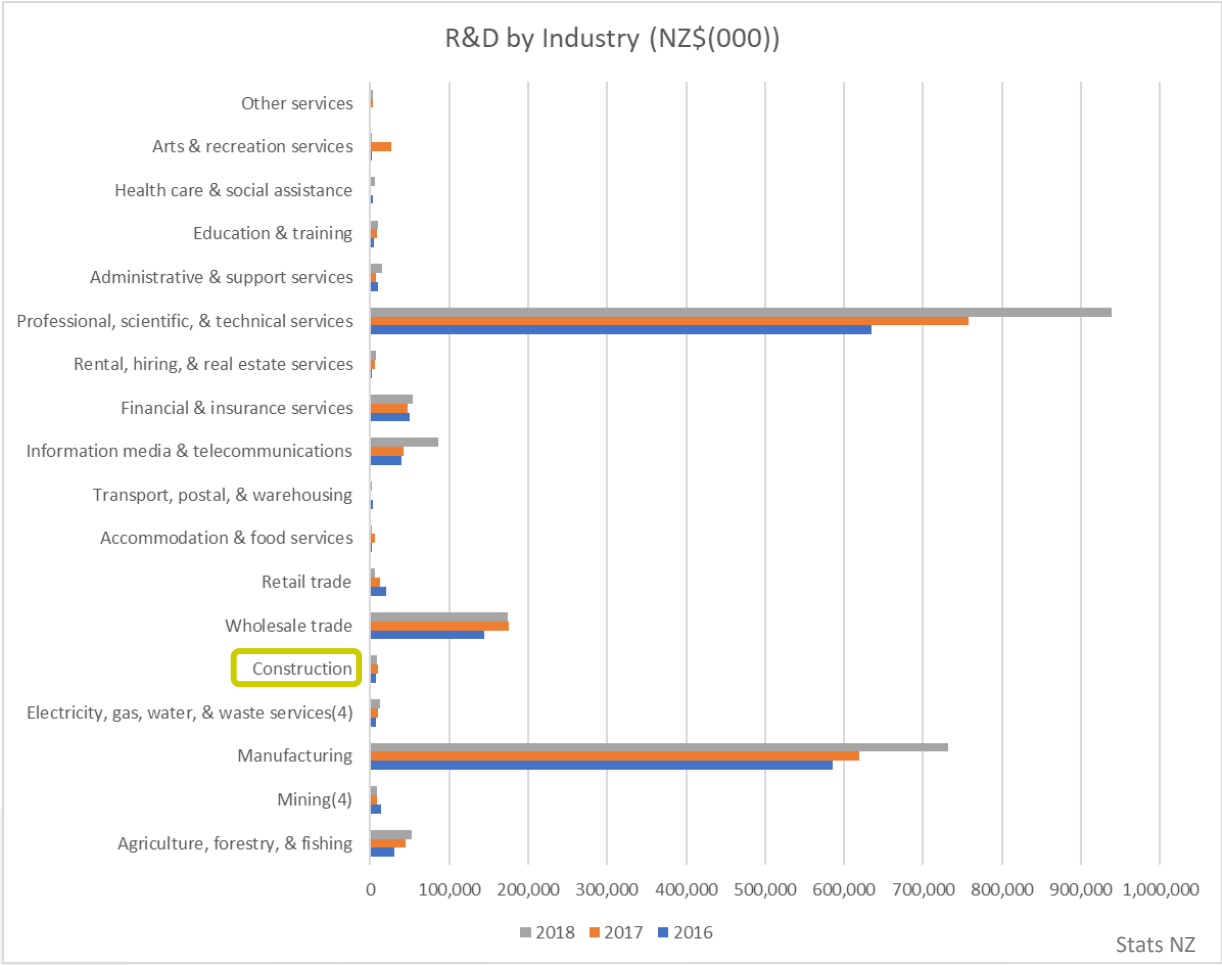
Source: Victoria University of Wellington and CRL Energy - Dr Tana Levi, Dr Murry McCurdy, Dr David Miller, Dr Antony Pelosi

NZ Construction Sector R&D Investment

One of the lowest of all sectors in NZ



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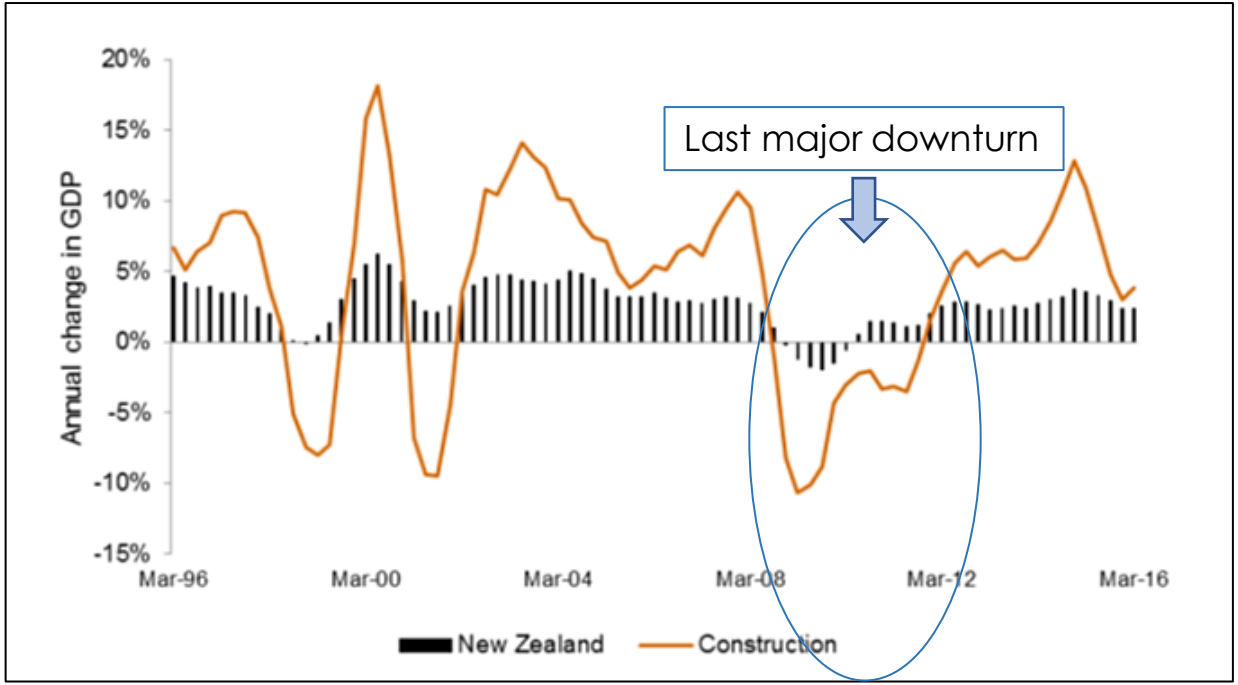
NZ Construction Sector - Historically Volatile

VUCA
Volatile, Uncertain, Complex and Ambiguous

Sector is still prone to boom and bust cycles.



NZ Construction Sector - Historically Volatile

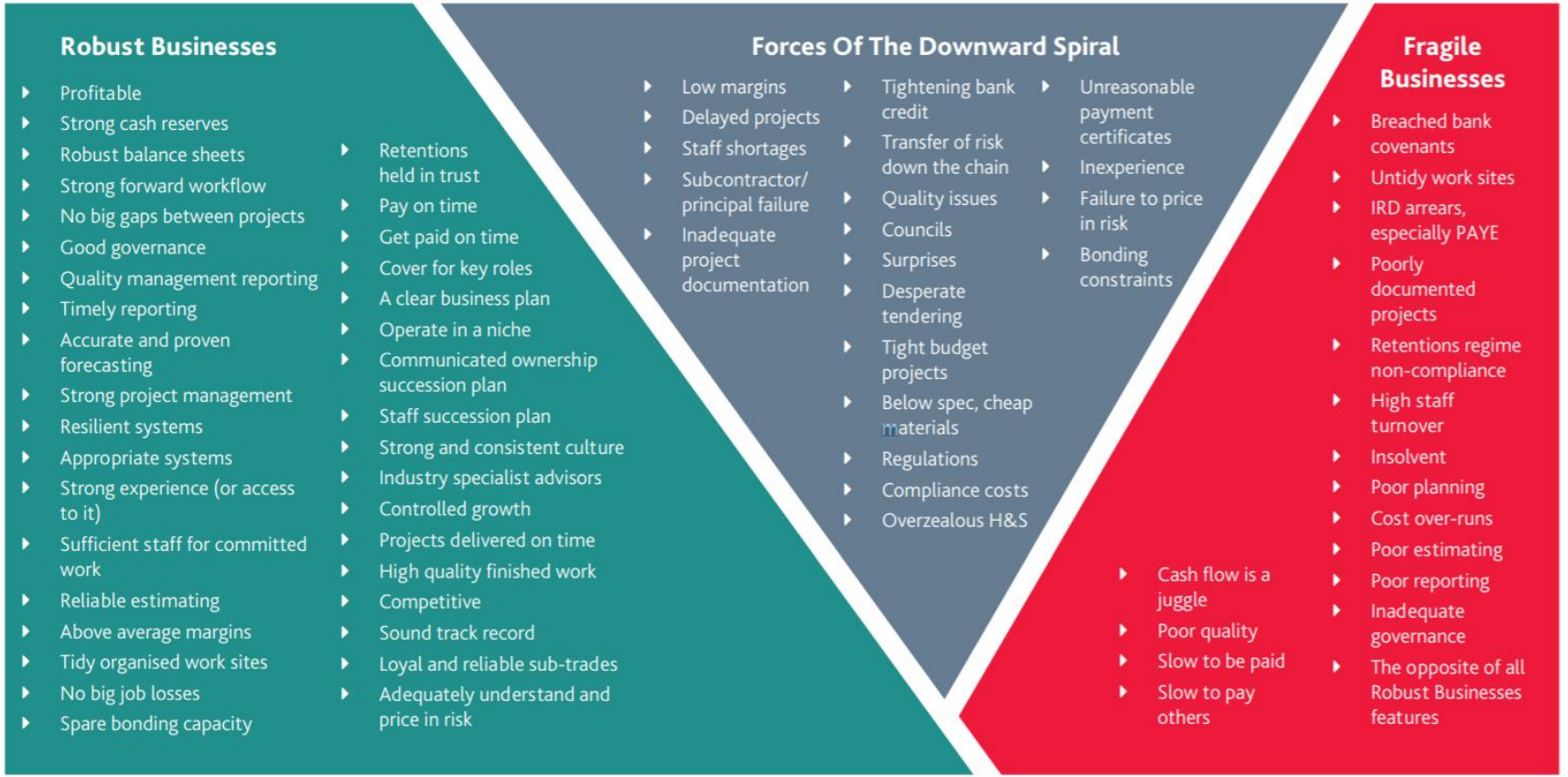
https://www.stuff.co.nz/business/128740312/construction-probably-entering-bust-cycle-with-92-companies-liquidated-this-year

Stuff ☰ business

Construction 'probably entering bust cycle' with 92 companies liquidated this year

Geraden Cann • 05:00, May 29 2022

Widening gap – Forces of downward spiral



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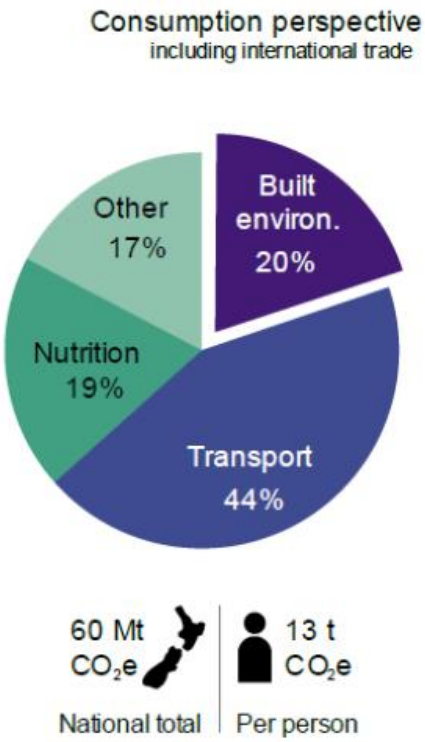
Source: BDO 2019 Construction Survey Report

Construction Sector – Environmental sustainability focus



- **20%** of New Zealand's GHG emissions
- Innovation in 'Environmental sustainability' is **good business as well as good for the environment**

The buildings and construction sector accounts for

39% of global CO_2 emissions

(IEA, 2019)

Global construction waste is set to double by 2025 to

2.2 billion tons

(Transparency Market Research, 2019)

Source: NZGBC – Under Construction report – August 2019

Global mega-trends – 6 of 8 directly impacting the Construction sector

Changing world order

Changing climate

Changing infrastructure

Healthcare revolution

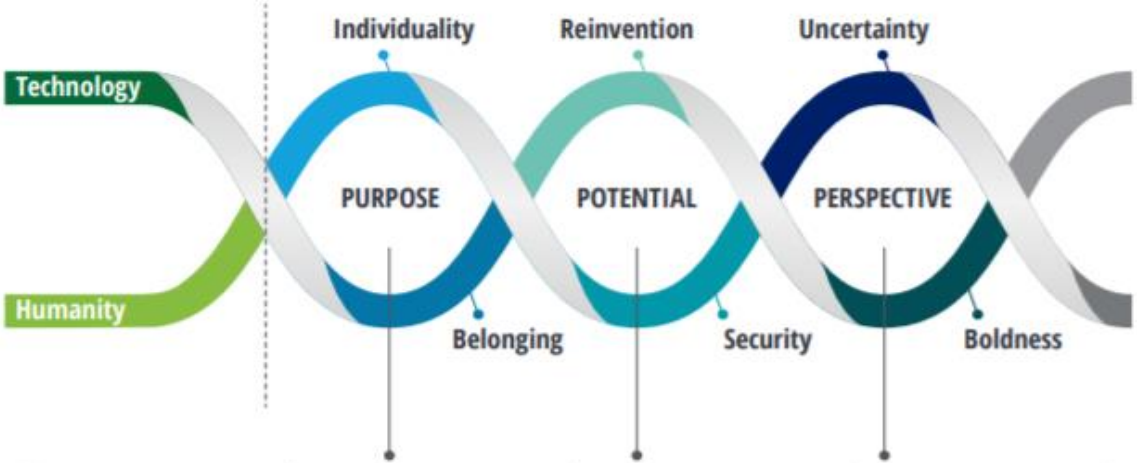
Changing demographics

The ethical/empowered consumer

Future of work

Future of business

Human & Technology – Creating Purpose, Potential and Perspective



Attributes of a social enterprise	An organization that doesn't just talk about purpose, but embeds meaning into every aspect of work every day	An organization that is designed and organized to maximize what humans are capable of thinking, creating, and doing in a world of machines	An organization that encourages and embraces a future orientation, asking not just how to optimize for today, but how to create value tomorrow

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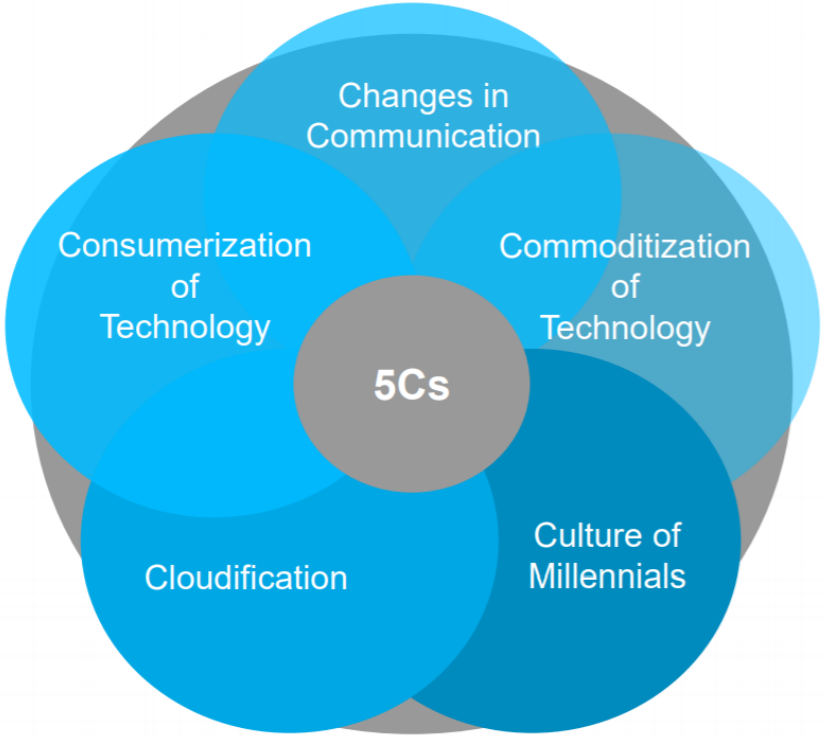
Source: Deloitte Insights: The social Enterprise at Work – Paradox as a way forwa

Digital Transformation



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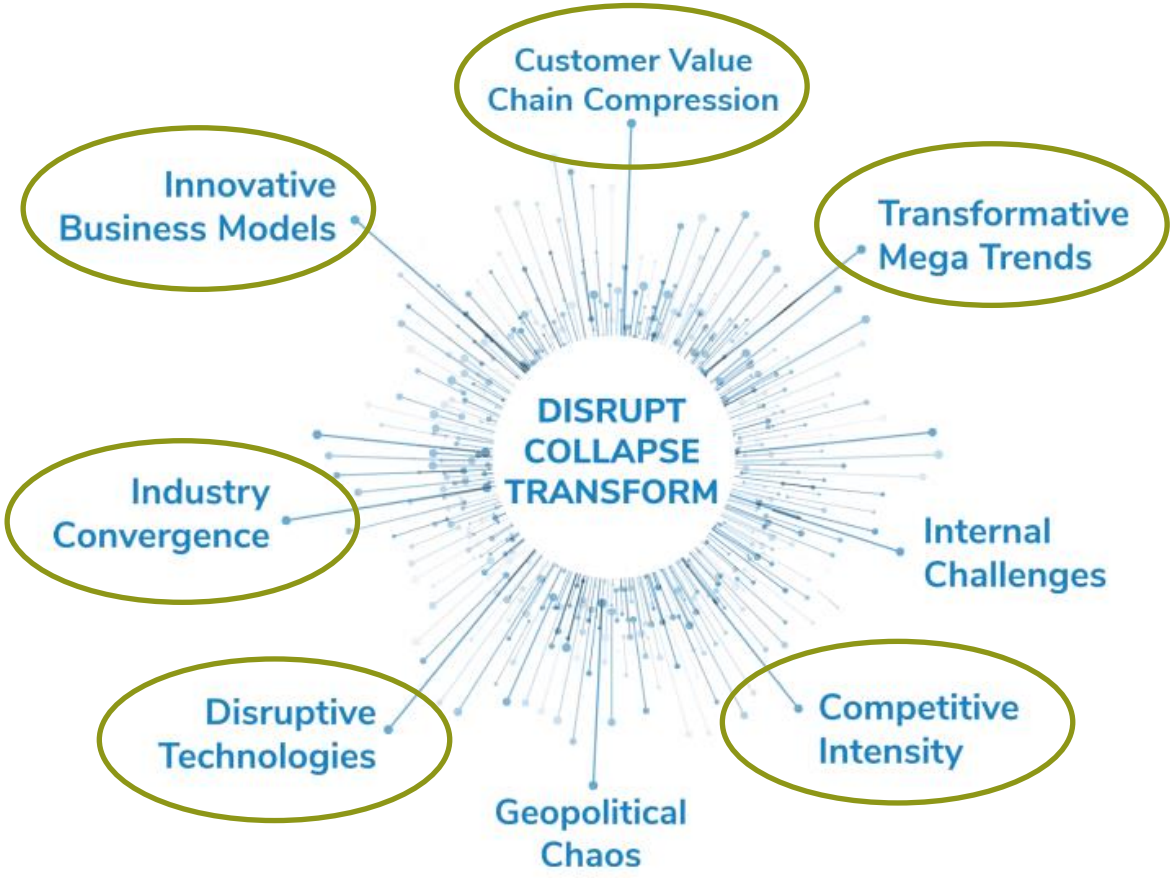
Source: Frost & Sullivan

Construction sector trends



Source: Frost & Sullivan

Global trends - Recent

Challenges Faced by the Global Homes and Buildings Industry Due to the New Variants of COVID-19 and Russo-Ukrainian War

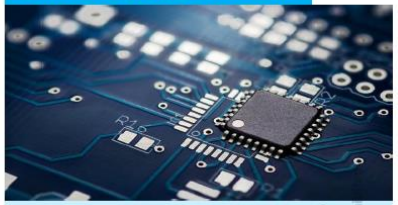
Construction Delay

- The construction industry is recovering at a steady rate, with increasing projects in the infrastructure and residential sector, especially in the high growth economies.
- However, the shortage of skilled labor has affected the productivity of the industry despite increasing investments and consumer demand. For instance, the US construction industry requires nearly 2.2 million workers from 2022 to 2024. Similarly, the Indian construction industry would require 16 million additional workers in the next couple of years.
- Delay in the delivery of projects is likely to have a chain effect on the homes and buildings markets that are reliant on the construction industry.

Supply Chain Disruption

- China's zero tolerance COVID-19 policy has disrupted the global supply-chain in the manufacturing sector, including automotives, machines, consumer electronics, semiconductors, and more.
- The sporadic outbreaks of Delta and Omicron variants in small pockets of some Chinese cities have triggered intermittent manufacturing and logistic shutdowns in key port cities, including Ningbo, Yantian, Dalian, Tianjin, Shenzen, and Shanghai.
- The Russo-Ukrainian war will add additional headwinds to industries because the closure of ports near the war zone will affect trade and disrupt supply chains.

Semiconductor Shortage



- In addition to a complicated chip manufacturing process, the pandemic-related factory shutdowns in 2020 and the resultant surge in consumer demand for consumer electronics, wearables, and work-from-home related gadgets created an acute shortage of semiconductors.
- This shortage has affected the inventory of the automotive, LED, consumer electronics, and IoT-related industries in 2021. Russia and Ukraine are key countries for the production of the rare metals and gases used in the semiconductor manufacturing process, and its disruption due to the ongoing war is expected to slow down the growth of LED lighting, smart homes, and other IoT-related markets in 2022.

