BUILDING LEADERS BRIEF INDUSTRY 2023

Digitisation for Compliance and Decarbonisation

Prof Chris Knapp PhD RAIA

Research Director, Building 4.0 CRC

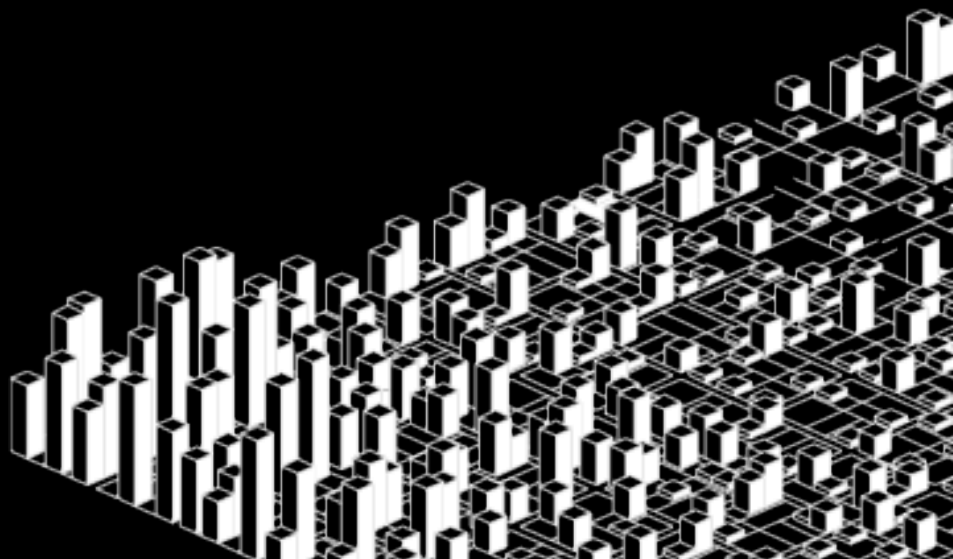
Prof Chris Knapp PhD RAIA

Research Director

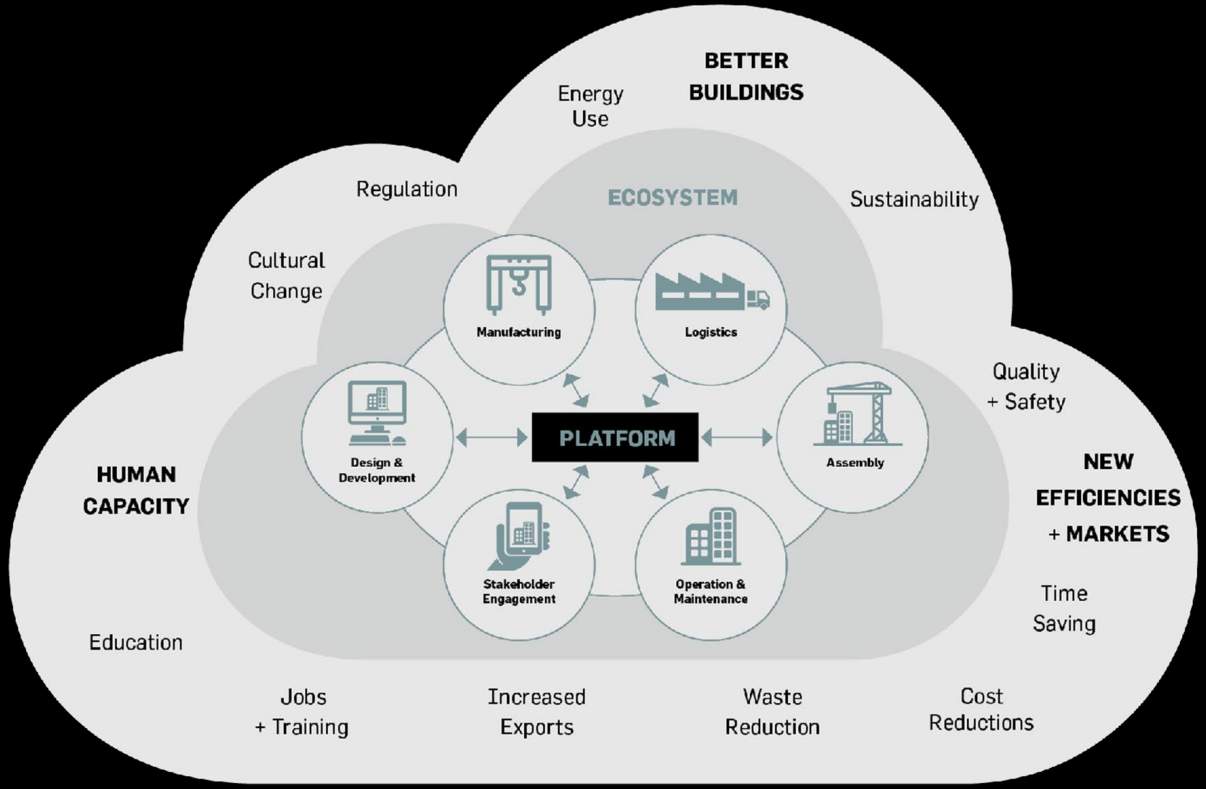
9 August 2023

Better buildings through increased digitalisation, industrialisation, culture change, and sustainability