Image Source: Getty Images

Source: National Association for Home Builders; Frost & Sullivan

Global trends - Recent

Key 2022 Homes and Buildings Predictions

AI and IoT-driven Building Solutions

Prioritized investments in the digitalization of buildings to increase adoption of AI and IoT-driven building solutions

Health and Wellbeing of Occupants

Occupant's health and wellbeing to remain top priority for facility managers across regions

Digital Twin in Smart Buildings

Rising demand for data-driven operation and maintenance to accelerate the adoption of digital twin in smart buildings

Connected Lighting Opportunities

Rebound lighting industry to explore connected lighting opportunities in improving occupant experience and wellbeing

Integrated Life Safety Systems

Increasing need for adaptive emergency response to further the demand of integrated life safety systems

Home Energy Personalization Service

Pressing need to address utility challenges and changing customer expectations to augment the deployment of home energy personalization services

Autonomous Home Awareness System

Expanding AI capabilities in home security to accelerate the growth of autonomous home awareness systems

Workplace Innovations

Shift towards hybrid working model and workplace innovations to accelerate the implementation of smart workplace solutions

Image Source: Getty Images

Source: Frost & Sullivan

The landscape remains unclear

75% vs **9%**

agree that technology disruption will continue

feel confident about leveraging the opportunities that disruption will create

McKinsey &Company Report. June 2020
The next normal in construction: How disruption is reshaping the world's largest ecosystem

- Ernst & Young Report. April 2020
Technology Advancements Disrupting the Global Construction Industry

The Opportunity

$265 billion

annual profit potential

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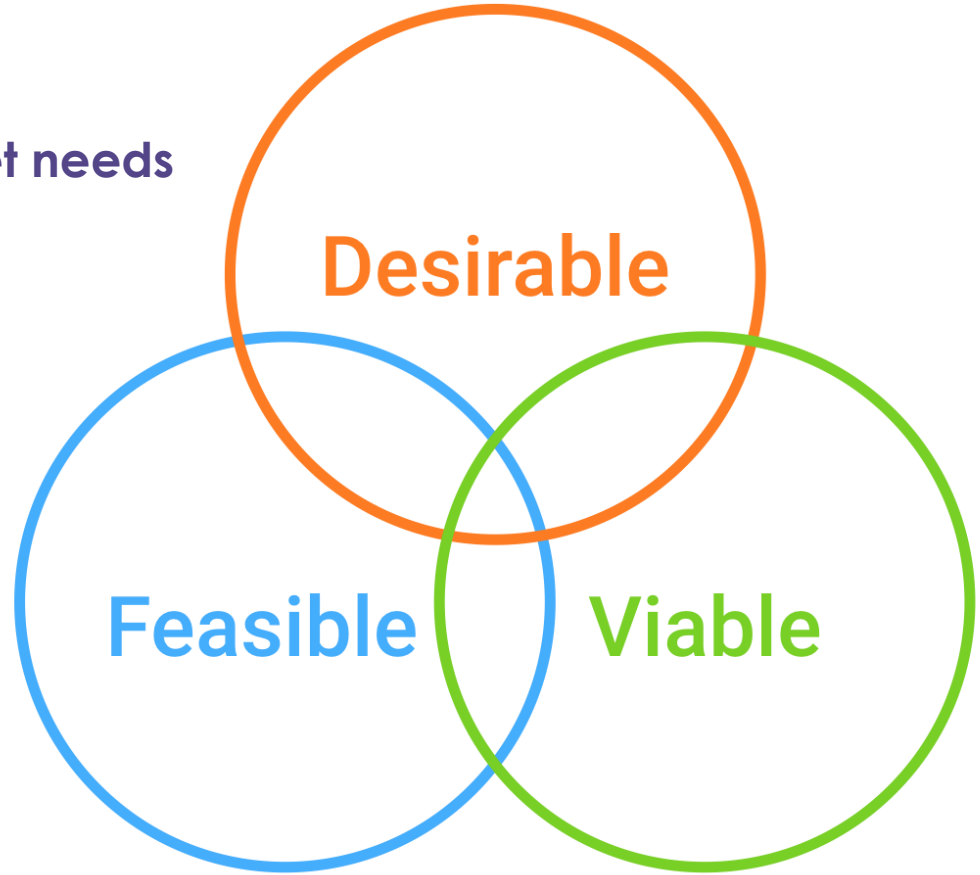
- McKinsey &Company Report. June 2020

The next normal in construction: How disruption is reshaping the world's largest ecosystem

Do they?

Meeting NZ market needs



Also targeting broader market opportunities & International Markets

Can we?

Should we?

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Desirable

The problem our customer wants to solve is?

Our customer cannot solve this problem today because?

The outcome our customer wants to achieve is?

Viable

Our acquisition strategy for obtaining new customers is?

Our customers will use our product repeatedly because?

We will generate revenue by?

Feasible

Our biggest technical or engineering challenges are?

Our biggest legal or regulatory risk would be?

Our team is uniquely positioned to win because?

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Ecosystem-Wide Collaboration

Promoting business-government and business-academia partnerships

NEW ZEALAND TRADE & ENTERPRISE
Te Taurapa Tūhono

Ministry for the Environment
Manatu Mo Te Taiao

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

BRANZ

SCION
FORESTS • PRODUCTS • INNOVATION

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha

MINISTRY OF HOUSING AND URBAN DEVELOPMENT

Kāinga Ora
Homes and Communities

Te Puni Kōkiri
MINISTRY OF MĀORI DEVELOPMENT

METALS NEW ZEALAND

EECA

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Ministry for Primary Industries
Manatū Ahu Matua

WAKA KOTAHI
NZ TRANSPORT AGENCY

HERA

NZGBC
NEW ZEALAND GREEN BUILDING COUNCIL

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA
NEW ZEALAND

AUT UNIVERSITY
AUCKLAND, NEW ZEALAND

MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga

Regional Business Partner Network

concretenz
BUILDING RESILIENCE

BCITO
buildingpeople

NZ TRADE GROUP

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

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The Transformation Plan 2022–2025 summary

CONSTRUCTION SECTOR ACCORD

VISION FOR THE SECTOR:
A thriving, fair and sustainable construction sector for a better Aotearoa New Zealand

MID-TERM GOALS

01 Increased capabilities of leaders to drive change

02 A more skilled and diverse workforce that is future ready

03 More thriving people and organisations

04 Greater Māori construction economy success

05 Reduced waste and embodied and operational carbon

06 Increased productivity through innovation, technology, and an enabling regulatory environment

FOCUS AREAS

PEOPLE

1. **Leadership for change (Goals 1, 2, 3)**
   To build the capabilities and capacities of large and small to medium enterprise (SME) leaders to lead business improvement and change.
   - 1.1 Building Leaders Advisory Service
   - 1.2 Next-Generation Leaders Programme
2. **Workforce development (Goals 2, 3)**
   To support the development, attraction, and retention of the workforce of tomorrow.
   - 2.1 Developing an Action Plan from the Construction Skills Strategy
   - 2.2 Construction Diversity Roadmap implementation
3. **Strong Māori construction economy (Goals 1, 2, 3,4)**
   To authentically partner recognising the important relationship with Māori in Aotearoa.
   - 3.1 Māori end-to-end supply chains*
   - 3.2 Māori SME capability development
   - 3.3 Kaiako Construction Mentorship Programme
4. **Wellbeing, health and safety for all people (Goals 1, 3)**
   To enable thriving people at all levels, and continued focus on a zero-harm and fatality-free sector
   - 4.1 Thriving Infrastructure Pilot Projects
   - 4.2 Construction Health, Safety and Wellbeing Strategy

CLIENT LEADERSHIP

5. **Procurement and contracting (Goals 2, 3, 4, 5, 6)**
   Drive better outcomes through improved planning, procurement and delivery practices achieved through increased collaborative behaviours.
   - 5.1 Broader outcomes for public sector initiatives
   - 5.2 Māori procurement panels
   - 5.3 Improve and drive best practice procurement, contracting and contract management
   - 5.4 Public procurement planning and phasing
   - 5.5 Client and contractor relationships
   - 5.6 Building Information Modelling (BIM) and digital engineering uptake
   - 5.7 SME capability
   - 5.8 Social, cultural and environmental outcomes for private construction projects

ENVIRONMENT

6. **Environmental and climate action (Goals 1, 5)**
   To accelerate the adoption of carbon and waste minimising materials and practices.
   - 6.1 Sustainable Construction Cross-Sector Forum
   - 6.2 Carbon and waste measurement tools
   - 6.3 Commercialising environmental research for construction
   - 6.4 Environmental performance measures for the sector

INNOVATION

7. **Advanced construction ecosystem (Goals 1, 3, 5, 6)**
   To accelerate innovation ranging from incremental business performance improvement to disruption and value creation.
   - 7.1 Construction Digital Boost 2.0
   - 7.2 A collaborative innovation eco-system*
   - 7.3 Supporting innovation focussed regulatory reform
   - 7.4 Innovation investment strategy*
   - 7.5 Innovation Accelerator and Piloting*
   - 7.6 Advanced Construction New Zealand Study Tours

EMERGING ISSUES & OPPORTUNITIES

8. **Response to emerging issues and opportunities (Goals 1, 3)**
   To bring the industry and government together to navigate and manage emerging issues and opportunities in order to create space for transformation.
   - 8.1 Emerging and Topical Issues and Opportunities Bulletins
   - 8.2 Accord Forum 2.0

ENABLERS

KNOWLEDGE

9. **Beacons (Goals 1, 2, 3, 4, 5, 6)**
   To shine a light on new and innovative approaches that put the Accord's principles into action and inspire others to embrace change.
   - 9.1 Beacons 2.0
10. **Data, information and insights to assist decision-making (Goals 1, 3, 6)**
    To enable the use of data and information for sound decision-making across the sector and to steer the work of the Accord.
    - 10.1 Construction Futures Think Tank
    - 10.2 Public and private pipeline development
    - 10.3 Construction Digital and Data Roadmap

NETWORKS

11. **Creating and leading networks (Goals 1, 2)**
    To convene peer networks, advisory groups and platforms that enable sharing, learning and alignment.
    - 11.1 Construction Leadership Summit
    - 11.2 Peer-to-Peer Advisory Platform
    - 11.3 Accord Network 2.0

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*Denotes integrations with Forestry & Wood, Advanced Manufacturing or Digital Industry ITPs (Industry Transformation Plans)

Construction Sector Accord / Industry Transformation Plan – FY22 – FY26

- $37m approved in 2022 budget for 3 year Accord 2.0 ITP

- Callaghan Innovation selected as Key Partner in ITP Focus Areas (approved by Cabinet in June 2022):

- **Innovation**
- **Environment**
- **Knowledge / Advanced Construction**

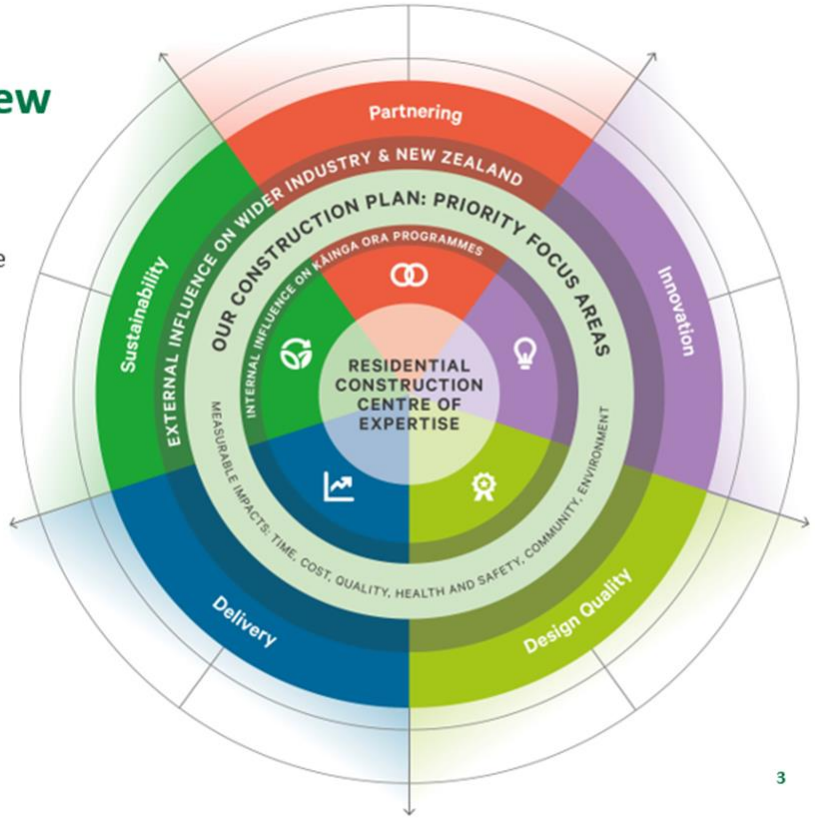
- These 3 Focus Areas include **16 initiatives** that Callaghan Innovation could potentially support

- Scoping and contracting will start in Aug 2022

Kāinga Ora – Callaghan Innovation – Partnership Agreement

Building Momentum overview

1. **Shift in behaviours** – towards greater trust, transparency and genuine partnership
2. **Industry leadership –** to influence and change the housing and construction industry
3. **Delivering more with better outcomes:** Our 5 key priority areas:
   - Partnering
   - Innovation
   - Design Quality
   - Delivery
   - Sustainability



Kāinga Ora
Homes and Communities

Manaakitanga
Mahi Tahi
Whanake

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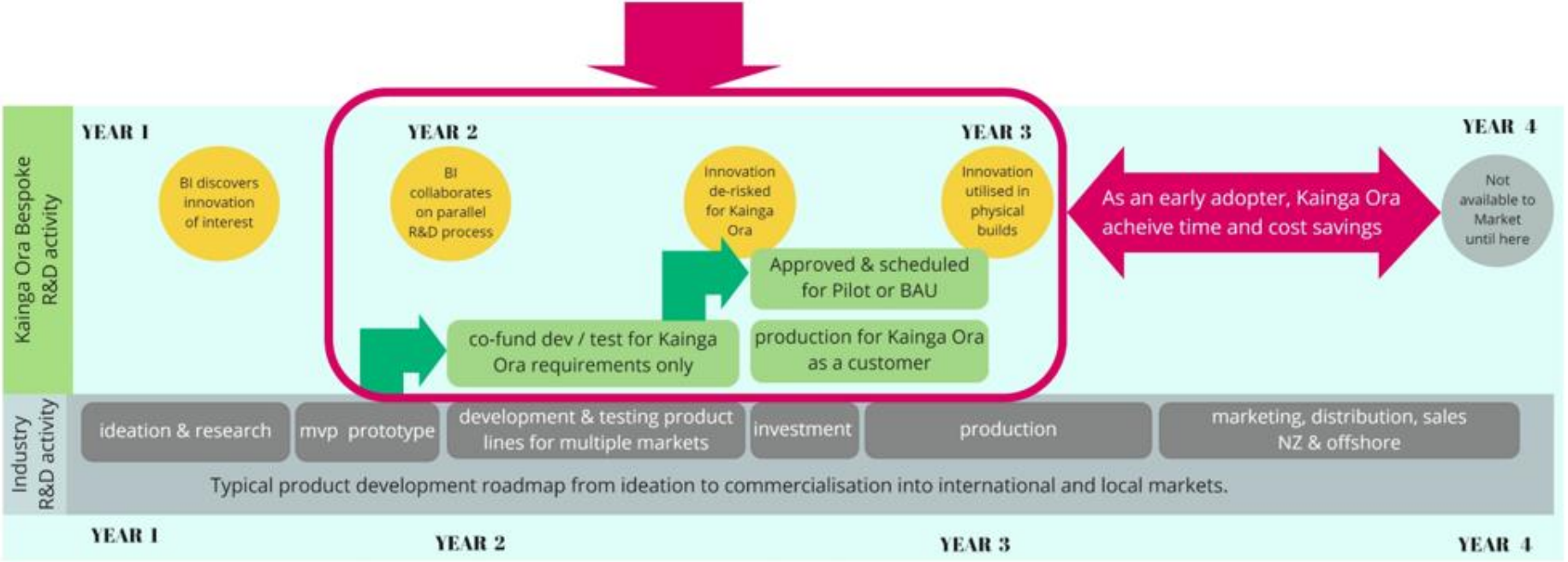
Our Research and Development Acceleration Model



Kāinga Ora
Homes and Communities

fast tracking R&D ...

The Māori Housing Initiative -
In Discovery Phase

Iwi Housing – Callaghan Innovation intervention [DRAFT]

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Low, Medium and High density housing

Whenua and economic development:

Iwi own c.60% of NZ forests

Own 1.4m hectares of land ready for immediate development

Own some natural resources that can be used for innovative building materials (e.g.: pumice)

Opportunity to partner with Scion:

- Forestry management
- Remote sensing & AI
- Robotics & Automation
- Wood processing
- Silicate treatment
- Waste-to-value (circular economy)

Whenua and economic development:

- New financial services: Banking, mortgages, business loans, insurances...
- Capability and capacity development
- New Māori businesses
- More employment and training (Future Workforce)

Opportunities:

- Wood processing
- Advanced Manufacturing
- New Māori business creation
- B-2-B partnerships
- B-2-G support (e.g.: PGF)
- Prefabrication capabilities
- Exports

Opportunities:

- Smart materials
- Waste-to-value (circular economy)
- New building systems
- HVAC
- Business Model Innovation (ten Types)
- B-2-B partnerships

Potential success outcomes for Iwi:

- ✓ Māori-designed (indigenous)
- ✓ Renewable energy (e.g. Hylink, solar, wind, geothermal)
- ✓ Smart, connected homes
- ✓ Healthy (HVAC), affordable
- ✓ Healthy, thriving communal spaces – schools, elederly care...
- ✓ International showcase

Opportunities:

- Multiple R&D in CleanTech, Prefabrication, Advanced Materials, Advanced Manufacturing, IoT & Data
- Fire, accoustic, seismic resistance
- Large waste-to-value streams (currently minimal)
- Business Model innovation
- Exports
- Ecosystem innovation and international partnerships

Māori businesses – Map existing capabilities, explore opportunities, establish B-2-B and B-2-G partnerships + Investors [R&D / innovation and commercialisation]

Capability & capacity development – Map existing, explore opportunities from gaps, invest and partner [Māori employment and training]

Callaghan Innovation ONE-Team (Cross-functional + industry secor partners – BRANZ, Scion, Kāinga Ora, HUD, Unis, local councils)

Value Chain

Supply Chain

Over-the-horizon technology disruption in Construction

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Why innovate ?

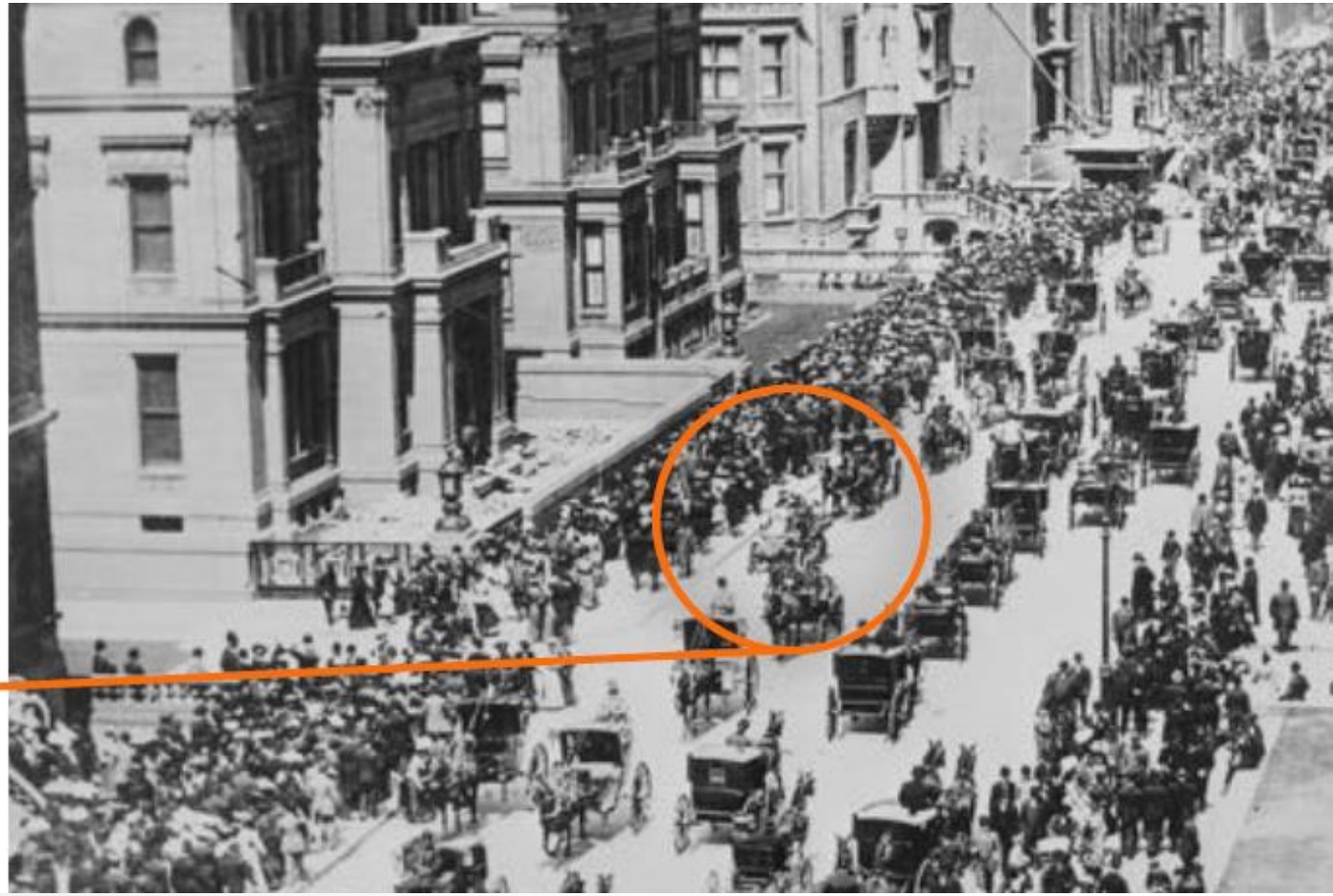
5th AVE NYC

1900

Where is

the

car?



Why innovate ?

5th Ave New York City, March 23, 1913

1913: Where is THE HORSE?