building 4.0 crc



B4.0 CRC - BUILDING THE FUTURE INDUSTRY

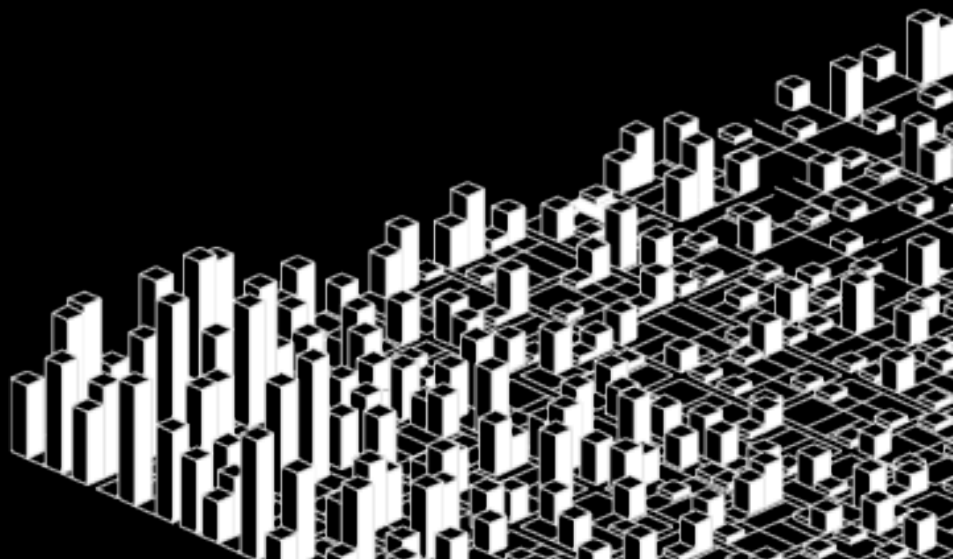


7 YEARS

3 UNIVERSITIES

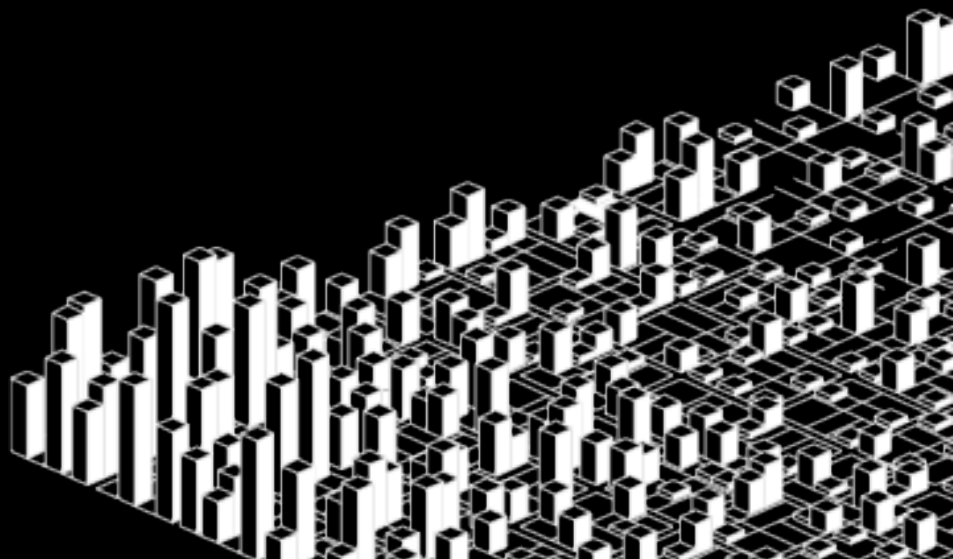
~30 INDUSTRY PARTNERS

$130M TOTAL RESEARCH VALUE



SINCE JULY 2020:

- 32 COMPLETED PROJECTS
- 18 ACTIVE PROJECTS
- 44 PIPELINE PROJECTS



Projects: pipeline, active, completed

Sustainability

Project 5 – Automatic Compliance & Energy Rating System
Project 11 - Environmental Credentials for Building Technology Platforms
Project 18 - Long-span Low-Carbon Floor Systems (Scoping Study)
Project 19 - Hybrid Timber-Steel Structural Systems for Mid to High Rise Buildings
Project 27 - Environmental Decision-Support for Structures
Project 35 - Prefab Housing Solutions for Bushfire & Disaster Relief
Project 37 - Aust Timber Fibre Insulation Scoping Study
Project 39 – Hybrid Timber-Steel Extension
Project 46 - Data analytics for structural fibre resources optimisation
Project 48 - Shared Interest Project: Circular Economy
Project 50 - Automation of energy rating tool
Project 54 - HVAC in a post-covid world
Project 59 - Strong Floor
Project 68 - Post and Plate CLT Scoping, Optimisation, and Testing
Project 72 - PassivHaus Tower Performance Evaluation

Digitalisation

Project 01 - e-Planning / e-Approvals Phase 1
Project 04 - Computational Design & Optimisation Tools for Prefab Building Systems
Project 06 - Field data collation to support real-time operational management
Project 12 - VR/AR Technologies in Vocational Education / Training
Project 16 - Fire Safety in Advanced Building Systems
Project 22 - Design Automation methods for Steel Framed Buildings Phase 1
Project 38 - Victorian Govt Digital Build
Project 42 - Workflow Automation Tools for Home Designs
Project 44 - Generative Architectural Design Engine
Project 53 - Automated Design Optimisation and AI Tools for Prefab Systems (Ext to 4)
Project 55 - Smart Contracts / Smart Finance in construction industry
Project 57 - Wind Comfort Simulation and New Engineering Design Process
Project 62 - Digital Building Approvals
Project 71 - Automated Resolution of BIM Clash Incidents
Project 73 – LLM for Material Tracking and Part Library

People, Practices & Culture

Project 02 - Auto-Tracking of Materials for Supply Chain Logistics and Provenance
Project 09 - Implementing DfMA & Lean Construction Principles
Project 14 - Building Products Supply Chain Naming Conventions and Standards
Project 15 - Resource optimisation Studies: Forest to Building
Project 21 - Regulatory Reform for Industrialised Building
Project 29 - Workplace Safety
Project 33 - Remote Compliance Inspections
Project 56 - Training and Optimising CRC Research in Construction
Project 58 - Construction Wellness
Project 60 - Mass Timber Wellness
Project 66 - Future of Construction Education

Industrialisation

Project 03 - Projects to Platforms
Project 08 - Prefab, Integrated Wall Systems - Scoping Study
Project 17 - Implication of Industry 4.0 for the construction industry: smart prefab
Project 19 - Hybrid Timber-Steel Structural Systems for Mid to High Rise Buildings
Project 20 - Sys & methods for robustness of mid-rise Light Gauge Steel (LGS) buildings
Project 23 - Prefab: Barriers & opportunities in the Australian housing market
Project 24 - Robust and Fire-resilient Light Gauge Steel Systems for Mid-Rise Buildings
Project 25 - Framework of steel fabrication & processing in the OSM & prefabrication
Project 26 - New materials for windows of the future
Project 28 - Componentised Internal Wall Systems for multi residential applications
Project 31 - Demystifying Volumetric Construction: A Study of the Bathroom Pod
Project 32 - Acoustic Flanking performance of mid-rise Light Gauge Steel (LGS)
Project 34 - Acoustic flanking (Scoping Phase 1)
Project 45 - Prefab Wall Integrated System Demonstration House & Market Study
Project 61 - Productivity
Project 63 - Componentised Internal Walls – Extension and Prototyping