Photo: Easter 1913, New York. Fifth Avenue looking north. George Grantham Bain Collection

Source: shorpy.com

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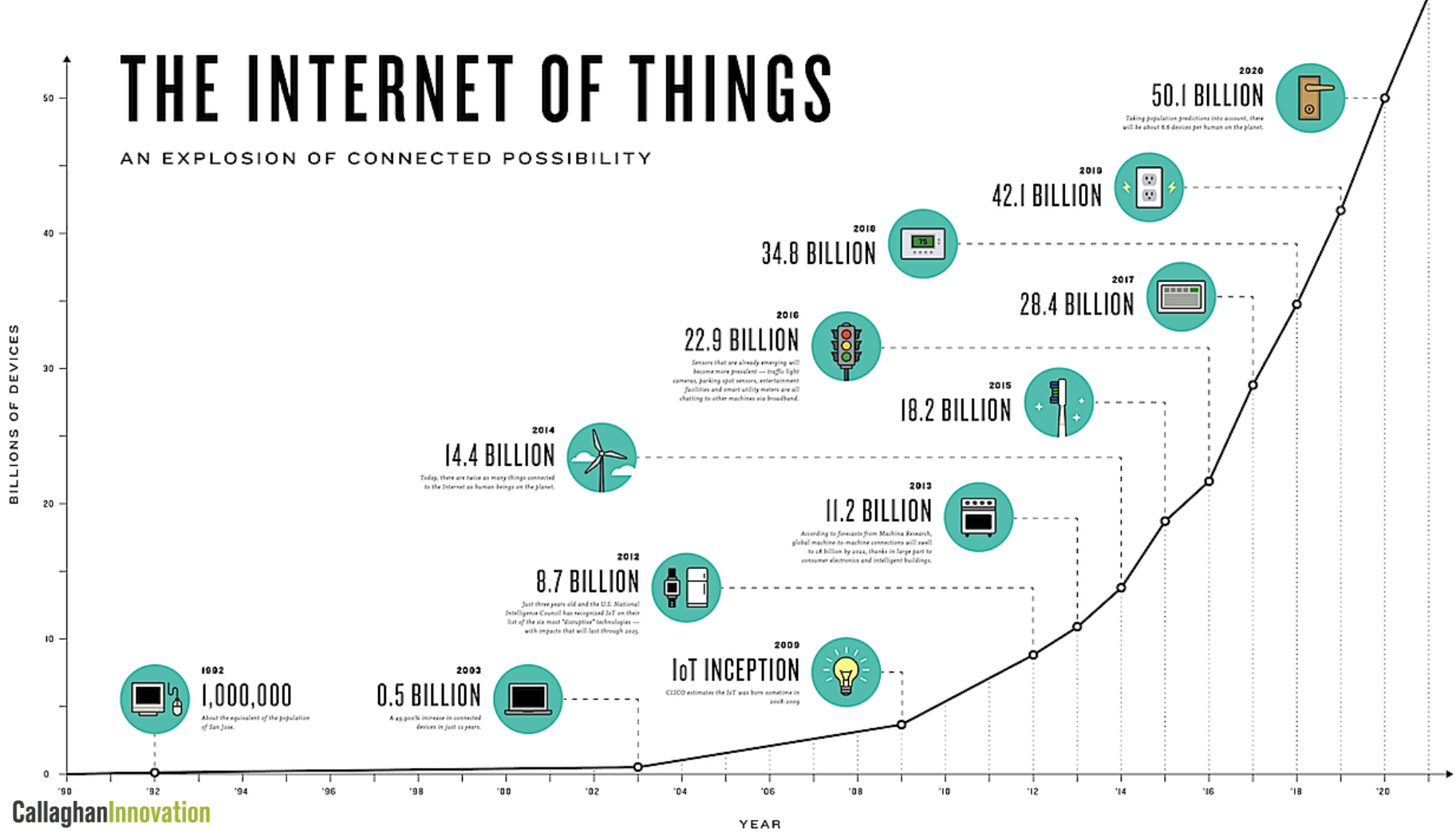
THE INTERNET OF THINGS

AN EXPLOSION OF CONNECTED POSSIBILITY



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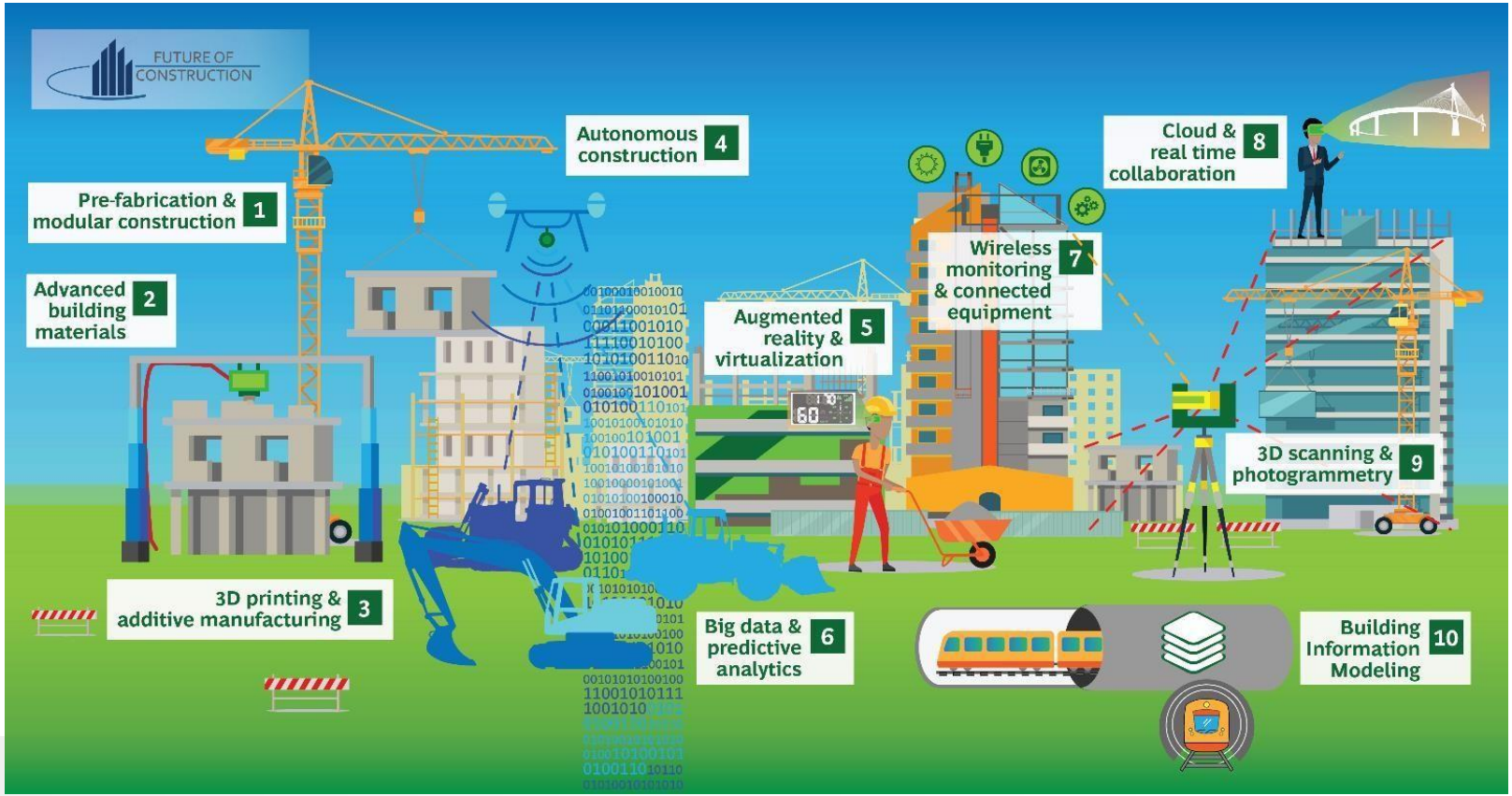
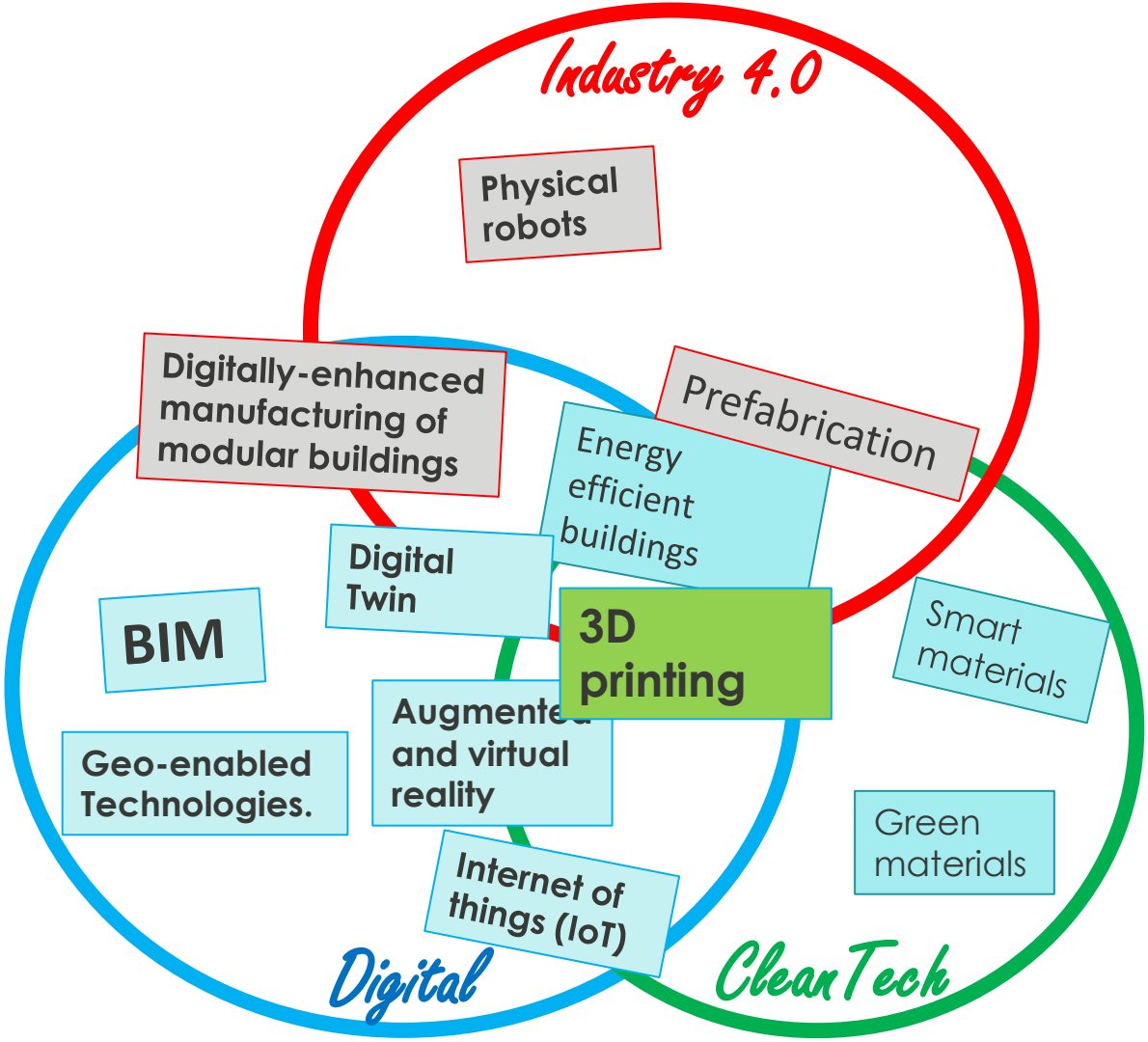
Top 10 Disruptive technologies in the Construction sector



Technology Convergence



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We help businesses **activate innovation** and **grow faster** for a **better New Zealand**

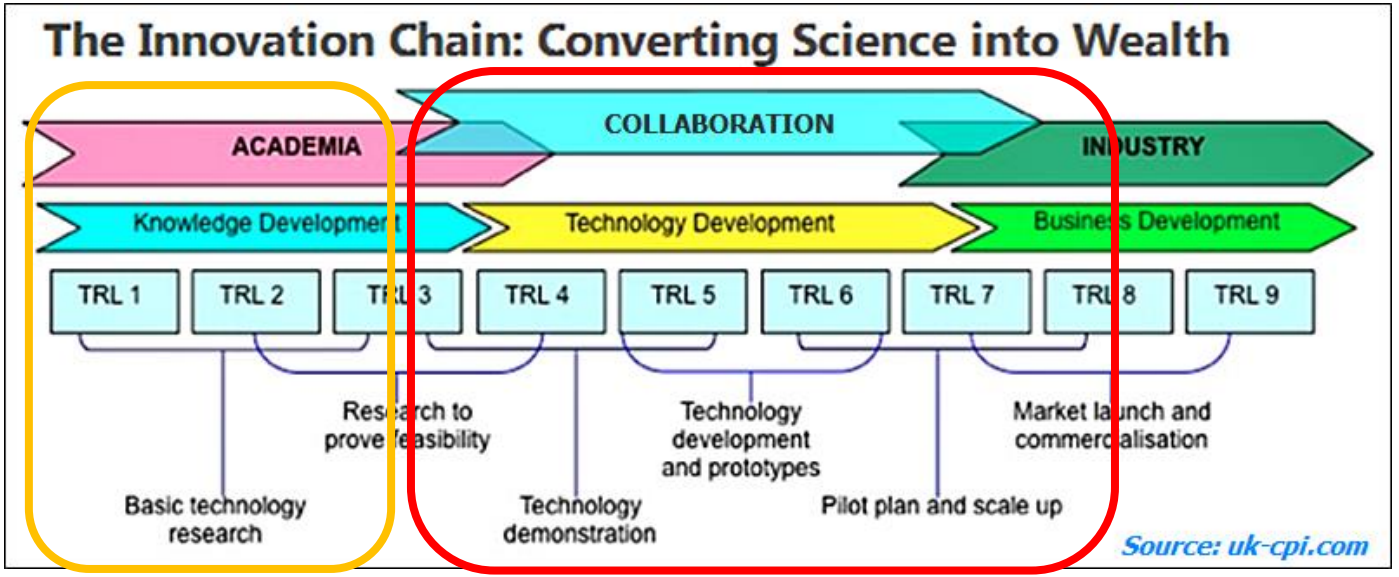
R&D / Innovation + Commercialisation

R&D is…

Creative work that is carried out **systematically** with the goal of increasing **knowledge**, is **original**, and has **investigation** as its primary objective

SIF: TRLs 1 to 3 – Deep-tech

TRL 4 to 7 – mostly



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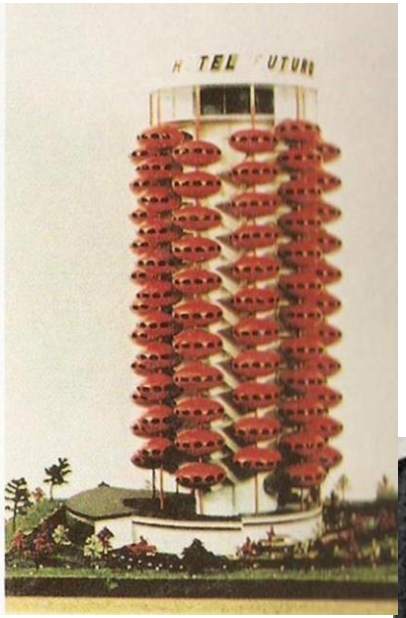
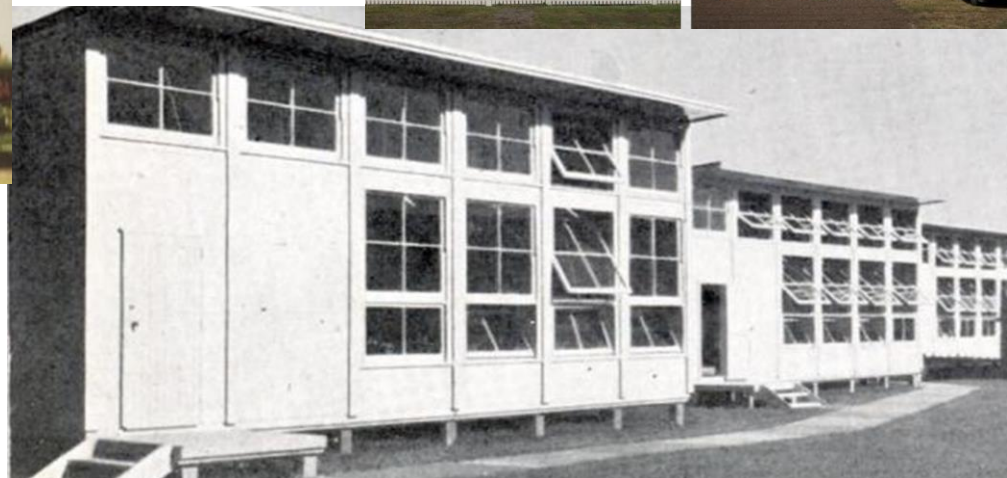
Technology Insights

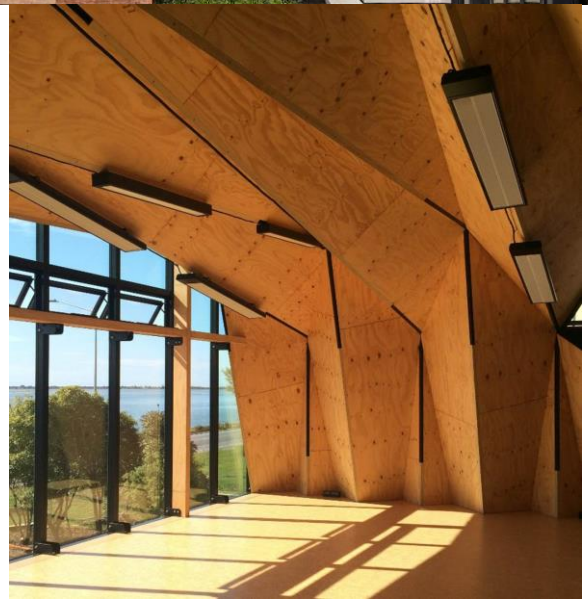
Manufacturing & Advanced Automation

Prefabrication / Off-Site Manufacturing of yesterday





Prefab / OSM of today



Modular construction - Benefits

- **Speed of construction:** Can be 30 – 50% quicker vs traditional methods
- **Minimal impact on the client:** Up to 80% of the work is carried off-site
  Can be automated, be safer and improve quality: Building modules uses more repetitive, highly specialised tasks
- **Sustainability:** Generates less material waste, materials can be re-used, reduces energy consumption and lowers on-site pollution.

Prefab / OSM and technology convergence

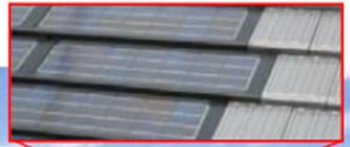
High performance insulation

Reduce heating and cooling load

Fuel cell

Reduce CO_2 emission by fuel cell cogeneration system

Reduce CO_2 emissions by solar PV generation



Cooling by bunch of trees

Sunny and airy design

Living normally in a comfortable home with CO_2 ± zero!

Energy-efficient equipment

LED Lighting

High-efficiency air conditioner

Energy-efficient Multi-functional toilet

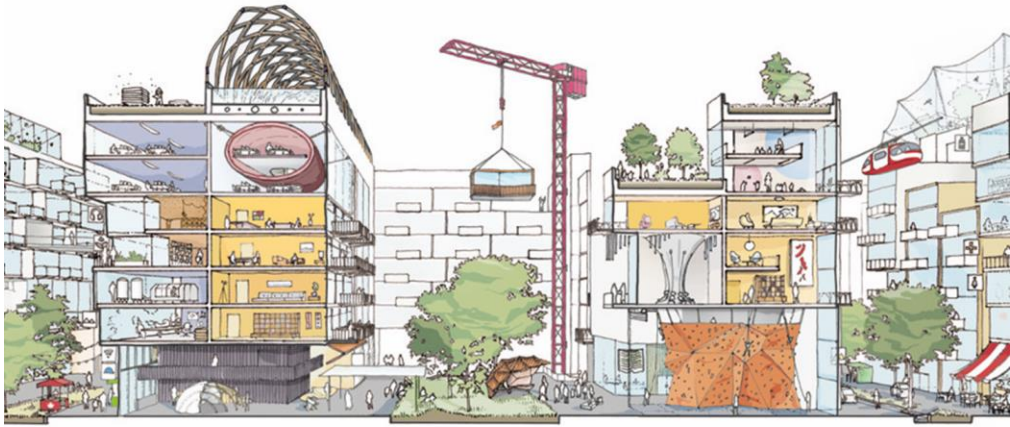
Reduce power consumption

Quiz

In Europe, in 2019:

- **11% of the entire economy was automated**
- **27.1% of the Manufacturing sector was automated.**

What's the percentage of the Construction sector in Europe that was automated as of June 2019 ?



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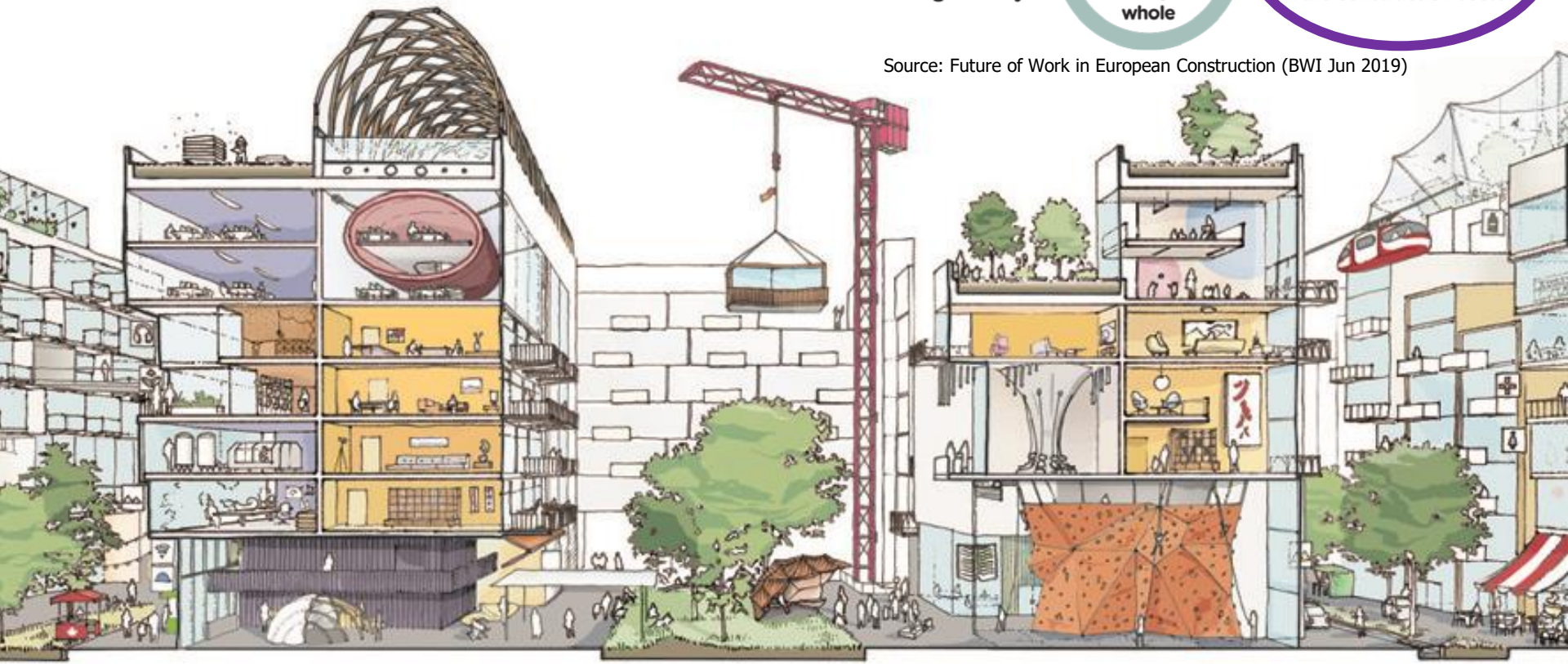
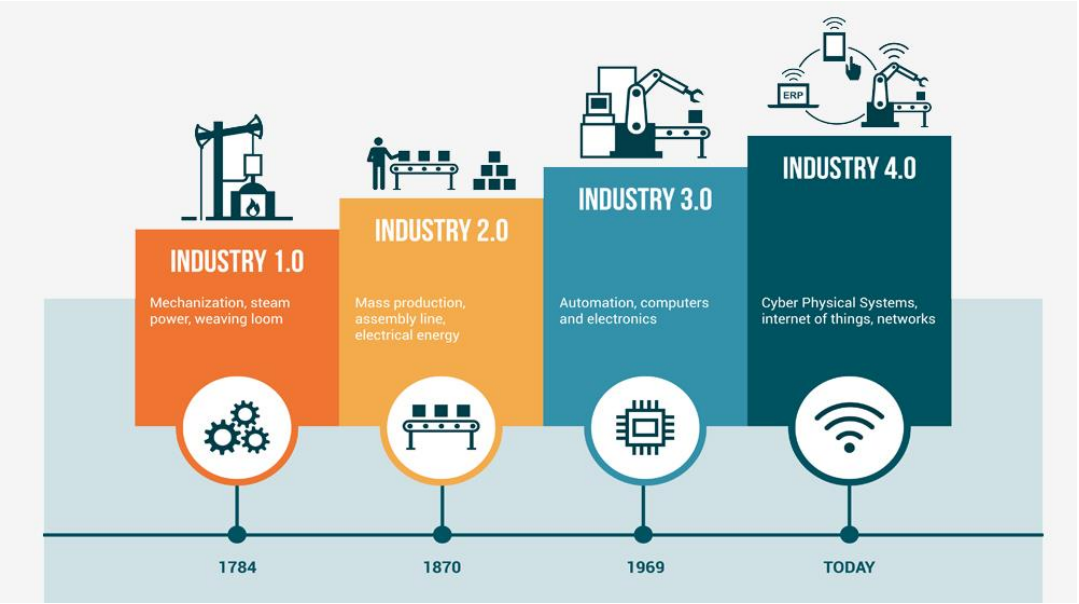
Quiz

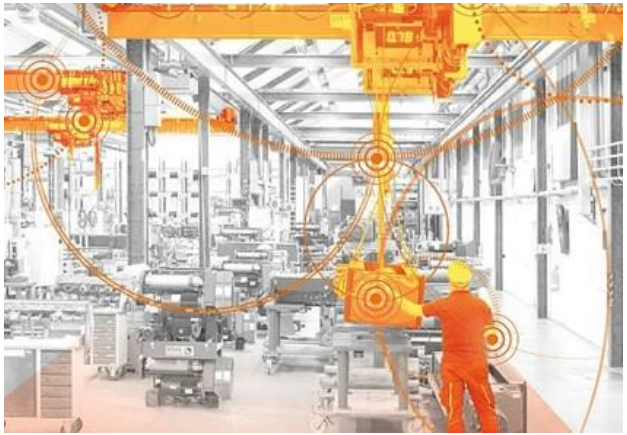
Automation in construction



Source: Future of Work in European Construction (BWI Jun 2019)

Significant growth in automation technology forecasted





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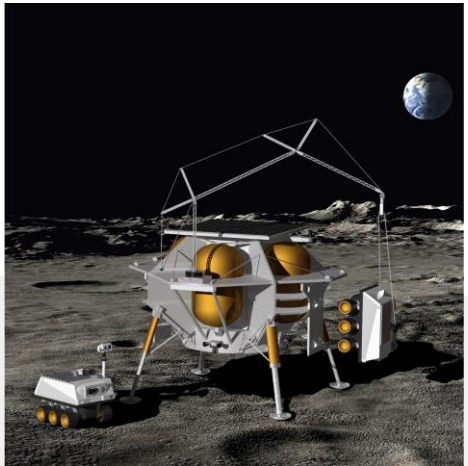
Automated cranes

- World-first autonomous crane system
- IntSite (Israel) – Start-up
- Powered by Computer Vision, AI / Machine Learning
- NASA Smart Crane (LSMS)

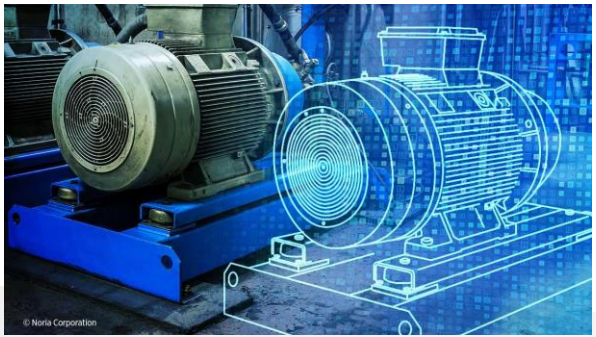
- Goals – Increase:
  - Safety
  - Productivity
  - Efficiency

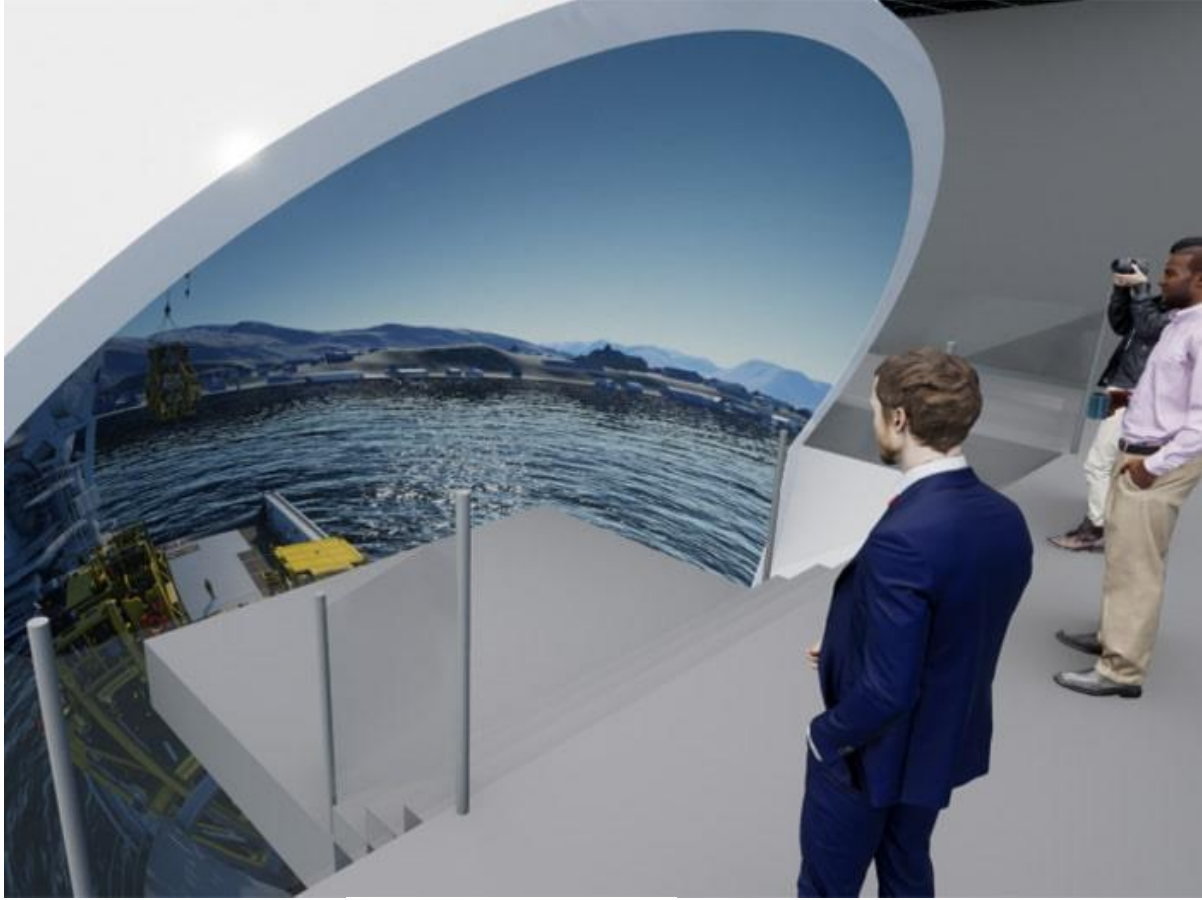


Crane Simulator

Use of Digital Twin

- Off-shore installation vessels
- Belgium-based Jan de Nul Group
- Staff training (simulate complex offshore installations in severe conditions in a safe environment)





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Jan De Nul GROUP

Source: Marine Log (July 2022)

3D Concrete Printing

Europe's first fully concrete 3D printed house Eindhoven (The Netherlands)

- **Building-code compliant load-bearing walls**
- **Thermally-efficient**
- **Smart-home**

- ✓ **Fast construction**
- ✓ **Cheaper**
- ✓ **Minimal waste**
- ✓ **Significant design freedom**

Eindhoven University of Technology and the Vesteda housing corporation partnership

Source: The Guardian – Saturday 1st May 2021

3D Concrete Printing

Business Challenge

3D concrete printing is an emerging technology that combines digital technologies and insights from materials technologies to allow free-form construction without the use of formwork.

What we do

We're developing the 3D concrete printer, investigating the mechanical properties and durability of the printed structure.

Business outcome

We aims to print the 1st 3D printed building in New Zealand.

It will showcase the advantage of this disruptive technology and de-risk the commercial application.

QOROX
INFINITE CONCRETE STRUCTURES

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Multiple B-2-B and B-2-G collaboration

Disclaimer: The image shown is for illustration purposes only
Image: Ammar Abbas

3D Concrete Printing

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QOROX
INFINITE CONCRETE STRUCTURES


M
3D-PRINTED
BRIDGE

Steel 3D printing

MX3D Bridge is located in the Red Light District in Amsterdam

Opened July 2021

Collaborative Robots

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

School of Advanced Manufacturing and Prototype Design - AMPED

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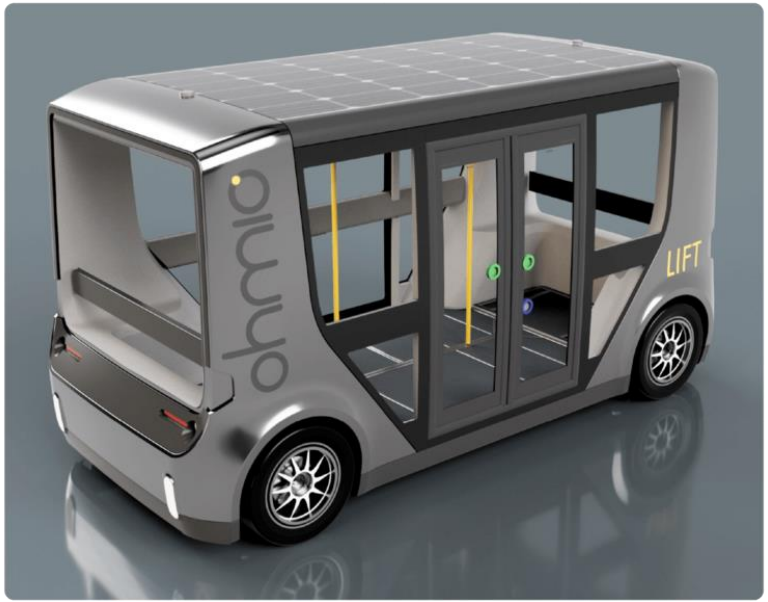
Autonomous Construction



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Te Pokapū Auaha o Aotearoa

Technology Insights

Engineered Timber

Sustainable buildings – Engineered Timber

14-storey wood building (2018)
Mjøstårnet by Voll Arkitekter in Brumunddal, Norway

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Sustainable buildings – Engineered Timber

Number of business in NZ increasing their innovation in Engineered Timber

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TIMBERLAB
NATURE ENGINEERED


FORTUNE

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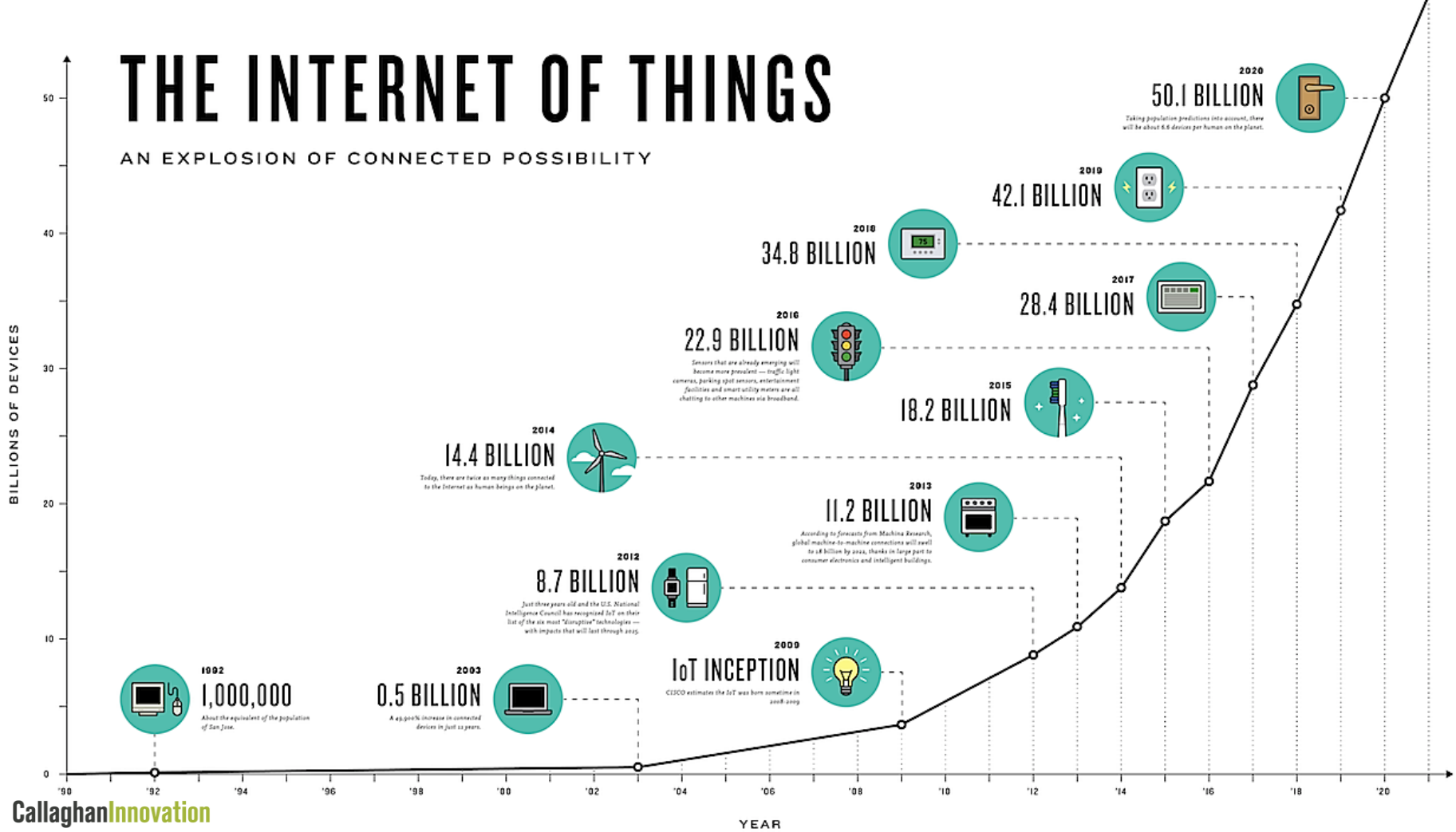
Te Pokapū Auaha o Aotearoa

Technology Insights

Digital Tools

THE INTERNET OF THINGS

AN EXPLOSION OF CONNECTED POSSIBILITY



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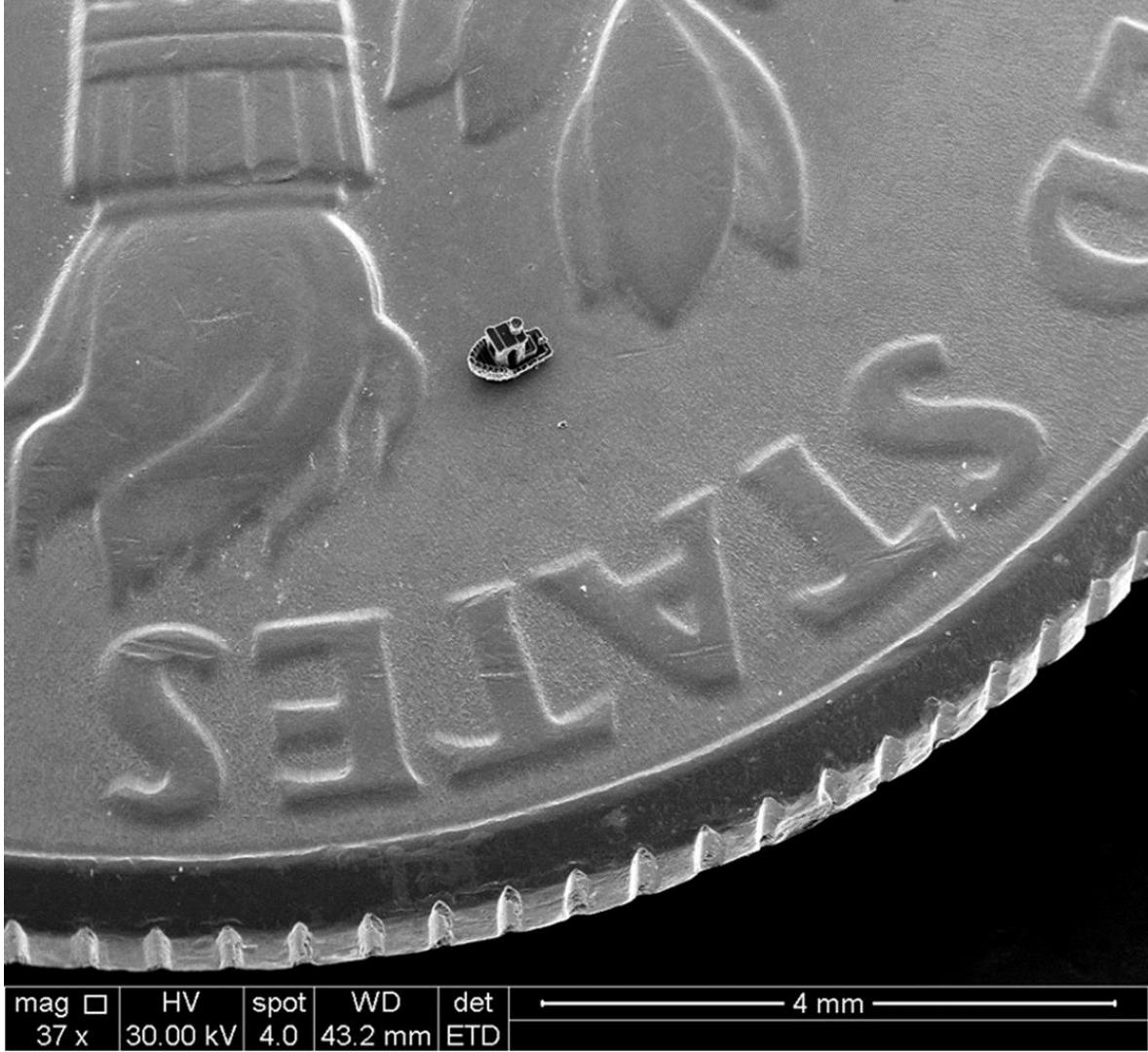
MicroMaker

3D-printing of Microstructures



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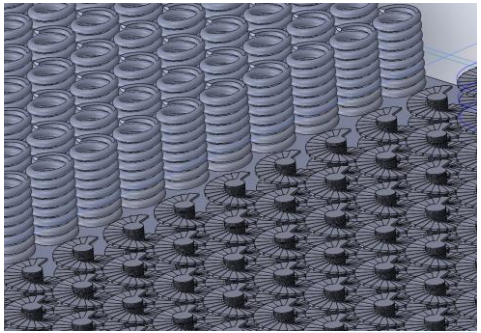
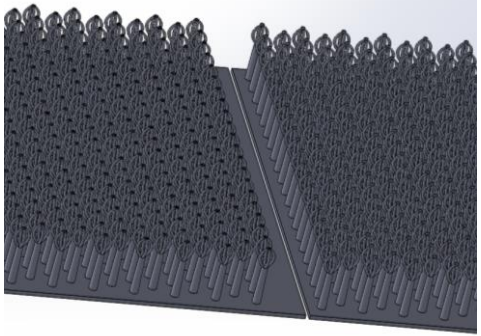
Combing Microfabrication with Molecular Sensing and Smart Composites