Projects: pipeline, active, completed

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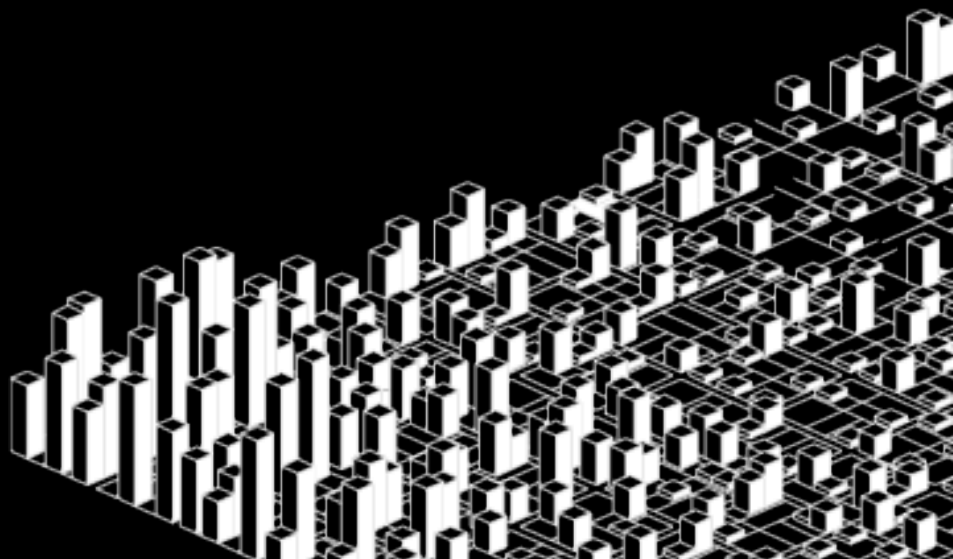
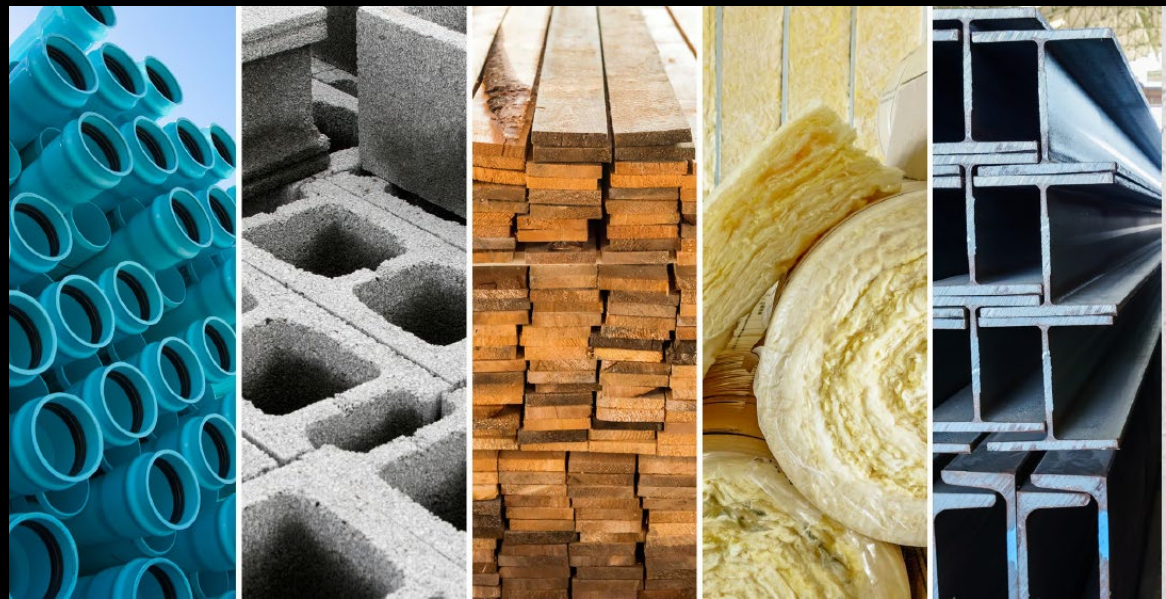
Selected B4.0CRC Decarbonisation Projects

- Project #2
- Project #5/#50
- Project #18
- Project #27
- Project #48



Auto-Tracking of Materials for Supply Chain Logistics and Provenance

- Project #2



building 4.0 crc

THE UNIVERSITY OF MELBOURNE

QUT

MONASH University

lendlease

SUMITOMO FORESTRY

BlueScope

VBA VICTORIAN BUILDING AUTHORITY

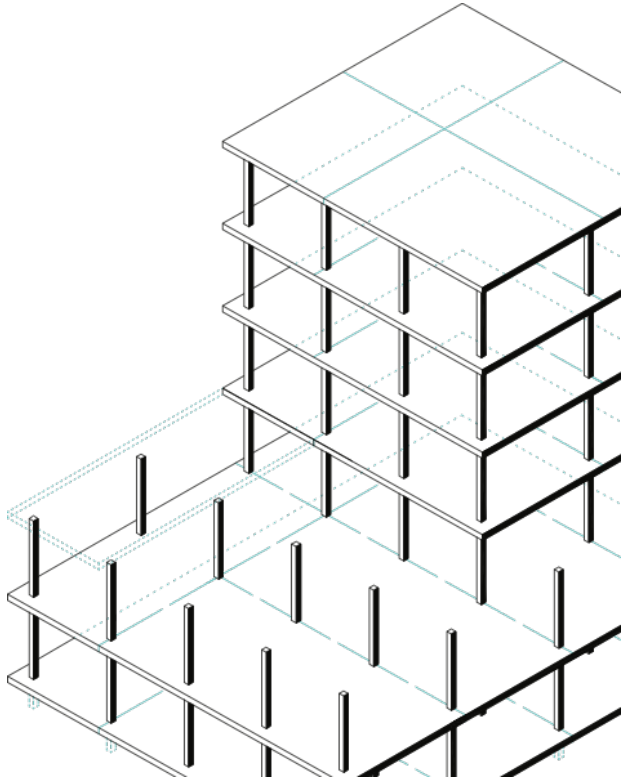
MASTER BUILDERS VICTORIA

salesforce

YNOMIA

aws

holmesglen



PROJECT OVERVIEW

- **Project Aim**
  This scoping study aims to understand the state-of-the-art traceability in the construction industry and key stakeholders' perspectives and recommend future research.

- **Project Lead**
  Dr Wen Li (University of Melbourne)
- **Research Team**
  Dr. Guilherme Luz Tortorella; Prof. Robin Drogemuller; Dr. Aravinda Sridhara Rao; A/Prof. Joseph Liu; Dr. Yihai Fang; A/Prof Tim Rose; Dr. Sara Omrani; Prof. Alistair Barros; Prof. Tuan Ngo; Mr. Declan Cox; Ms. Negar Adebi; Mr. Noor E Karishma Shaik; Mr. Siyu Chen; Mr. Xin Ma; Mr. Tendai Makasi
- **Public report will be released soon**

THE CONTEXT

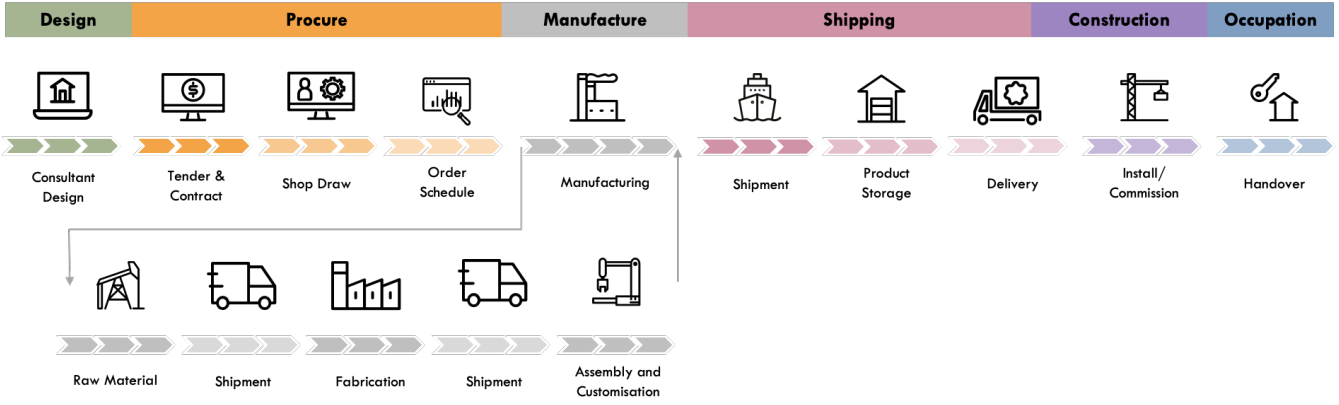
Traceability – *The ability to track and trace*

*Traceability is **Challenging** due to the nature of the construction supply chain:*

- *Make-to-order*
- *Unstable*
- *Highly fragmented*
- *Geographically dispersed*

*Traceability is also **Beneficial** for construction industry as it contributes to:*

- *Building compliance & safety*
- *Project efficiency*
- *Sustainability*
- *Building performance*



LESSONS LEARNT FROM THE FOOD INDUSTRY

- **Key Drivers** for traceability includes safety and quality, optimizing process efficiency, improving sustainability performance, and increasing consumer confidence.
- **Comprehensive legislation, regulations, and international standards** mandating traceability exist in the food industry.
- International organization, **GS1,** plays a pivotal role in traceability, providing standards for identifying, capturing, sharing, and using information related to a product.
- The GS1 12 Identification Keys contains information describing the critical tracking events, being carried with **mature technologies** like barcodes, RFID, and QR codes.
- Digital traceability has potential in providing high resolution and quality data for **assessing carbon footprint and improving sustainability performance**.

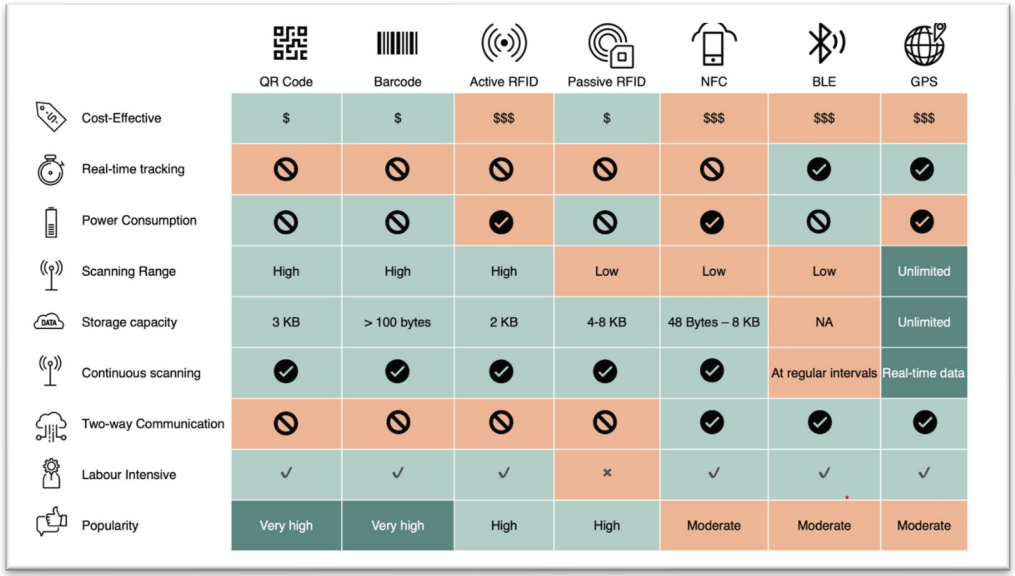
SUPPLY CHAINS IN BUILDING DESIGN, CONSTRUCTION, AND OPERATION

Supply chains in building projects differ from other industries:

- the complexity and inter-related nature of construction projects and their legal context, normally undertaken by a **temporary consortium of firms**;
- unique activities such as excavation, where the “supply activity” is **a removal activity**,
- the active role of the Demand Chain participants in checking and approving the results of Supply Chain activities,
- the heavy use of **a flexible mix** of “supply only”, “service only” and “supply and service” **subcontracts**,
- and the role of the **lead contractor** (construction systems integrator) in creating and managing a production facility which **can change dramatically** throughout the single contract.