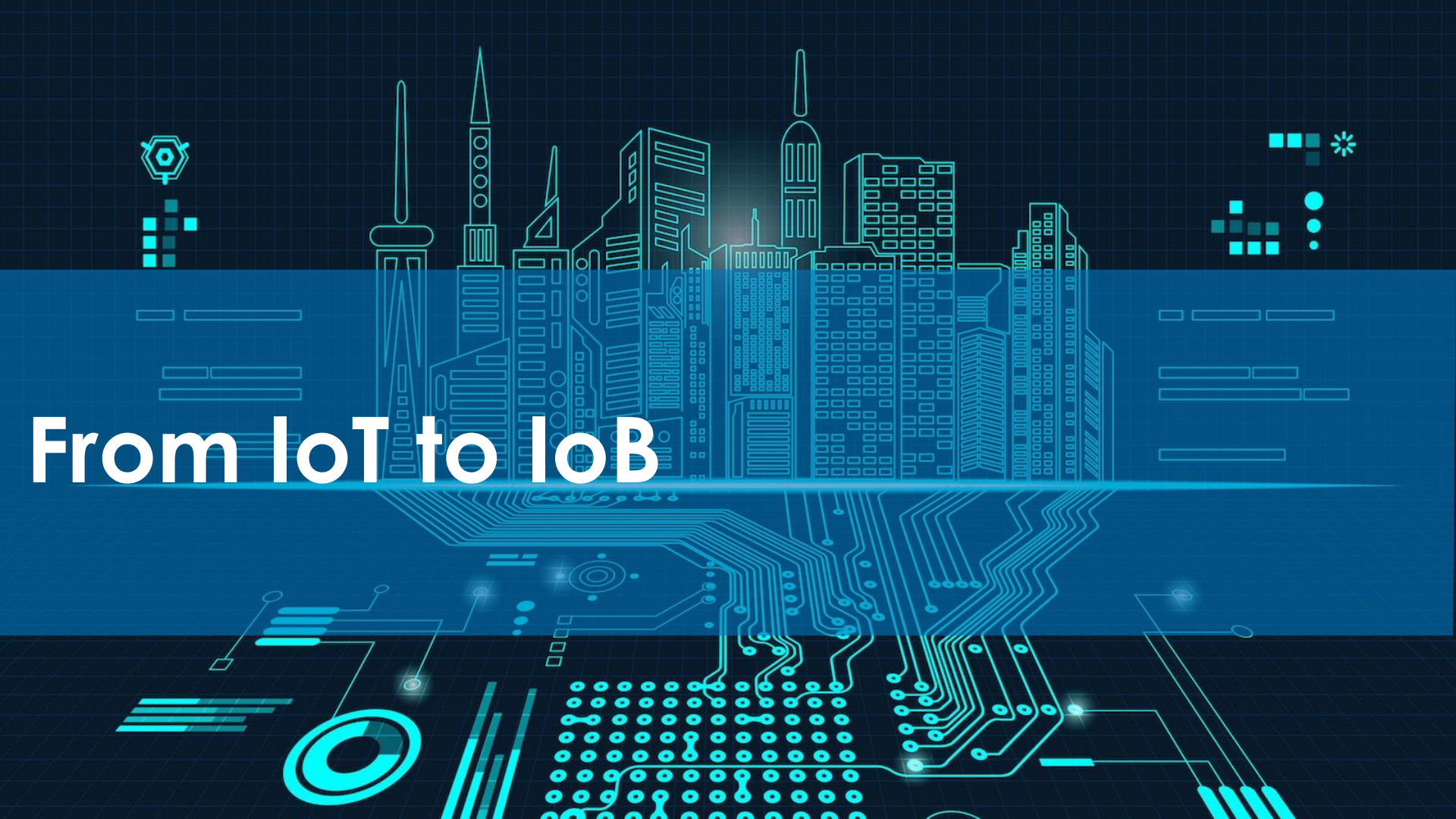




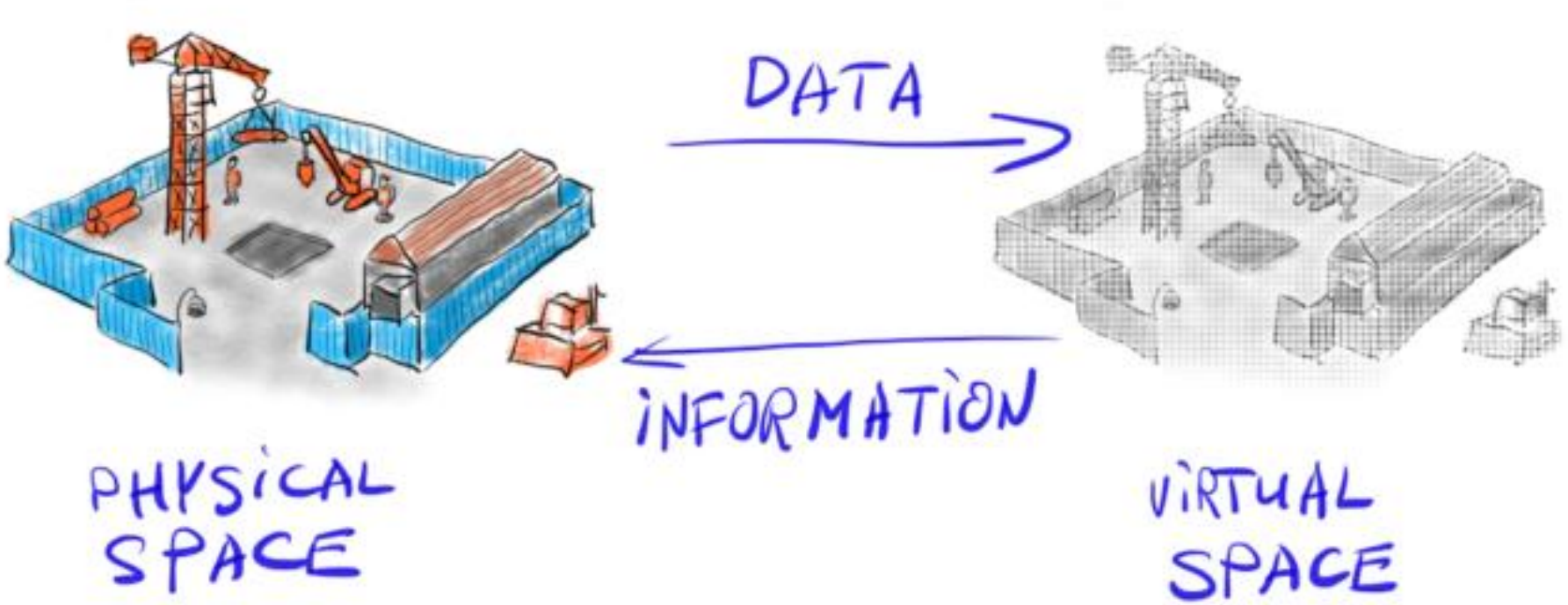
IoT in Smart Home Automation

37% of US homes have at least one IoT device

Optimised by AI


From IoT to IoB

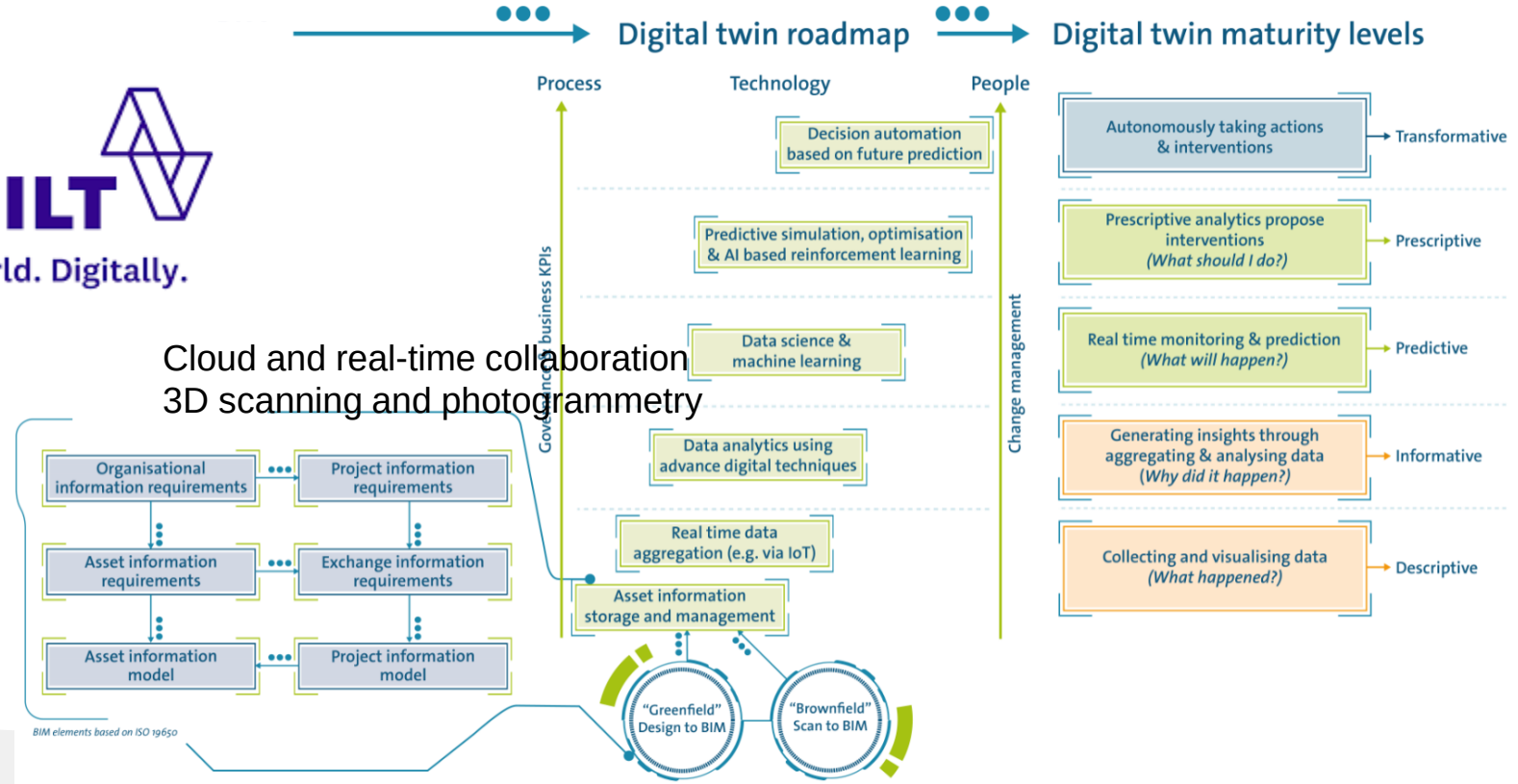
Digital Twin



BIM, Cloud / Real-time collaboration, 3D scanning and photogrammetry

ASBUILT
A Smarter World. Digitally.

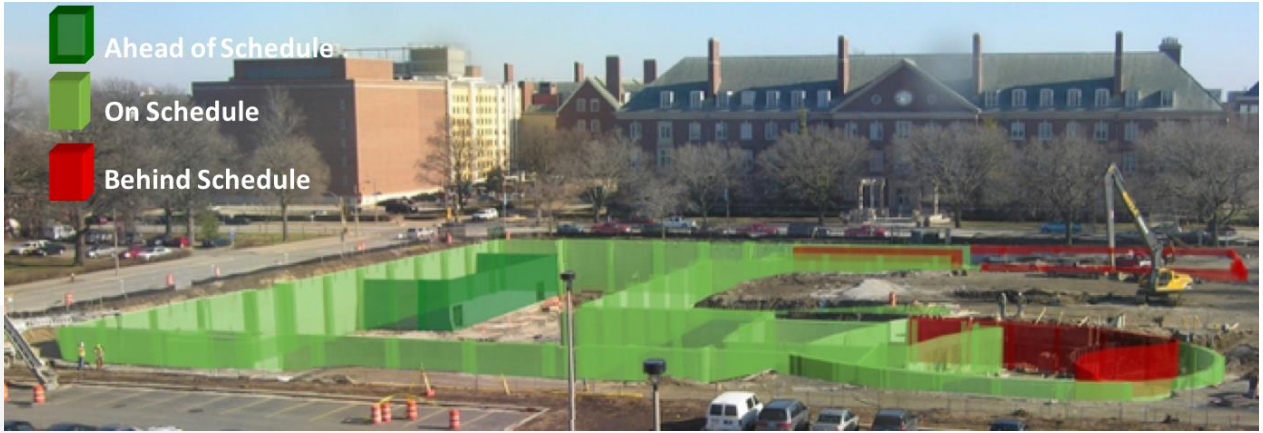
Cloud and real-time collaboration
3D scanning and photogrammetry



Augmented Reality

- AI / Machine Learning
- Data Vision
- Predictive analytics

- Significant productivity increase
- Lower costs / Reduced time



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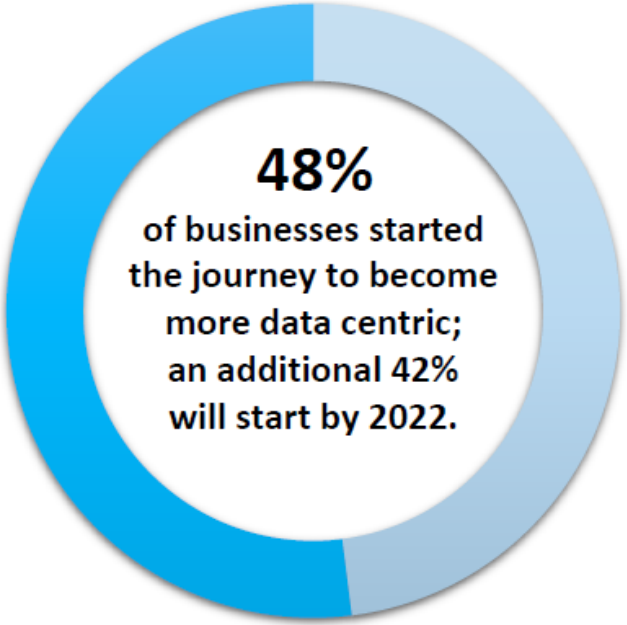
Enterprises Rapidly Embracing Data as a Core Strategic Resource



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Technology Insights

Waste Minimisation and Circular Economy

Quiz

How many litres of water are needed to create one single cotton t-shirt ?

Quiz

The building and construction industry accounts for -

Around **36%** of global energy consumption

40% of global direct and indirect GHG emissions

About **25%** of global water consumption

Textile – Waste-to-value

Usedfully®

- Fibre-to-fibre upcycling
- Roading materials
- Other Construction materials

Cement – Waste-to-value

- NZ produces 10 millions tonnes of concrete p.a.
- 300K tonnes going to landfill p.a.
- Equivalent to 7 Sky Towers

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ENVIROCON
CAPTURING CONCRETE EXCESS

Construction Sector – CleanTech across LCA

Waste reused /recycled

Indoor environment

Energy efficiency

Building Materials

Off-site building

Fire, noise and earthquake resistance.

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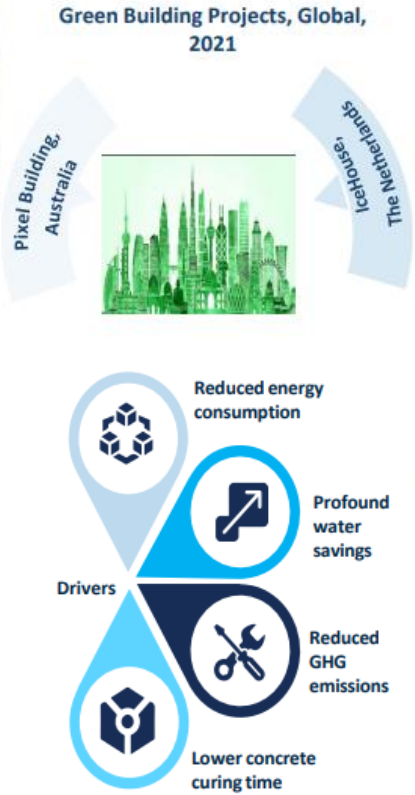
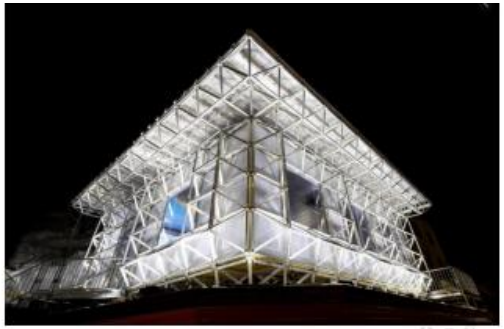
Sustainable buildings

The Pixel Building, Melbourne, Australia

- It is the country's first carbon neutral office building consisting of solar panels and vertical wind turbines to generate its own power.
- The building was constructed using recycled concrete, which contained 50% lesser embodied carbon as compared to conventional carbon.
- Renewable gas source with carbon intensity of 0.21 kg CO_2/kwh is used replacing the traditional Victorian brown coal based power electricity which had six times more carbon intensity, i.e., 0.34 kg CO_2/ kwh.





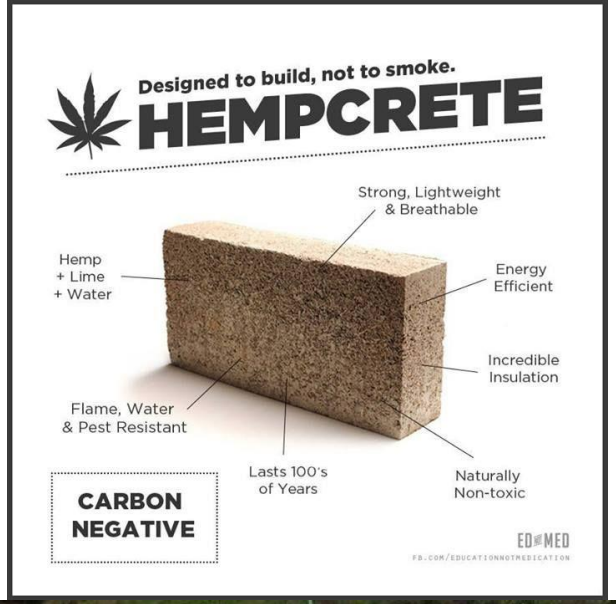
SABIC's IceHouse™, The Netherlands

- SABIC's IceHouse™ made use of 100% recycled materials, recovered aluminium and nano-gel-based sustainable insulating materials. These recycled materials have enabled the construction of cost-effective and energy efficient houses as they helped in 50% energy savings.
- The materials used have 250 times more impact resistance than mono-layered glass and other traditional materials used in conventional construction.

Source: Frost & Sullivan; Image Source: Google Images

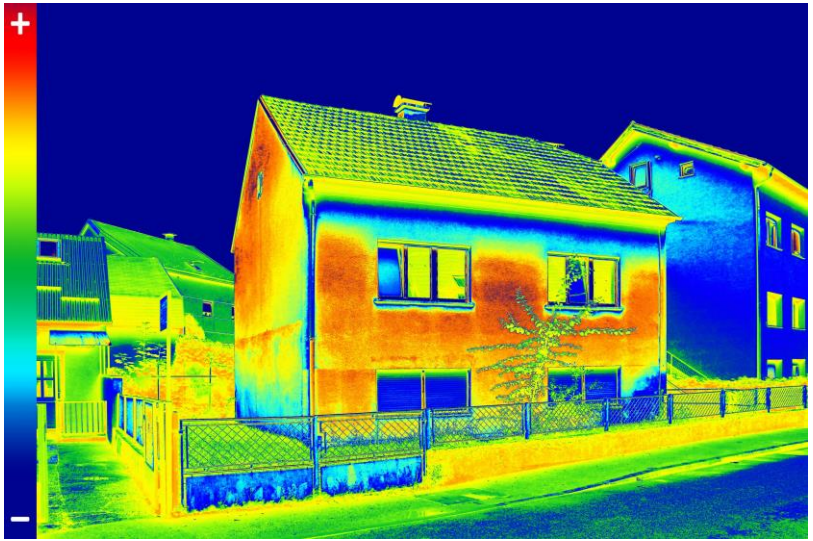
Reduced carbon cement

- Cement (and concrete) have a large carbon footprint due to the manufacturing process
- By incorporating other materials the carbon footprint of concrete can be reduced significantly
- Examples include natural pozzolans
- Alternative concretes such as hempcrete and timbercrete
- Alternative binders are also being investigated to reduce the carbon footprint, such as Magnesium



Insulation

- Sustainability in insulation is becoming increasingly important
- A range of natural insulations are currently available (wool, hemp)
- Recycled plastic as insulation
- **What might next generation insulation look like?**



Recycled Plastic

- Recycled plastic has been used as a modular building material
- Houses have been built from 600,000 PET bottles
- Bricks of recycled plastic

Ferrock

- Ferrock is an example of an alternative to cement
- Its created from waste steel dust and silica
- The iron reacts with CO2 and rusts to form Ferrock

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Waste-to-Value

TORRCOAL
Bio-Carbon Solutions

ArcelorMittal

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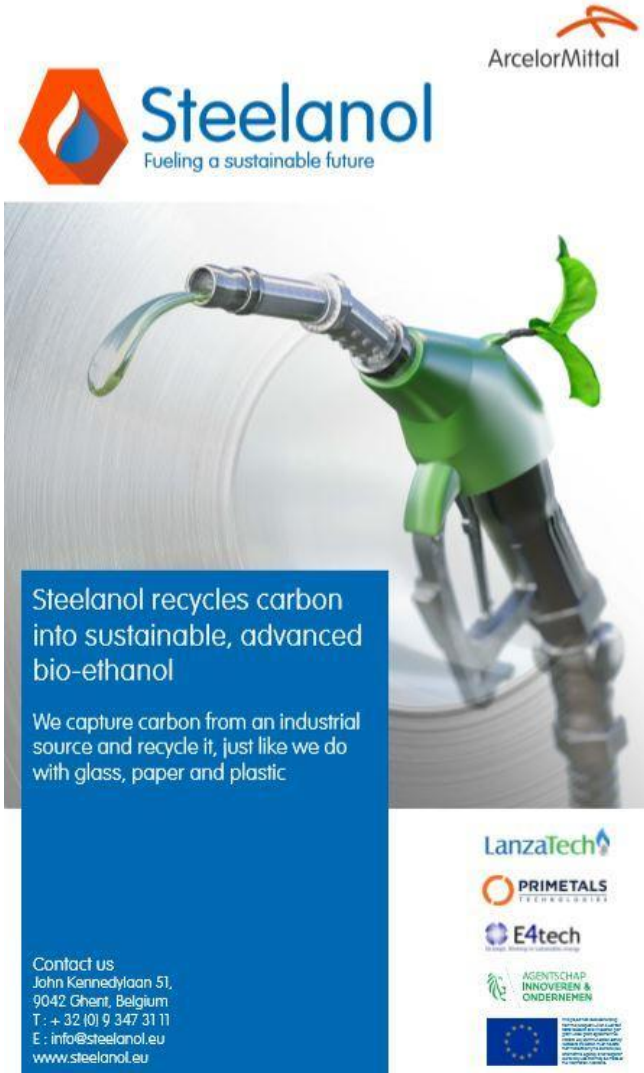

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Technology Insights

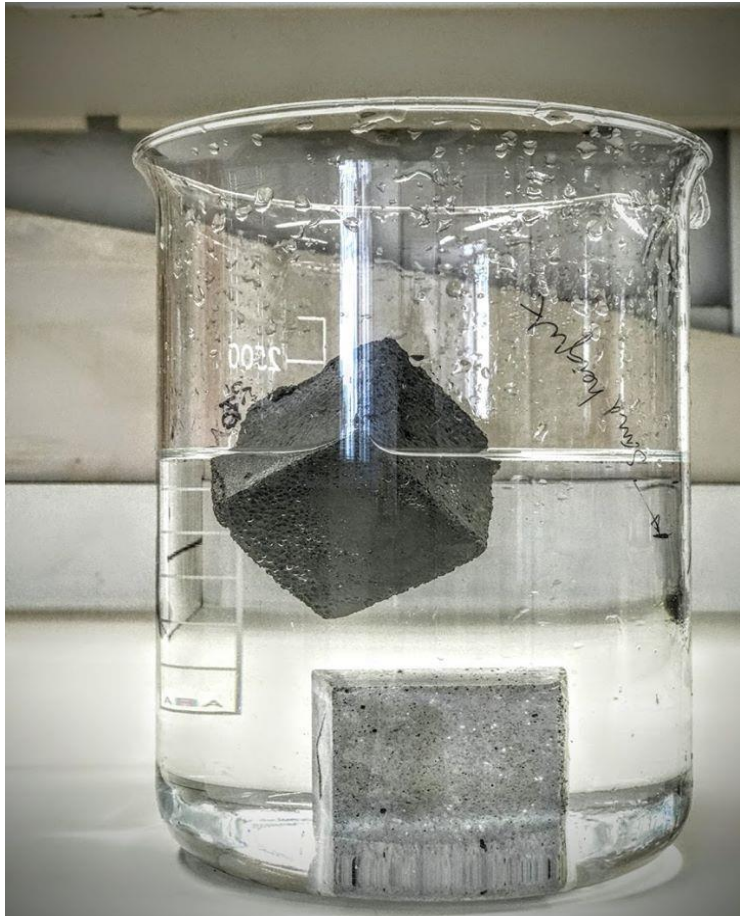
Decarbonisation of Buildings

Quiz

What is the world's 2nd most used material in the world (after water) ?

Concrete - 2nd most used substance in the world after water

- First used by the Romans
- 5 bn tonnes cement produced globally p.a.
- 8% total carbon emissions in the world
- Only coal, oil and gas produce more greenhouse gases
- Betolar in Finland (80% carbon reduction in concrete)
- Neocrete here in NZ doing R&D in low carbon concrete as well
- Huge demand locally and internationally



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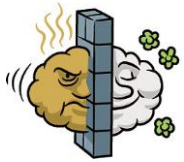
BETOLAR

NEOCRETE
REDEFINING CONCRETE

Depolluting Concrete – Deep-Tech



Background

- The problem of **deteriorating air quality** in urban areas has become one of the major challenges of recent times.

What we do

- Incorporating the **photocatalyst** into concrete.

Business outcome

- Dirt, soot, mould, bacteria and chemicals that cause odours are among the many substances that can be decomposed by photocatalytic concrete.
- It also helps to promote aesthetic endurance, keeping the structure looking like new over time.

Photo Credit: Expo-2015_palazzo-italia_Milano

Quiz

Concrete is the no.1 biggest contributor of GHG emissions in the Construction sector.

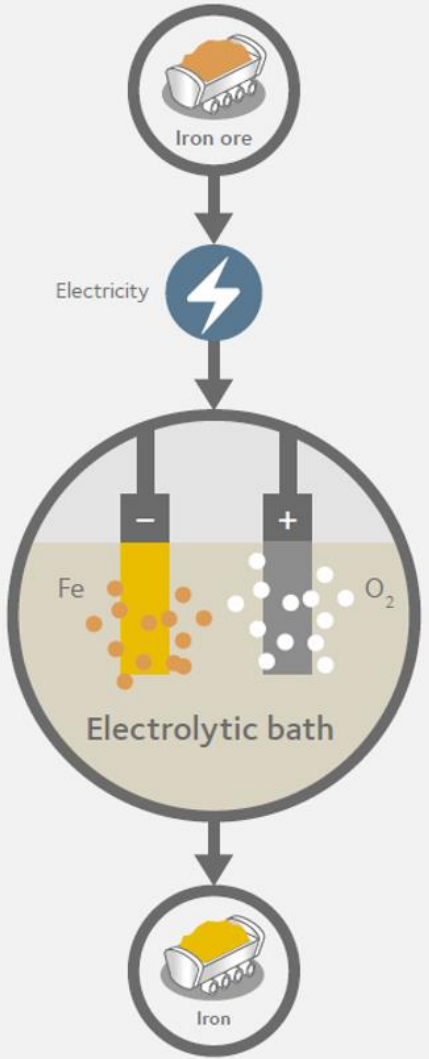
Which material is the 2nd biggest contributor, accounting for 7% of total emissions globally ?

Quiz

Steel

Low-carbon steel

- Steel production by electrolysis (without CO_2 emissions)
- ArcelorMittal (LUX), Siderwin project, bringing together 12 European partners.
- Launched in October 2017 – pilot from a few kilos to hundreds of kilos of iron metal.
- Long-term step-change.



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ArcelorMittal

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Technology Insights

Nature-based solutions & Biodiversity

Green roofing

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Biodiversity regulations - Urbanisation

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Technology Insights

Climate adaptation and resilience

Quiz

What is being used to put out this fire ?

Quiz

Sound waves

The **acoustic extinguisher** works by using **sound waves**:

- A type of pressure wave to push oxygen away from the source of a flame and spread it over a larger surface area.
- This breaks the fire combustion triangle made up of heat, fuel, and oxygen, the three elements required for a fire to burn.