STATE-OF-THE-ART IN TRACEABILITY TECHNOLOGY

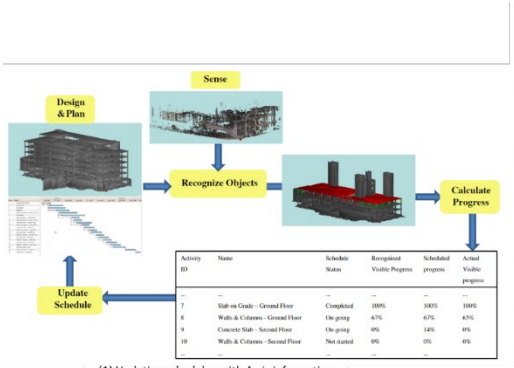
- The available technologies are relatively advanced, and the commercial solutions would easily cater to most construction processes.
- Cost and associated factors may limit organizations from adopting such technologies.
- Many technologies require tedious setup, frequent sensor repositioning for unblocked line-of-sights when tracking on site.
- Design models, schedules, site layout plans, are essential information for material tracking onsite but often not available in an integrated information platform



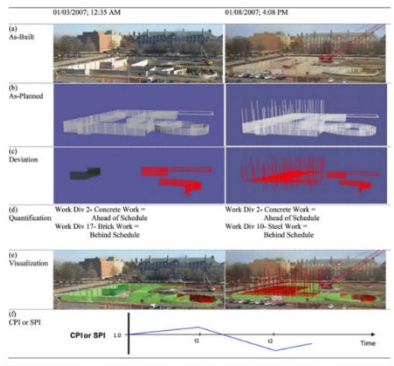
	QR Code	Barcode	Active RFID	Passive RFID	NFC	BLE	GPS
Cost-Effective	$	$	$$$	$	$$$	$$$	$$$
Real-time tracking	⊘	⊘	⊘	⊘	⊘	✓	✓
Power Consumption	⊘	⊘	✓	⊘	✓	⊘	✓
Scanning Range	High	High	High	Low	Low	Low	Unlimited
Storage capacity	3 KB	> 100 bytes	2 KB	4-8 KB	48 Bytes – 8 KB	NA	Unlimited
Continuous scanning	✓	✓	✓	✓	✓	At regular intervals	Real-time data
Two-way Communication	⊘	⊘	⊘	⊘	✓	✓	✓
Labour Intensive	✓	✓	✓	×	✓	✓	✓
Popularity	Very high	Very high	High	High	Moderate	Moderate	Moderate

STATE-OF-THE-ART IN TRACEABILITY TECHNOLOGY

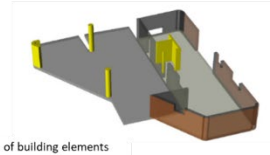
- BIM can act as a “repository” for storing some results of demand chain management.
- The ISO 19650 series of standards cover the current requirements for integrating BIM into building projects.
- However, many things are not captured in BIM, such as regulatory requirements and temporary works, so BIM is likely to remain a useful adjunct to demand chain and supply chain management for the foreseeable future.



(1) Updating schedules with As-is information

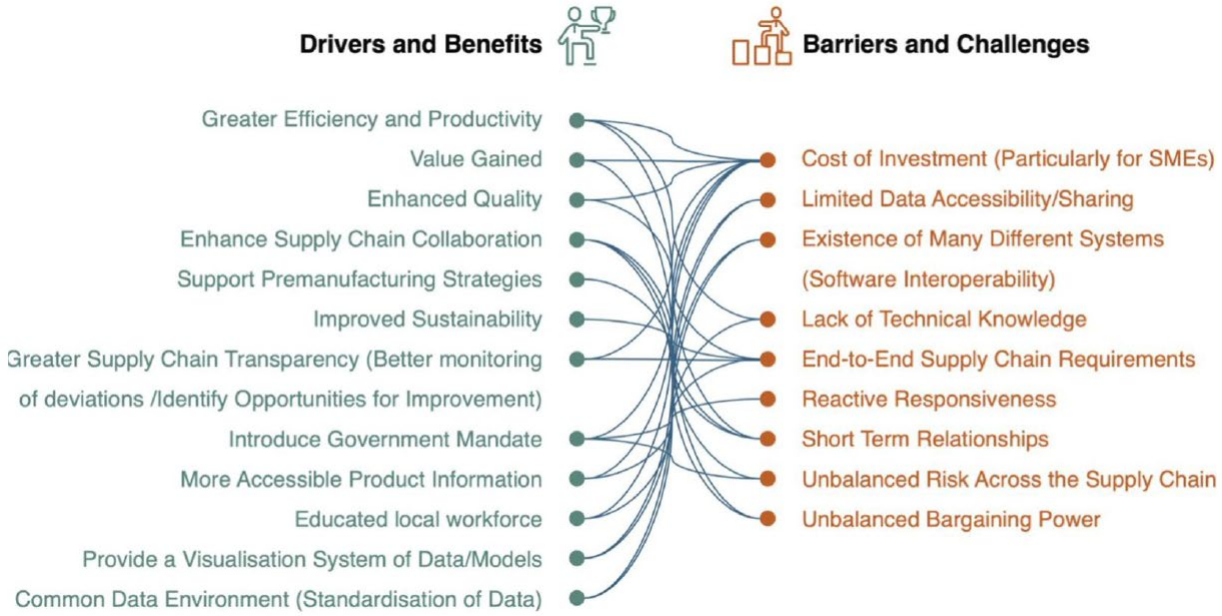


(2) Performing Earned value analysis (EVA)



(3) Detecting absence of building elements

STAKEHOLDER'S PERSPECTIVES



KEY FINDINGS

1. Fragmentation is a primary barrier to traceability.
2. Tender processes inhibit long term supply relationships and therefore long term solutions.
3. Product information is not easily maintained due to intermediate fabrication/modification steps.
4. Sensor technology is abundant and mature, but requires customisation to suit construction materials.
5. Tracking needs to be integrated with BIM/data in order to be useful.
6. Lack of digitisation is a hurdle (for example, mills process & output parts with hand-written labels).
7. Construction manufacturers don’t see a benefit in digitising.
8. Contracts are competitive and closed, so lack of transparency inhibits tracking availability.
9. There is not a champion driving creation of traceability protocols in the ecosystem.
10. Discrepancy between labelling the packaging vs labelling the product. Will materials be substituted without validation; who inspects?
11. Adoption of a decarbonisation framework requires thinking of the building as a product, not a project.

FUTURE RESEARCH AGENDA 1

1. **Roadmap for Sector-wise Transformation:**

This research direction aims to understand the construction supply chain further, examine how we can leverage digitisation as a traceability solution for a streamlined workflow, and develop roadmaps for digitalising the construction supply chain in Australia:

- Identify the **influential contextual variables** (e.g., company size, tier level, product family, etc.) for the digitalisation of the construction supply chain.
- Verify how to **deploy behavioural changes** (i.e., sociocultural factors) required for a successful digitalisation across the construction supply chain.
- Structure **roadmaps for digitising** the construction supply chain in Australia.

FUTURE RESEARCH AGENDA 2

2. Digital Traceability Solution Development:

This research direction aims to develop cost-effective technological solutions for automated material tracing for the construction supply chain.

- Develop **cost-effective product identification methods** for tracking highly critical building elements like steel, timber, concrete, wall panel, façade, cladding, etc.
- **Integrate** with central building information management models and platforms for sharing product traceability information.
- Explore the possibility of **Blockchain technologies** for tracking, contracting and transferring.

FUTURE RESEARCH AGENDA 3

3. Education and Training:

Through scoping study, it was analysed that the digital traceability solutions are new and innovative, so **technical knowledge and skills gaps** are perceived to understand and operate it:

- Review current curriculum design and develop course materials for construction supply chain management. A few key considerations are identified related to traceability and the construction supply chain:
  - 1) Risk;
  - 2) Digital Technologies;
  - 3) Sustainability;
  - 4) Lean construction
- Develop workshops and training programs for upskilling.

FUTURE RESEARCH AGENDA 4

4. Pilot Study & Living Lab:

Through interviews conducted in scoping study, it was found that **industry partners are hesitant to invest** in digital traceability solutions because of being unsure whether the proposed solution will aid in project performance. So, this project idea will focus on testing/**trialling the proposed digital traceability solutions** in the construction supply chain to check their feasibility and effectiveness:

- Turn an actual building project into a **living lab** by deploying proposed digital traceability solutions
- Benchmark digitalised supply chains with a **comparative** conventional one by monitoring supply chain-related KPIs (Key Performance Indicators), such as lead time, productivity, project delays, etc.
- Use digital traceability information to **conduct carbon footprint and life cycle assessment** of a construction project or building product.

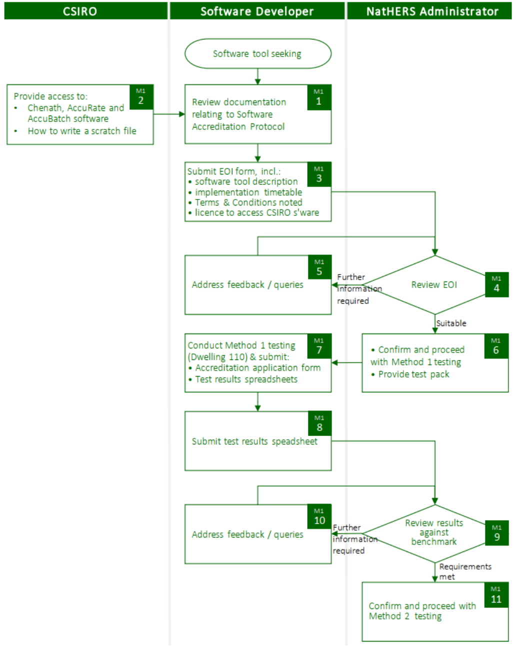
Automatic Compliance and Energy Rating System

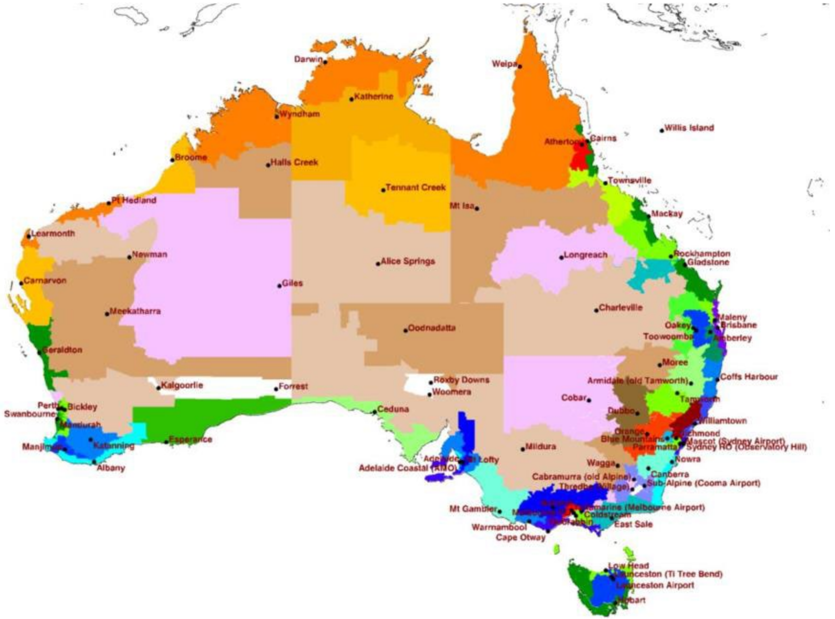
- Project #5

DONOVANGROUP

Green Building Council Australia

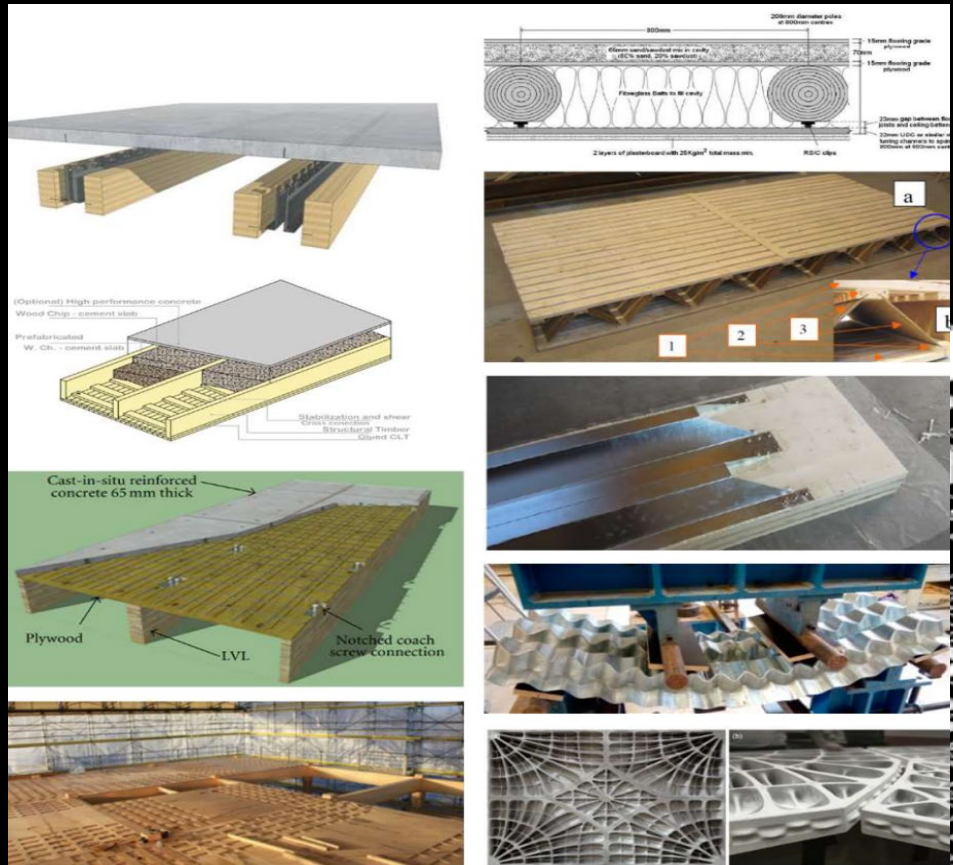
FIGURE 2: EXISTING NATHERS SOFTWARE TOOLS - LEFT TO RIGHT - ACCURATE (CSIRO), FIRSTRATE5 (SUSTAINABILITY VICTORIA), B.E.R.S. PRO (ENERGY INSPECTION) & HERO