Droughts and bush fires are exacerbated by Climate Change

Casing increasingly major impact to wildlife and nature

Also impacts the built environments

Water is scarce

Foam is toxic and expensive


Vocativ Shorts
Airborne
Bass Speakers
Fight Forest Fires

Climate resilient designs

Anatomy of a High Wind & Hurricane Resistant Home

deltec HOMES

deltechomes.com
800.642.2508

All aspects of a Deltec home are ingeniously designed to work as a system, making it the smartest home you can build for high wind areas.

A. SHAPE

Aerodynamic circular building envelope works with nature, not against it

1. Wind can't build up enough pressure on any side to cause a structural failure
2. Reinforced clear span roof is at optimum pitch (6/12) for wind deflection and reduced lift
3. Circular structure transfers environmental loads most efficiently, with a high degree of redundancy providing extra resilience and performance during critical events

B. ENGINEERING

Creating a building envelope to resist high wind and provide safety to its occupants

4. Radial truss array in roof and floors work like spokes on a wheel
5. Potential energy from sustained winds is dispersed throughout the structure instead of building up in a single area

C. MATERIAL EXCELLENCE

Merging superior materials with a superior design results in a stronger and more durable structure

6. Machine rated 2400 psi framing lumber used in trusses and walls is twice as strong as typical framing material
7. Five Ply 5/8" plywood sheathing used instead of OSB on exterior walls, roof and floors strengthens the home and prevents flying debris from penetrating the structural envelope of the home
8. Reinforced windows with impact glass prevent wind and water from entering the home

E. SUSTAINABILITY

Utilizing products and construction techniques that enhance livability in the event of a prolonged power outage

12. Solar water heater provides uninterrupted hot water
13. Enhanced insulation maintains a more balanced temperature inside the home
14. High wind rated reflective metal roofs helps reduce radiant heat gain in the home
15. Passive solar design helps heat and cool the building through appropriate shading and window placement

D. CONNECTIONS

Emphasis on maintaining continuous load paths and strong connections between the roof, exterior walls, floor systems and foundation

9. Oversized truss hangers keep roof system anchored to walls
10. Walls have multiple construction ties to the floor system for structural stability and to transfer shear forces
11. Continuous metal strapping from roof trusses to foundation helps maintain structural stability

Climate resilient designs

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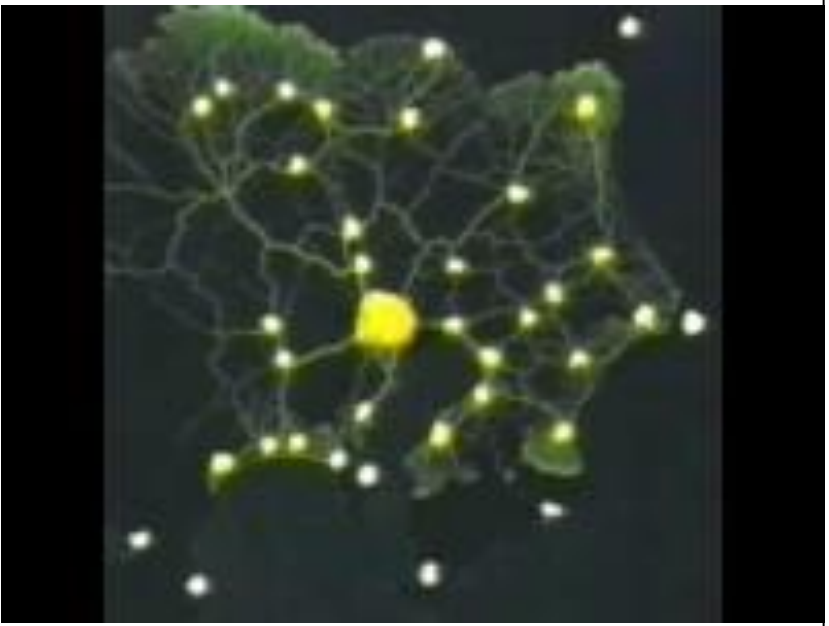
Te Pokapū Auaha o Aotearoa

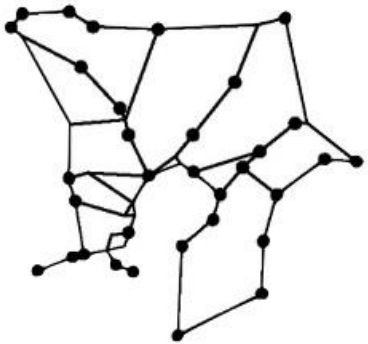
Technology Insights

Materials

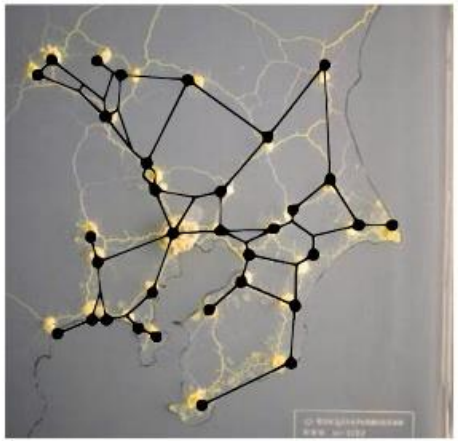
Biotech generative design



Actual Rail Network



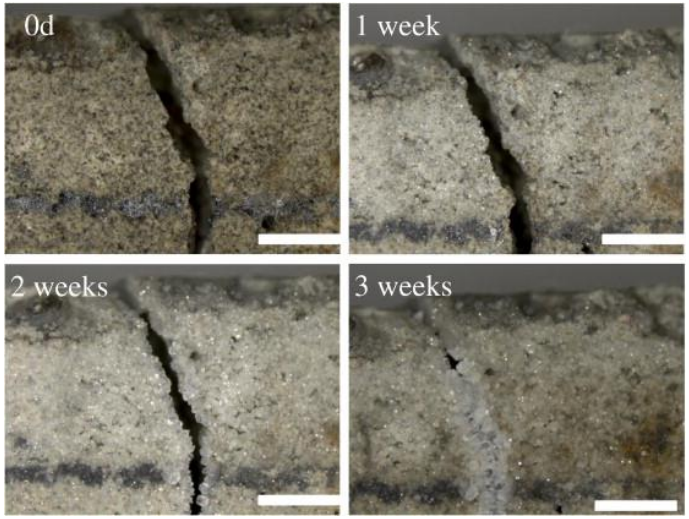
Slime Tubule Network

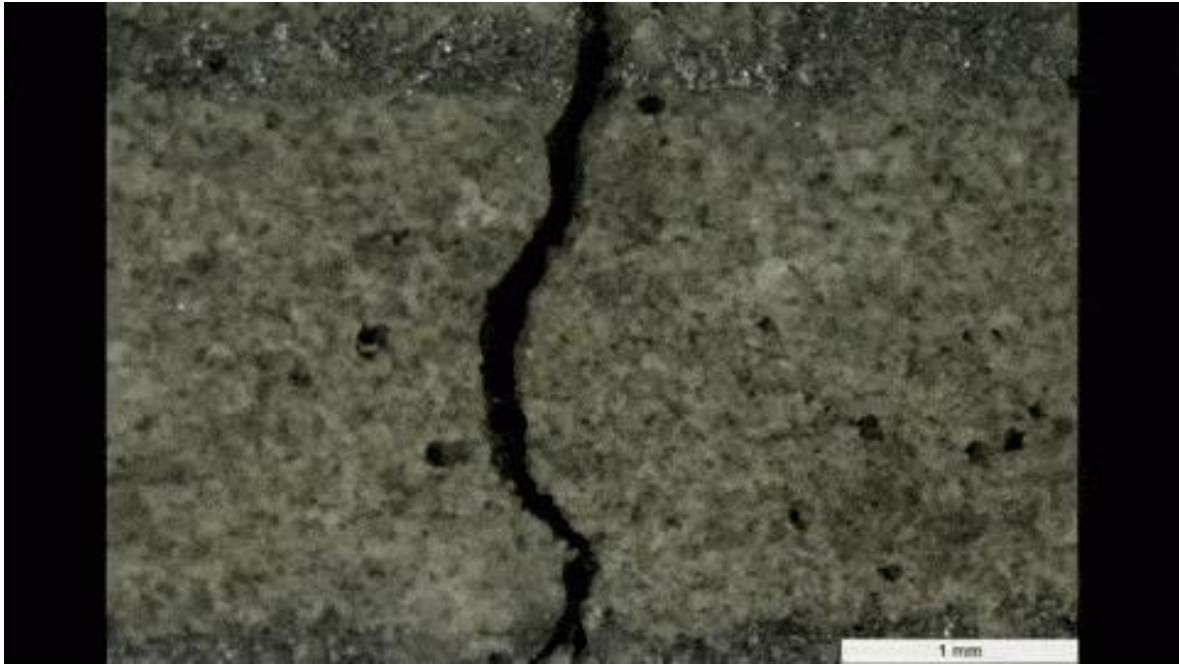


- efficiency
- fault tolerance
- cost

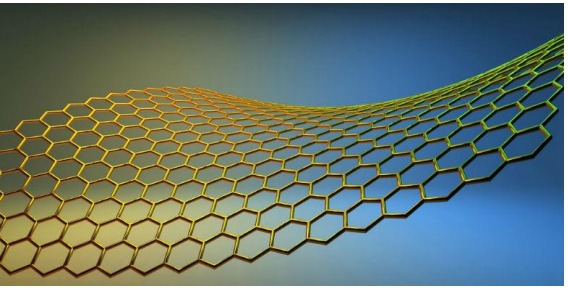
Tero et al. *Science* 2010

Self-healing concrete





Graphene



Graphene

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Quiz

What is the material used to make the bricks used in this tower in Queens, New York ?

Prize

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Quiz

Mushrooms

Specifically the fungal roots or mycelium

Mycelium

BIOFAB

- Mycelium when dried can be used as a super strong, water, mould and fire resistant building material

SCION
FORESTS ▪ PRODUCTS ▪ INNOVATION

BRANZ

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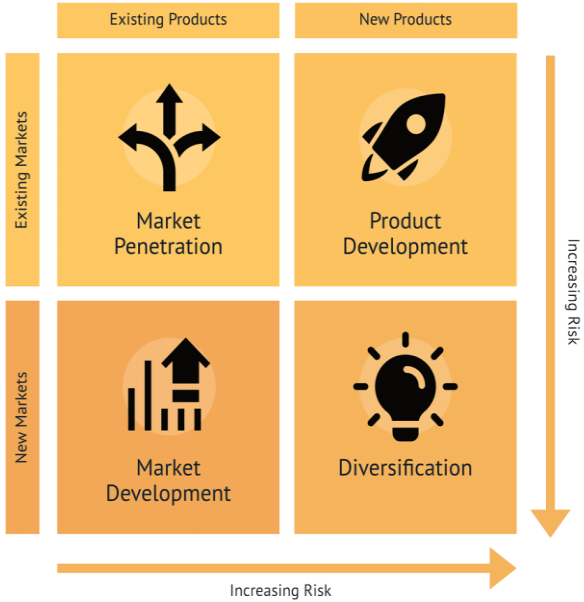
Mycelium

- <u>Lateral diversification</u> in markets to commercialise the R&D - E.g.: Packaging replacing polystyrene and plastic



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Acoustic Dampening – Deep-Tech

Business Challenge

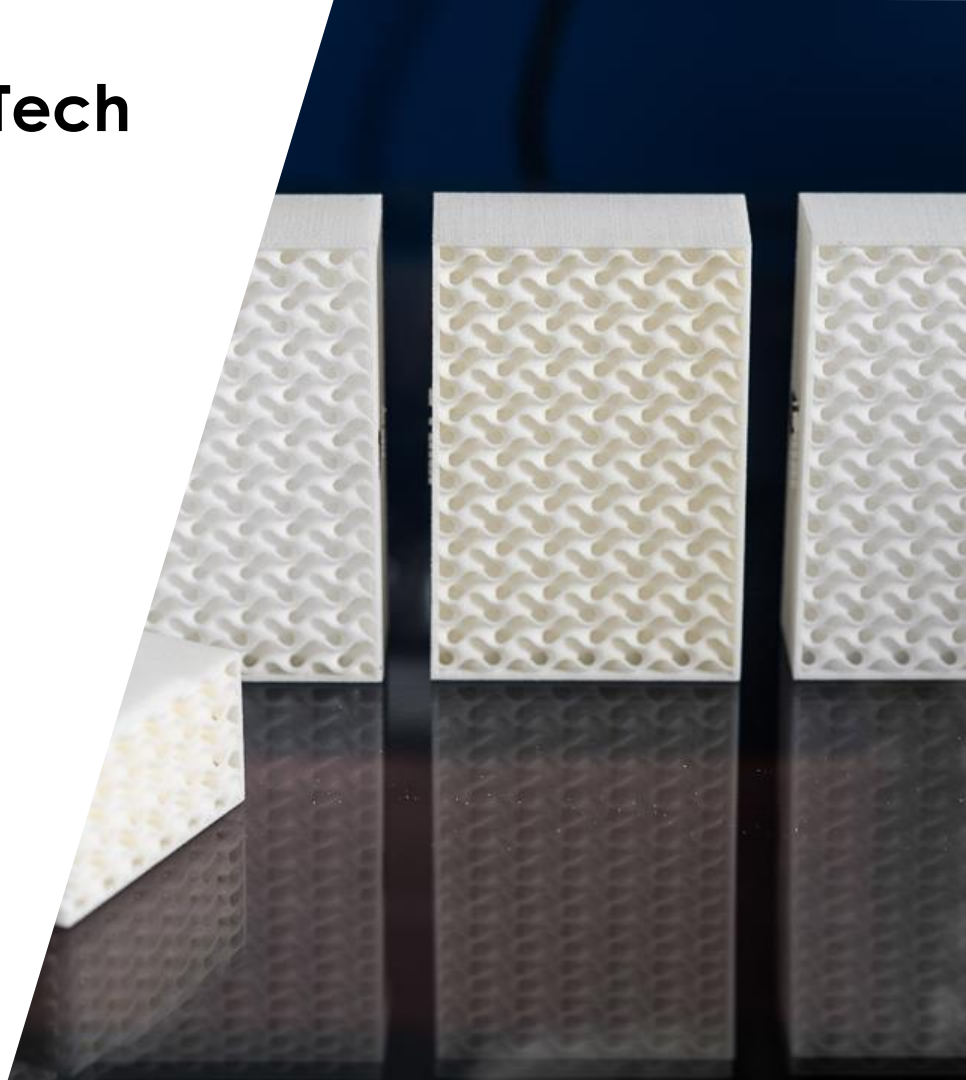
Minimising low frequency noise transmission in medium density housing and the built environment

What we did

Developed expertise in modelling of acoustic response of metamaterials and demonstrated proof of principle materials

Business outcome

Validated digital tools for optimizing and improving the acoustic behaviour of walls and floors/ceilings using new meta-material approaches.



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Active Surfaces

Dulux®

Inhibit COATINGS

Self Cleaning Surfaces – Deep-Tech

Business Opportunity

The global commercial cleaning market is tipped to reach US$74B by 2022. What if we could make surfaces that were self cleaning?

What we did

We have developed a proof of concept self-cleaning coating that can be applied to a range of surfaces.

Result

Opportunities in differentiating your products, the production and supply of novel coatings, and/or in cost savings associated with reduced cleaning and maintenance

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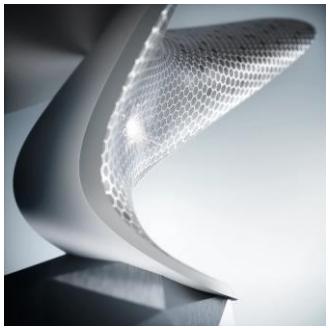
Material Texture by Design

Laser texturing is a process that alters a material's surface properties by modifying its texture and roughness.



Alter surfaces of metals, glass, ceramics, textiles or plastics

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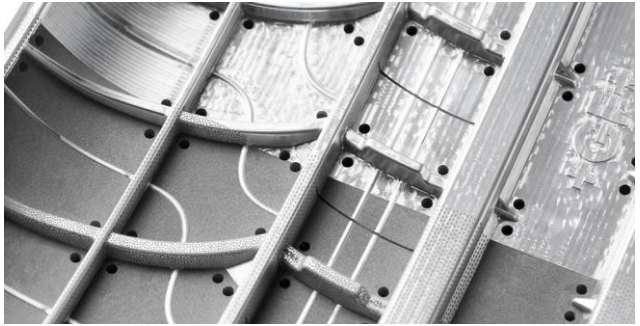


Decorative textures - product design, texturing in moulds, security marking

Friction - reducing wear, improving surface adhesion for coatings (adhesives, paint or ceramic)

Wetting - repel or attract water, anti-icing

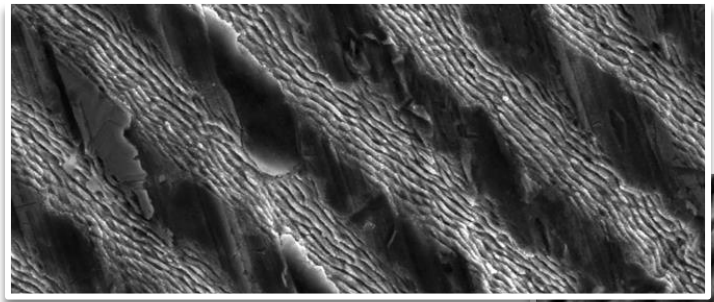
Biological - anti-microbial, anti-viral

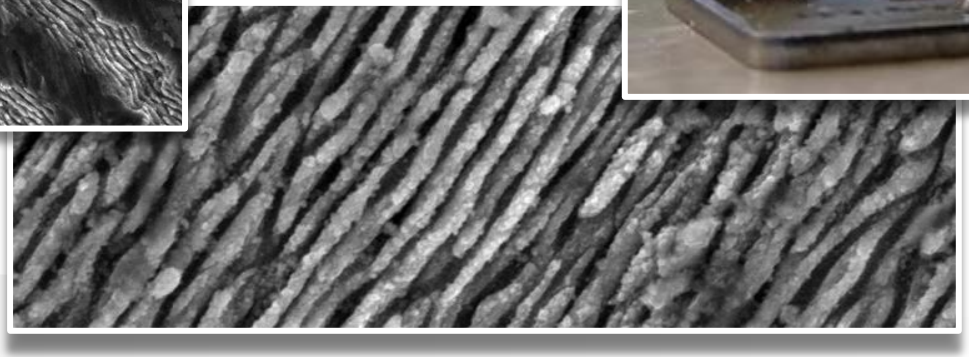
Optical properties – anti-glare

Reduced environmental impact (no chemicals). Digital designs applied to 3D objects

Some of the early practical work in our Advanced Materials team:

- Built a laser texturing system based around an emerging class of laser.
- Practical demonstration of surface texturing of metal surfaces on the nano- and micro-scale.
- Demonstration of superhydrophobic and superhydrophilic metal surfaces

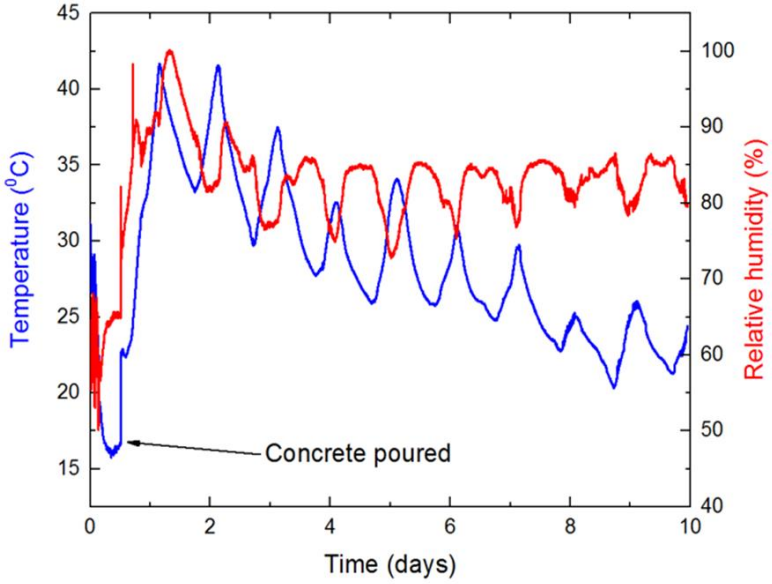




Our work - Cement/Concrete monitoring

Fibre optic moisture, temperature and strain sensors were developed, fabricated and packaged. The sensors were incorporated into the reinforcing mesh prior to pouring of the concrete.

Continuous monitoring of concrete relative humidity and temperature can be used as a QC/QA method and to calculate the compressive strength. It can help flooring companies to decide when to install floor covering. Long term monitoring of the moisture level can also give an early indication if any problem exists due to moisture ingress through the soil or leaks. Using fibre optics, it is possible to measure several locations simultaneously within the slab using only one single fibre making installation easier.



Structural Health Monitoring (SHM)

Business Challenge

Why rely on visual inspection when you can have real data!

Monitor the structural integrity of buildings in-situ and in real time

What we do

We're developing novel sensors to monitor stress/strain, temperature, moisture, and gases in remote and harsh environments

Business outcome

Greater continuity of service for infrastructure, in terms of structural health, and optimisation of repairs and maintenance. In other words: savings in costs, time, and potentially lives!

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Measurement Standards Laboratory of New Zealand

Structural Health Monitoring

Structural health monitoring of civil structures such as bridges, dams, tunnels. Sensors used to measure strain, acceleration, temperature and how these vary with time. Aim to determine the structural integrity of these structures under long term loads or events such as earthquakes and storms.

Advantage of using fiber optics:

Sensors are stable over time especially compared conventional strain gauges

Easy wiring for multiple sensors

Ease of incorporation due to small size

Remote readout and no power needed on site

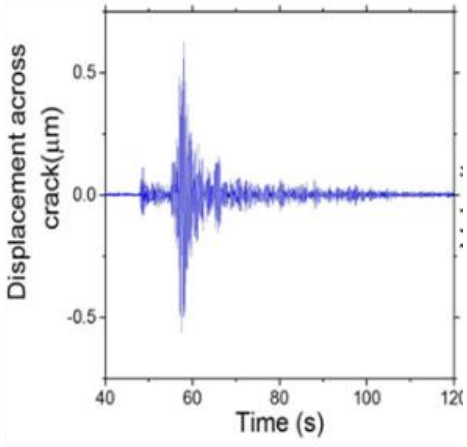
Sensors can be installed during built phase or retrofitted afterwards.

https://lunainc.com/hzmb-hyperion-blog

Our work - Crack monitoring

Fibre optic sensors were retrofitted to a rebar and across cracks that were observed in a building after the Kaikoura quake. The movement and evolution of these cracks could be tracked during subsequent aftershocks.

Incorporating fibre optic sensors in buildings can provide additional data during the inspection of buildings after an earthquake, leading to potentially more accurate assessment of the integrity of structures. This can decrease inspection time and increase safety due to faster and more reliable decisions.



Typical application: Perimeter control

Fiber optics can be used to for the detection of intrusion attempts. A fiber is positioned in proximity of the perimeter to be monitored and will detect any sound or vibrations caused by intrusion attempts. Up to 80km can be monitored with a single controller, and detection accurate to within 10 meters.

Advantage using fiber optics:

High sensitivity

Large area covered with one unit

High position accuracy

No dead zones

Continuous monitoring

Typical application: Traffic flow monitoring

Monitoring traffic on motorways (or railways) to determine location and speed of every vehicle over distances up to 80km using Distributed Acoustic Sensing. One fiber placed along motorway can replace several hundred conventional sensors to monitor traffic flow and incidents.