CSIRO
Software Developer
NatHERS Administrator
Software tool seeking
M1 1
Review documentation relating to Software Accreditation Protocol
M1 2
Provide access to:
• Chenath, AccuRate and AccuBatch software
• How to write a scratch file
M1 3
Submit EOI form, incl.:
• software tool description
• implementation timetable
• Terms & Conditions noted
• licence to access CSIRO s'ware
M1 4
Review EOI
Further information required
Suitable
M1 5
Address feedback / queries
M1 6
• Confirm and proceed with Method 1 testing
• Provide test pack
M1 7
Conduct Method 1 testing (Dwelling 110) & submit:
• Accreditation application form
• Test results spreadsheets
M1 8
Submit test results speadsheet
M1 9
Review results against benchmark
Further information required
Requirements met
M1 10
Address feedback / queries
M1 11
Confirm and proceed with Method 2 testing


Darwin
Weipa
Katherine
Wyndham
Willis Island
Atherton
Cairns
Broome
Halls Creek
Townsville
Tennant Creek
Pt Hedland
Mt Isa
Mackay
Learmonth
Newman
Alice Springs
Longreach
Rockhampton
Gladstone
Carnarvon
Giles
Charleville
Meekatharra
Oodnadatta
Maleny
Brisbane
Oakey
Toowoomba
Moree
Coffs Harbour
Kalgoorlie
Forrest
Roxby Downs
Woomera
Cobar
Perth
Bickley
Swanbourne
Ceduna
Dubbo
Williamtown
Esperance
Katanning
Orange
Blue Mountains
Parramatta
Albany
Mildura
Adelaide Coastal (AMO)
Nowra
Wagga
Canberra
Cabramurra (old Alpine)
Sub-Alpine (Cooma Airport)
Mt Gambier
East Sale
Warrnambool
Cape Otway
Low Head
Launceston (Ti Tree Bend)
Launceston Airport
Hobart

Long Span, Low Carbon Floor Systems

- Project #18



crc# 18

Long Span, Low Carbon Floor Systems (Scoping Study)

Project Overview

13.10.21

Lendlease

Sumitomo Forestry

Building 4.0 CRC

Future Building Initiative

Monash University

University of Melbourne

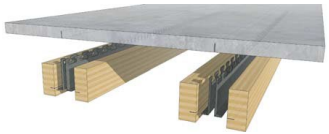
objectives Understand the research and market developments in long span, low carbon floor systems

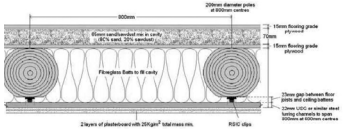
Provide a framework to inform future design work in the development of such systems.

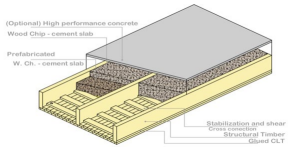
methods Market search and literature review

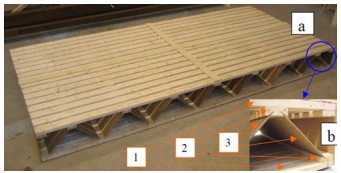
Benchmarking to **identify, evaluate** and **compare** existing systems according to a number of selected criteria.