Advantage of using fiber optics:

Fiber optics ideally suited for distributed sensing

Large distance with one unit

Easy installation

Lower cost per sensing unit

Continuous tracking of vehicles without dead spots

Typical application: Smart sewers

Fiber optic sensors can be installed in sewer systems to enable detection of illicit discharge, sewer blockages, leaks and manhole overflow events. A single unit can be used to monitor extended area of sewer systems. Monitoring of sewer operational patterns using installed sensor can be used to optimise their use.

Advantage using fiber optics:

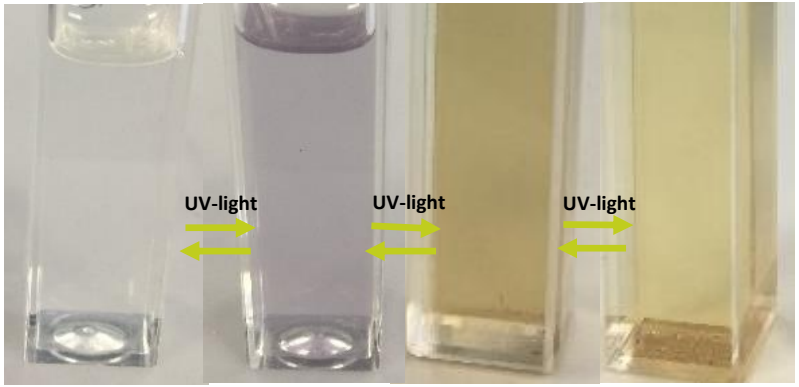
Resistant to corrosion and harsh environments encountered in sewers

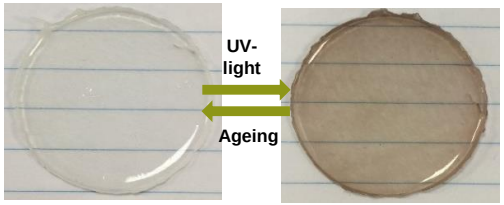
Detection over long distances using a single unit

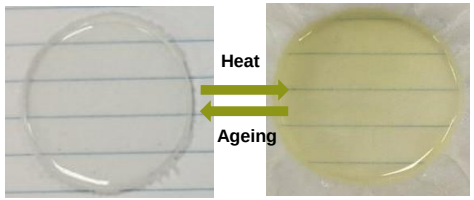
No dead zones

Good location accuracy

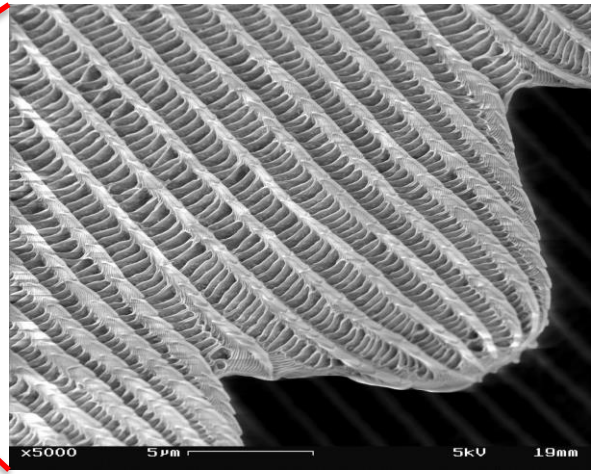
Smart Composites – Photo- and Thermochromic Silicones







Colour through Structure – Deep-Tech



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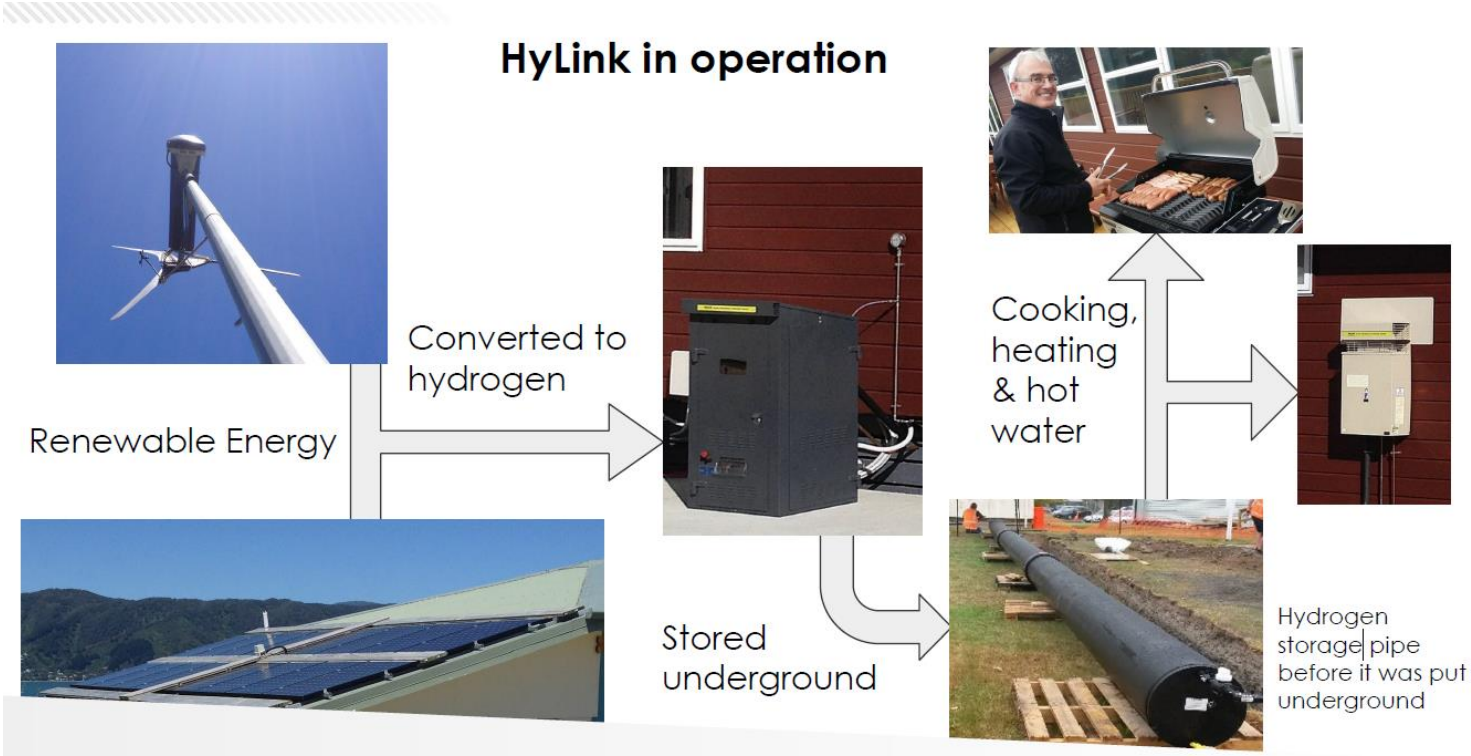
Te Pokapū Auaha o Aotearoa

Technology Insights

Energy

Hydrogen - HyLink



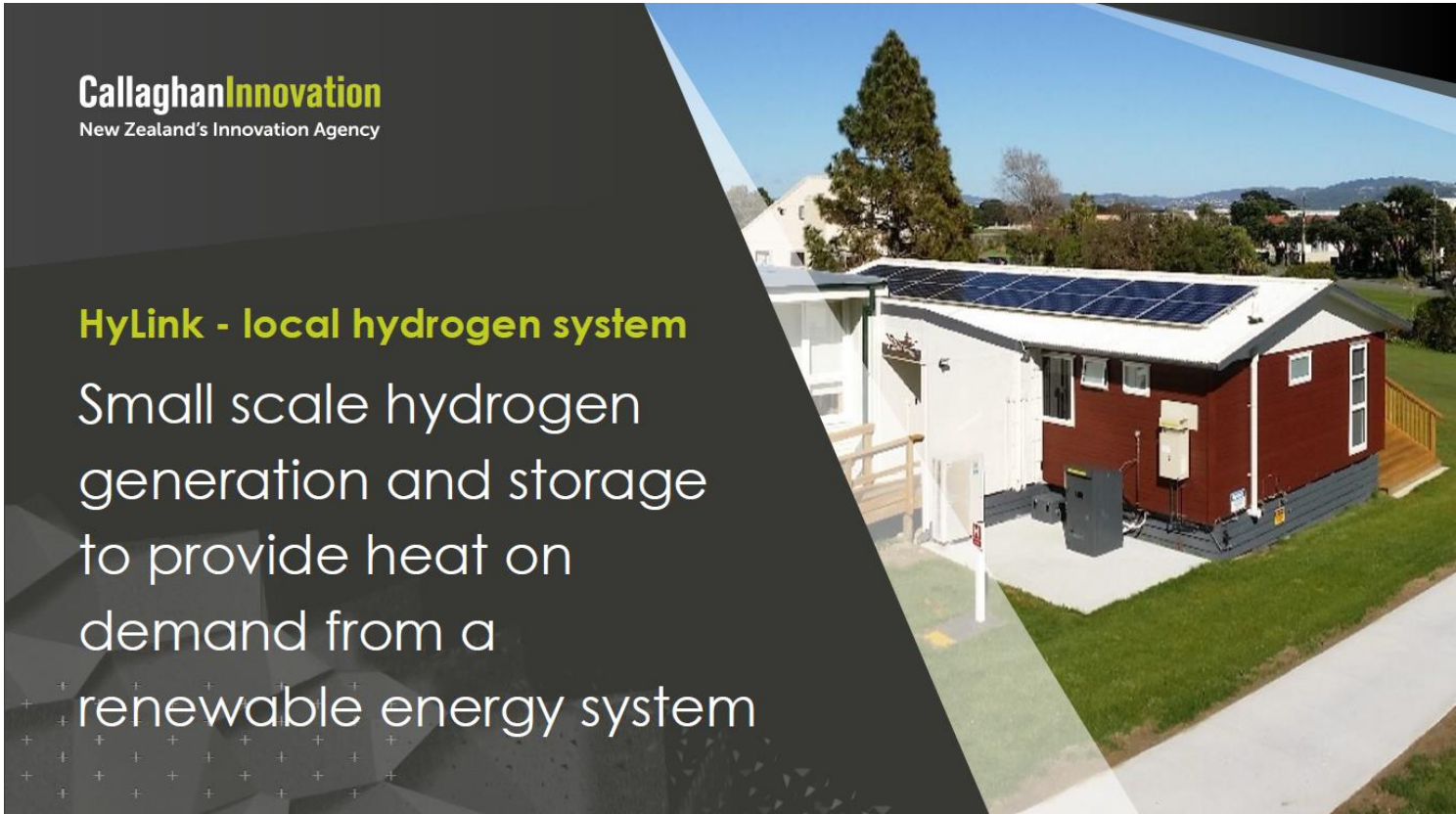
Hydrogen - HyLink

Totora Valley (PoC) 2007

Pacific Island Forum 2012

Matiu-Somes Island 2012

Gracefield Site full size 2016



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Solar Concentrating Windows

Business Challenge

Windows that capture light to generate electricity

What we do

Working with a partner we have developed a proof of concept demonstration window that is lightweight, robust and harvests energy

Business outcome

Successful implementation of this technology will provide a clear point of difference with widespread applications

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Embedded Lighting

Business Challenge

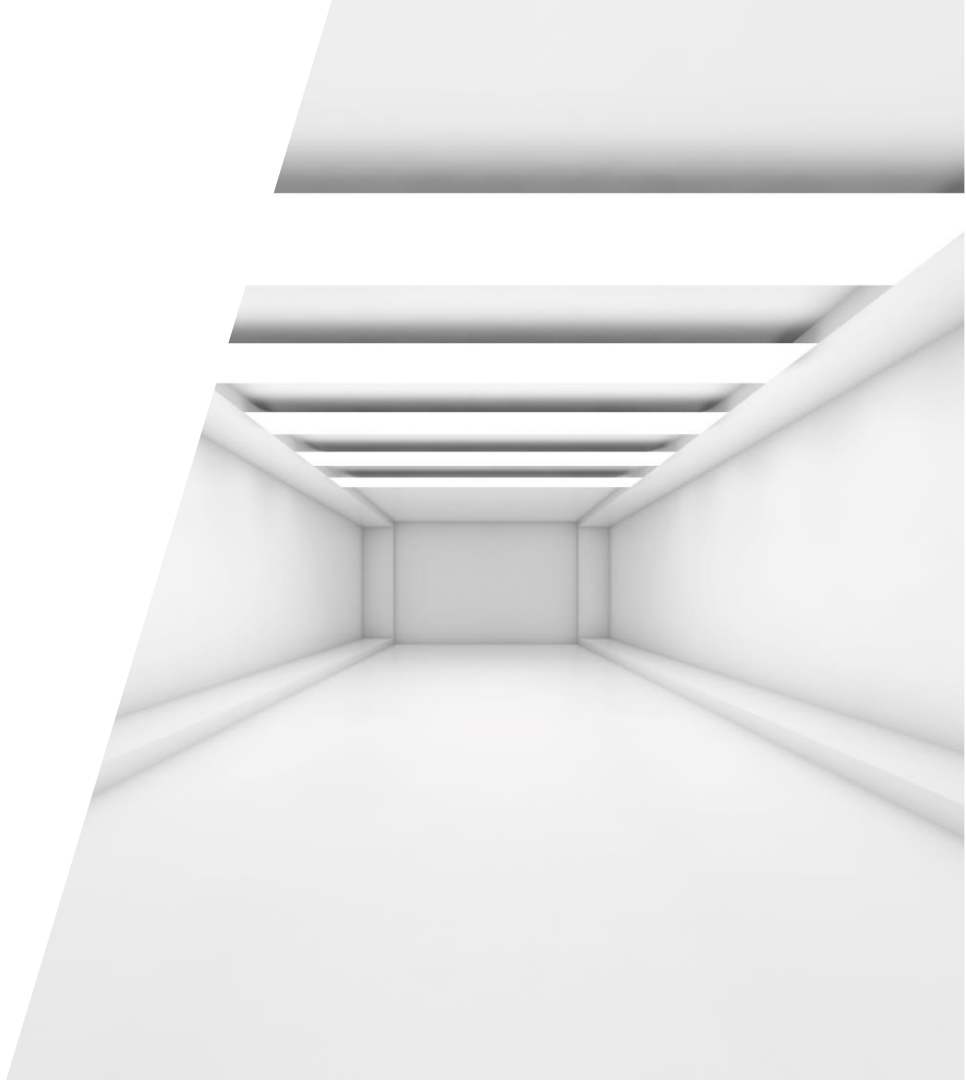
Surfaces that glow

What we did

We are exploring the potential to develop novel wave guiding systems to create more even and diffuse lighting systems for a range of applications

Business outcome

This technology will give us the opportunity to create disruptive lighting concepts across a range of applications



Concrete as a thermal energy storage medium – Deep-Tech

Background

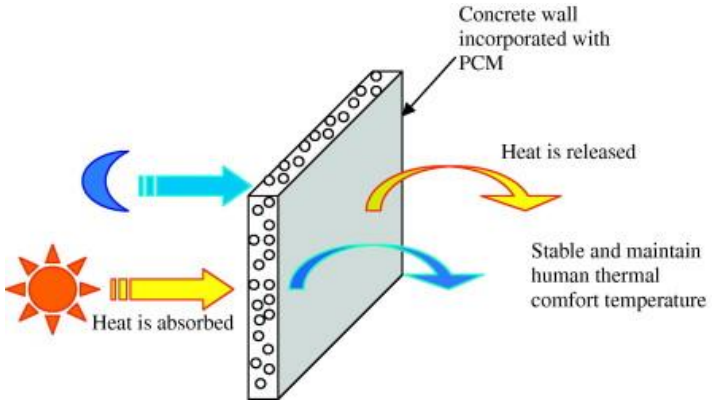
- Cementitious material is widely used due to its **low price and mechanical performance**.
- Concrete is **easy to incorporate into the building landscape** (walls, floor, etc.)

What we do

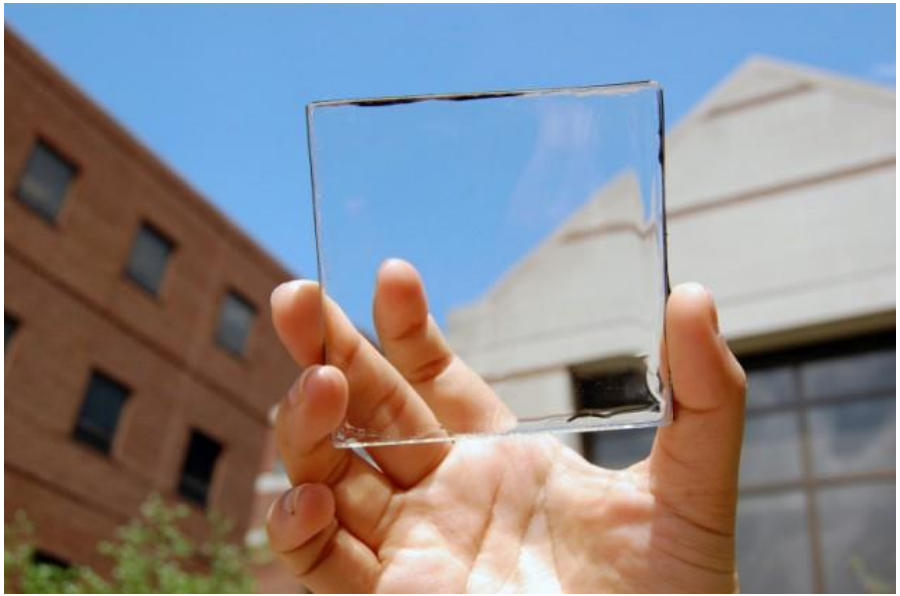
- Use of **phase change materials** for thermal energy storage in concrete

Business outcome

- Absorb/Release the heat when ambient temperature go up/down.



Integrated Photovoltaics – Deep-Tech



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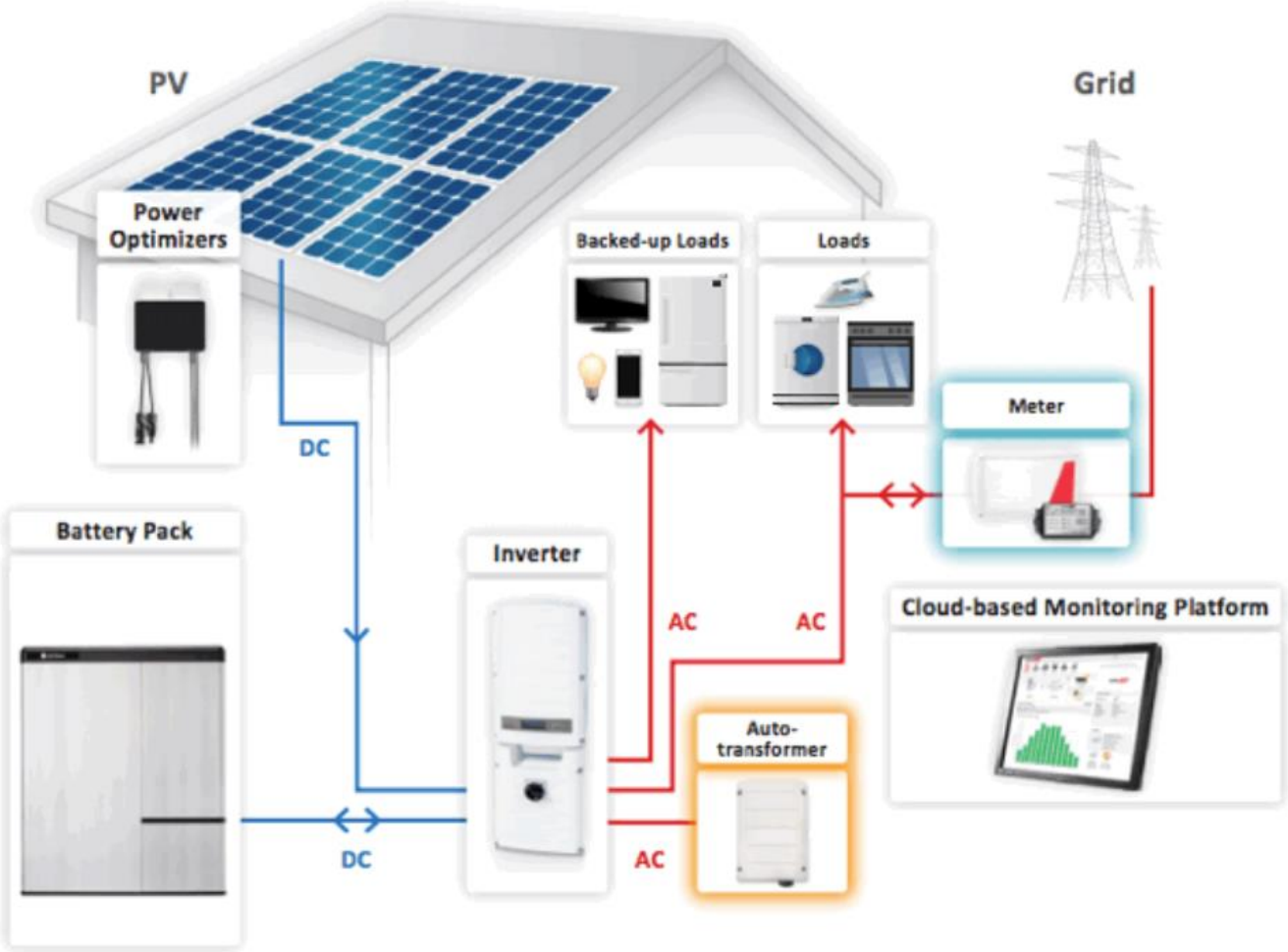
PV
Grid
Power Optimizers
Backed-up Loads
Loads
Meter
DC
Battery Pack
Inverter
AC
AC
Cloud-based Monitoring Platform
Auto-transformer
DC
AC

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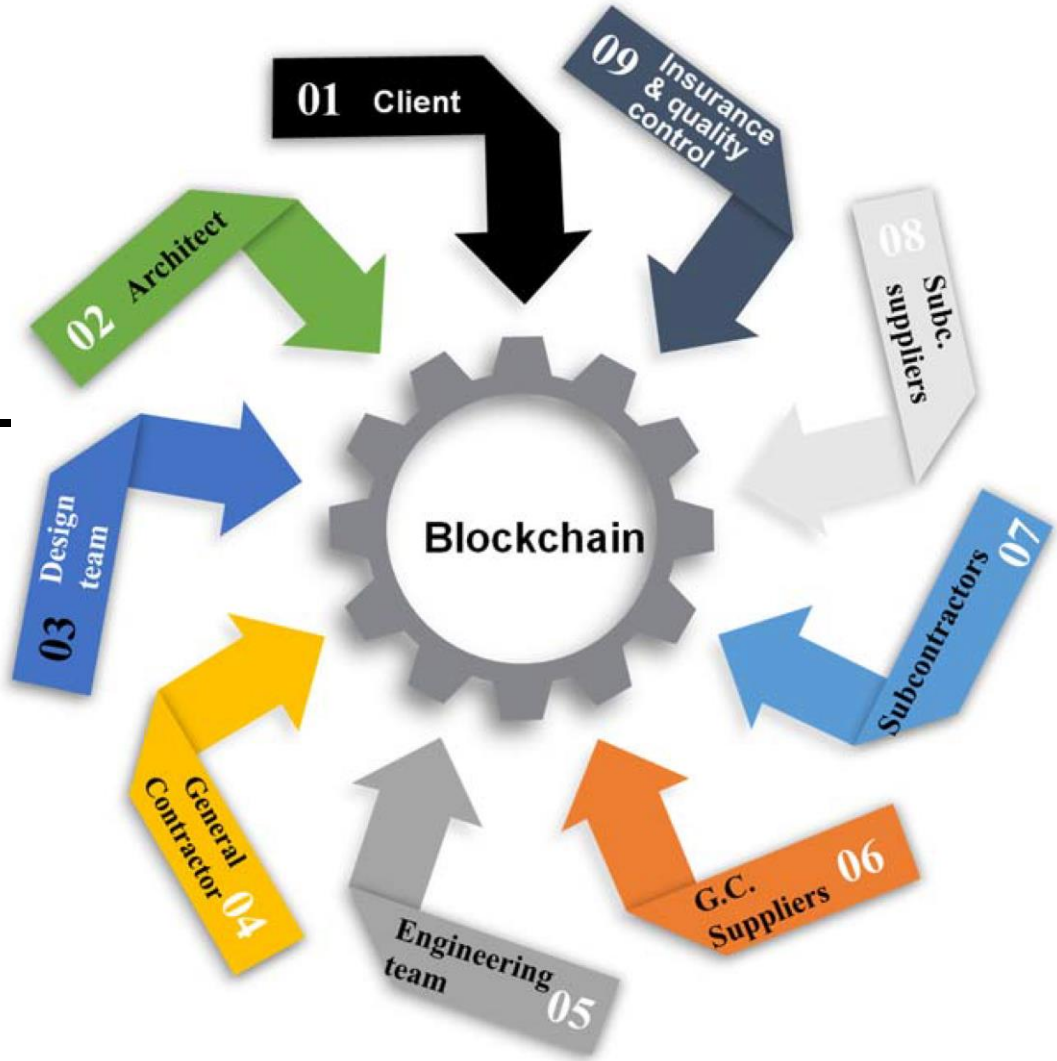
Te Pokapū Auaha o Aotearoa

Technology Insights

Supply chains

Supply Chain Innovation – Blockchain



Business Model Innovation

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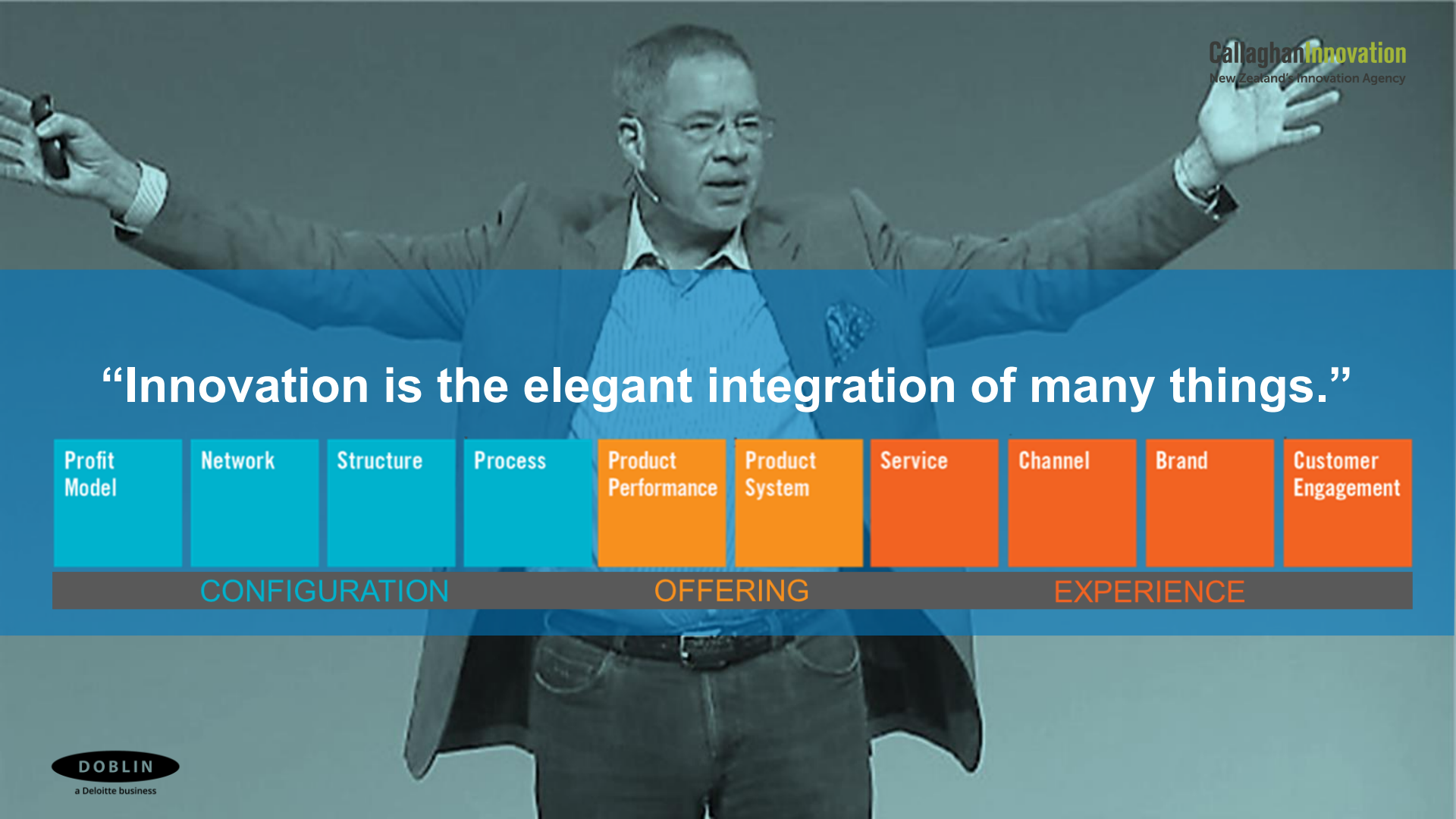
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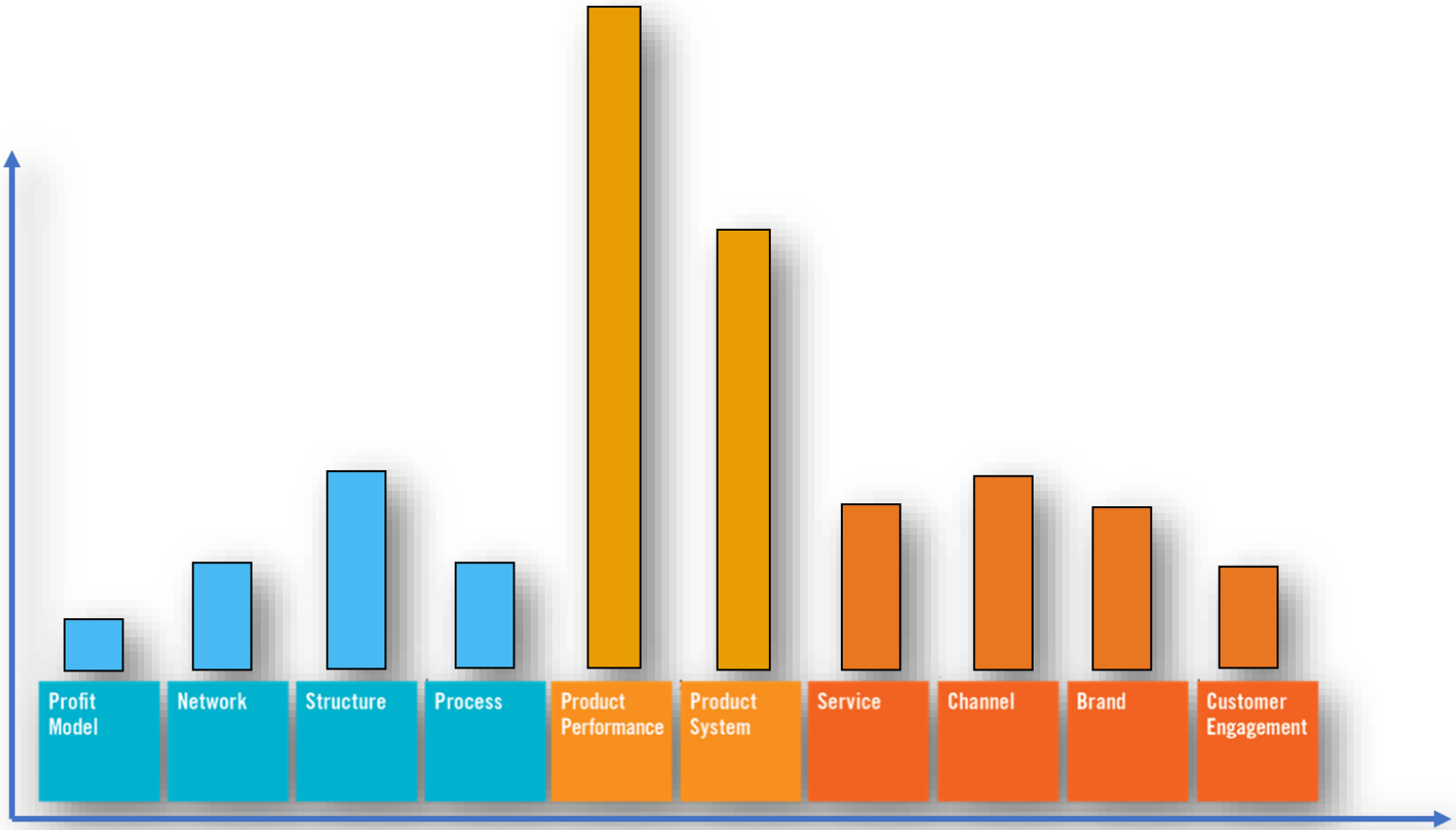
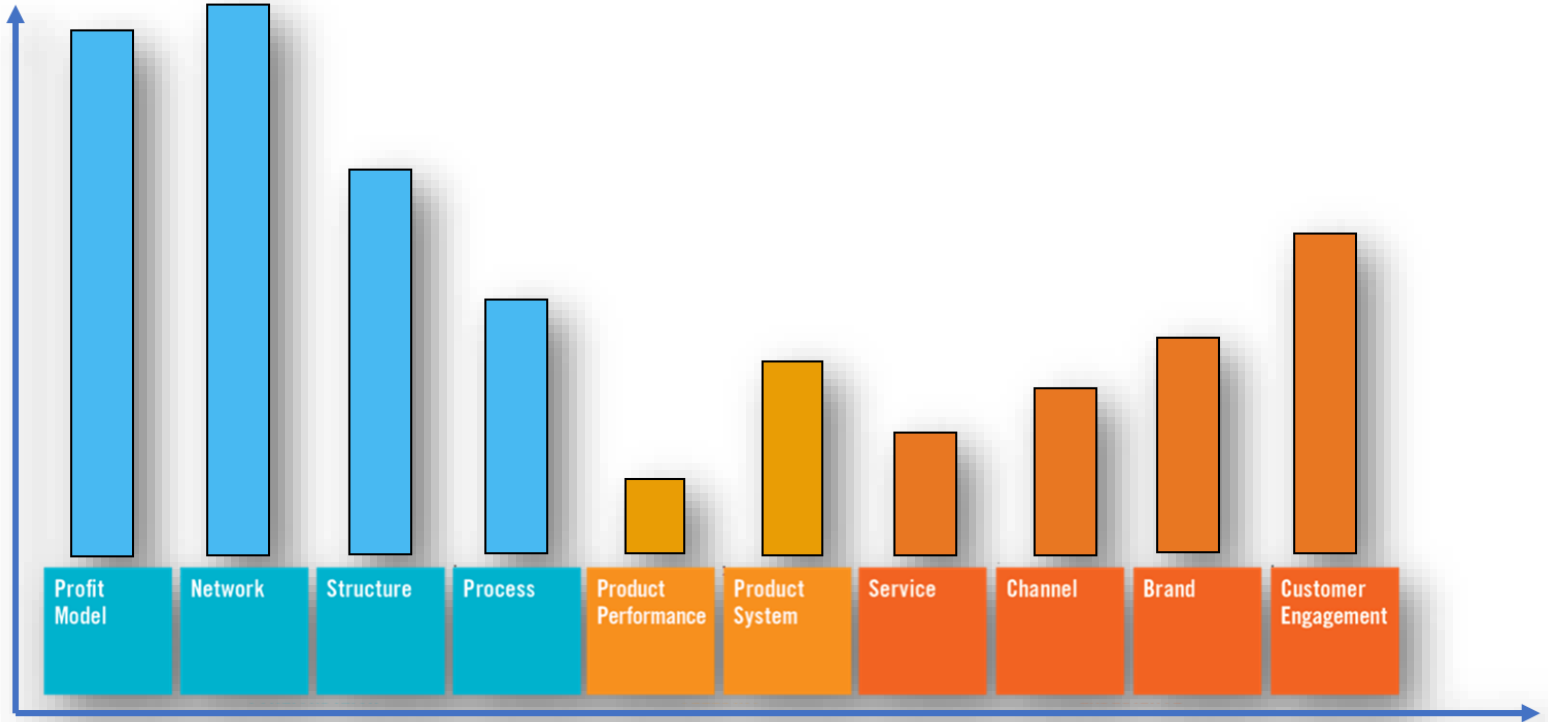
"Innovation is the elegant integration of many things."
Profit Model
Network
Structure
Process
Product Performance
Product System
Service
Channel
Brand
Customer Engagement
CONFIGURATION
OFFERING
EXPERIENCE
DOBLIN
a Deloitte business

DOBLIN
a Deloitte business



Source: Doblin

DOBLIN
a Deloitte business



Source: Doblin

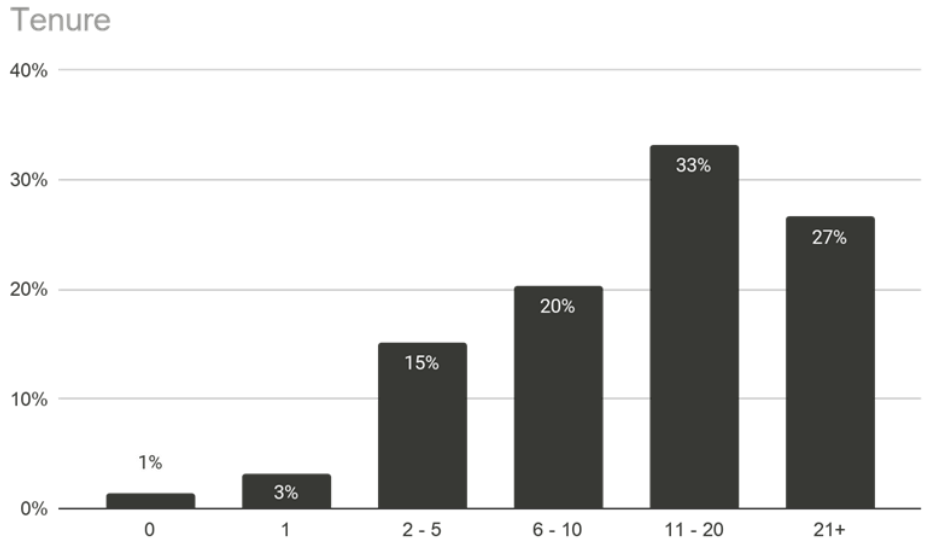
Overview

374

companies **tagged** as Construction in our CRM (**almost doubled over the past 3 years**)

+29

New businesses 2021



MĀORI ECONOMY

6 new companies are ticked as Māori Business

HIGHTECH PRODUCTS

90% of the companies are under the Manufacturing and Niche Sector, 4% under Digital and 3% Energy & Environment

**Source: CRM – 19 November 2020 - dates are when the companies have been created in CRM, not tagged as construction.*

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Construction Sector by region

39%

companies are from **Auckland** with a 12% increase last year.

13%

companies are from **Wellington**. In 2 years, we had an increase of 63%.

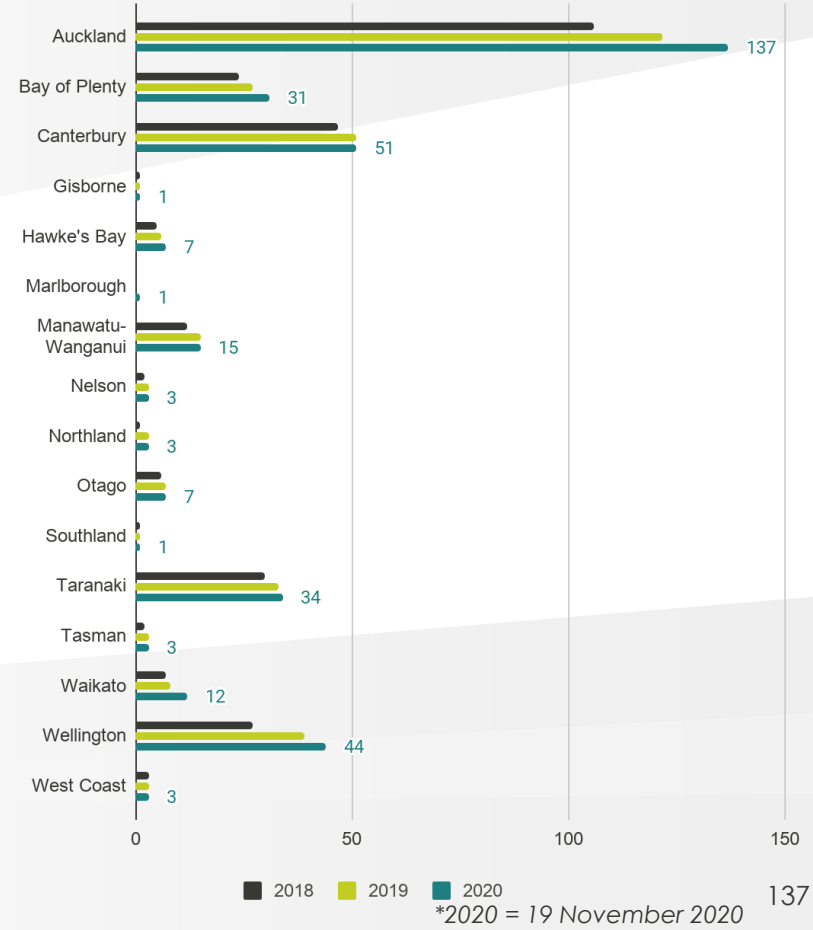
10%

companies are from **Taranaki.** 11% of the Taranaki companies in CRM are from the construction sector.

9%

companies are from **Bay of Plenty.**

Region Over Time



*2020 = 19 November 2020

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Construction Sector – key impact metrics for our companies

For the companies we provided **funding + Advisory** support the last 2 years, we saw:

+10%

Increase YoY on revenues (median)

+8%

Increase YoY on FTEs (median)

+11%

Increase YoY on R&D (median)

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**Source: IMS Financial Report 2019-2020: based on 69 companies, latest report*

Over the past four years (2017-2021), Callaghan Innovation customers have:

- ✓ **Grown revenue by 11.5% per year**
  (4.2 times faster than the New Zealand rate over the same time)
- ✓ **Grown revenue per worker (a basic proxy for labour productivity) by 7.3% per year**
  (8.2 times faster than the New Zealand rate)
- ✓ **Grown export revenue by 12.3% per year**
  (2.5 times faster than the New Zealand rate)
- ✓ **Grown employment by 4.8% per year**
  (2.4 times faster than the New Zealand rate)
- ✓ **Grown R&D spend by 15.8% per year**
  (1.5 times faster than the New Zealand rate)

A team of over 450 people

Serving customers nationwide

- 200+ scientists and engineers in R&D Solutions and our commercial businesses
- R&D centres in Wellington, Auckland and Christchurch
- 14 Regional Business Partners

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New Zealand's Innovation Agency

Our core services to empower innovators

R&D SOLUTIONS

Leading scientists and engineers dedicated to solving tough technical problems

INNOVATION SKILLS

Giving business the knowledge, skills and motivation to grow faster

R&D FUNDING

Funding support to help businesses pursue ideas and realise commercial success

CONNECTING TO EXPERTS

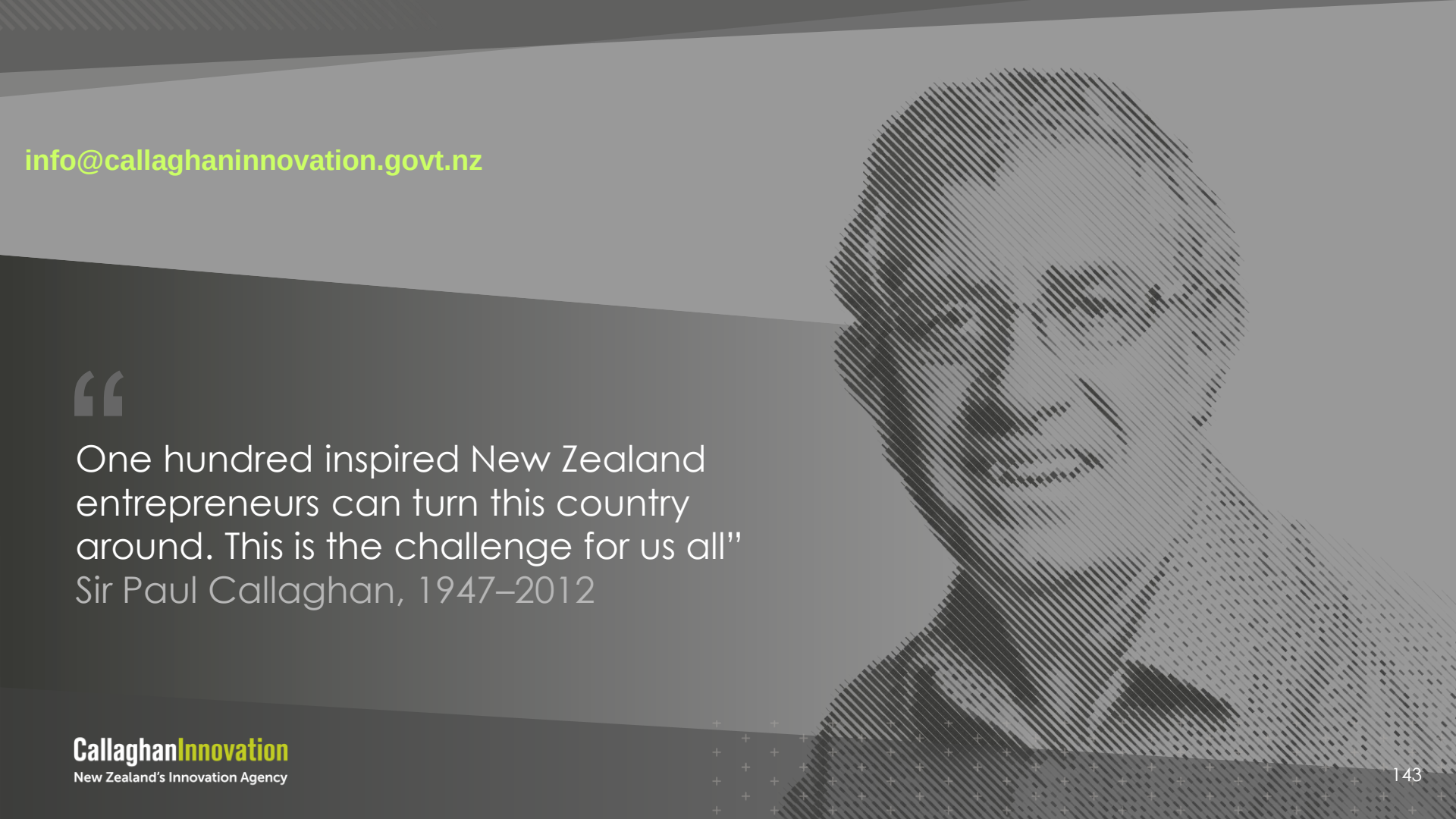
Advisors and tools that connect businesses with expertise and opportunities, locally and globally technical problems

PROPERTY INSTITUTE
The Home of Property Professionals

CallaghanInnovation
New Zealand's Innovation Agency

Any Questions?

info@callaghaninnovation.govt.nz



"One hundred inspired New Zealand entrepreneurs can turn this country around. This is the challenge for us all"
Sir Paul Callaghan, 1947–2012