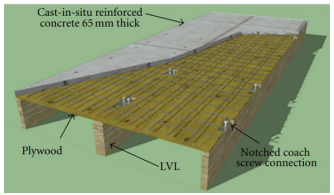
project objectives + methods

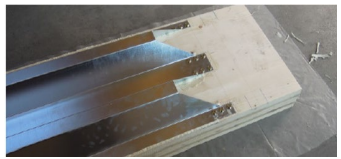


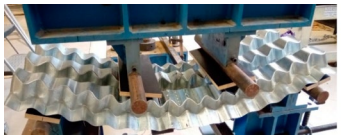


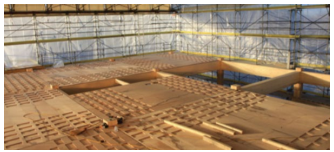


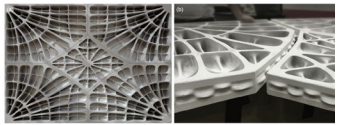






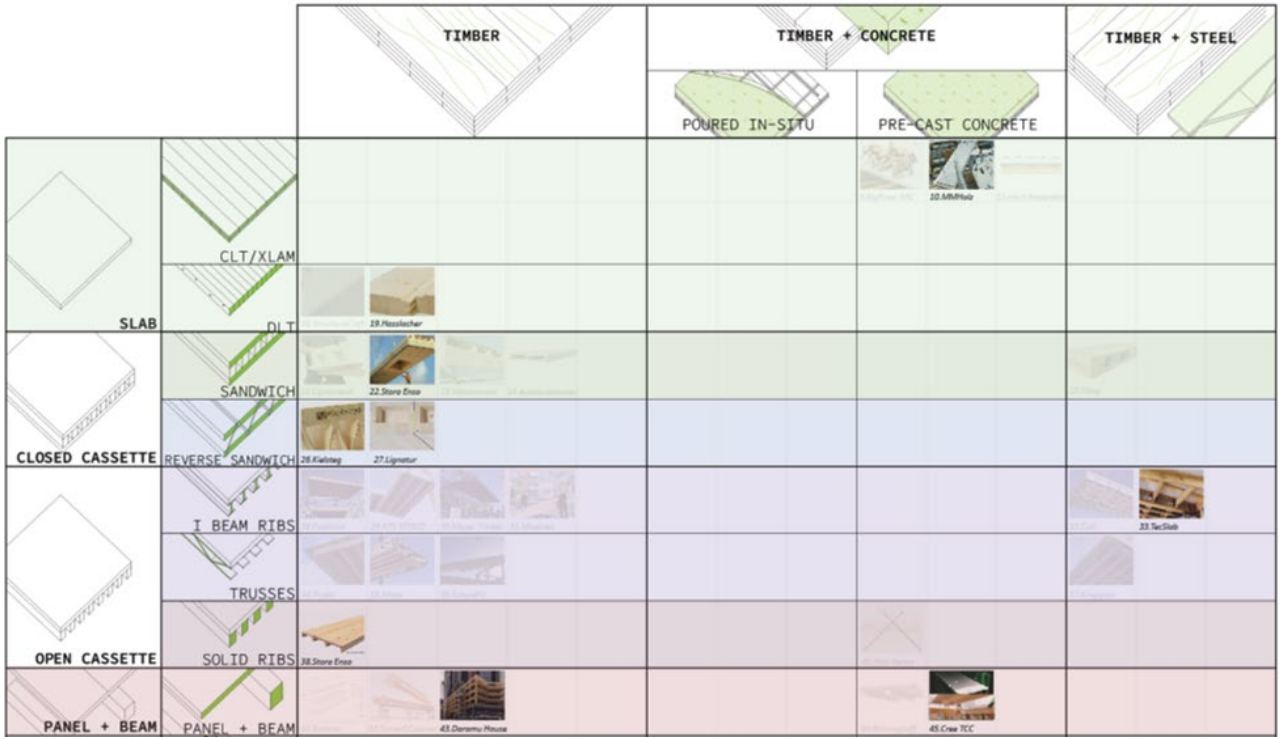




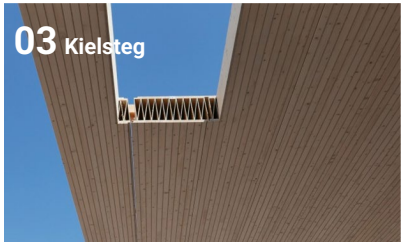


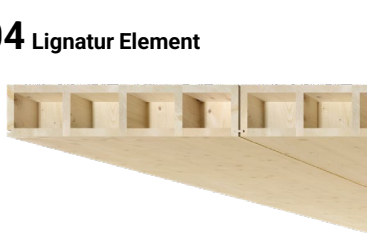
floor system design

literature review



element typology



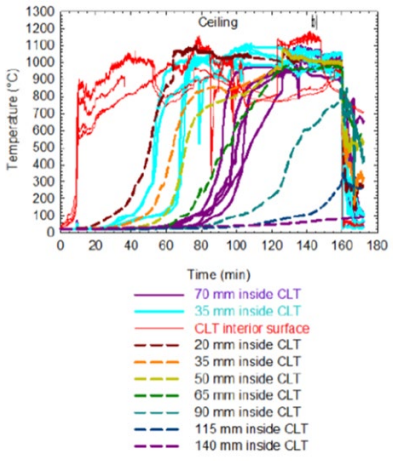


timber only

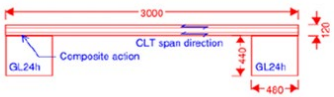
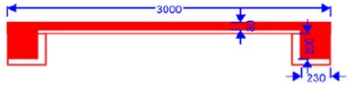
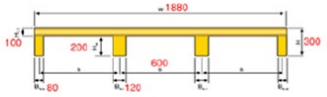
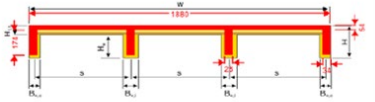
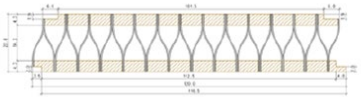
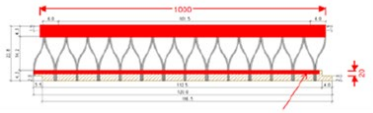
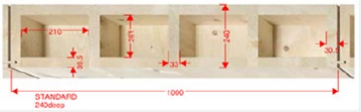
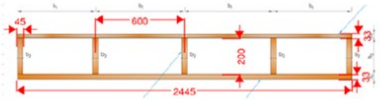
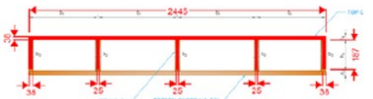
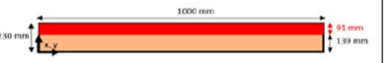
composite

systems selected

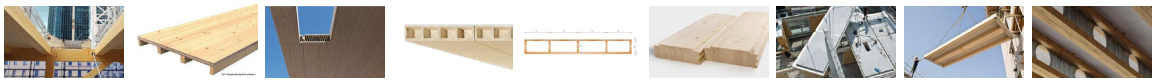
fire



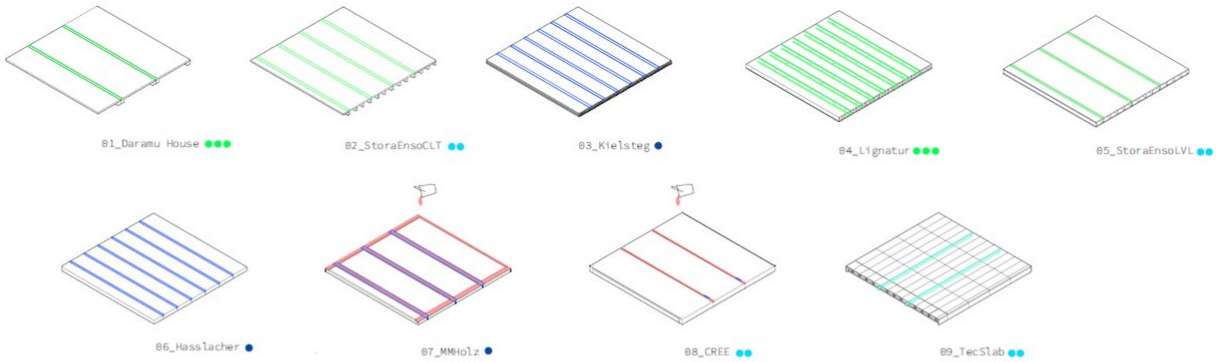
+

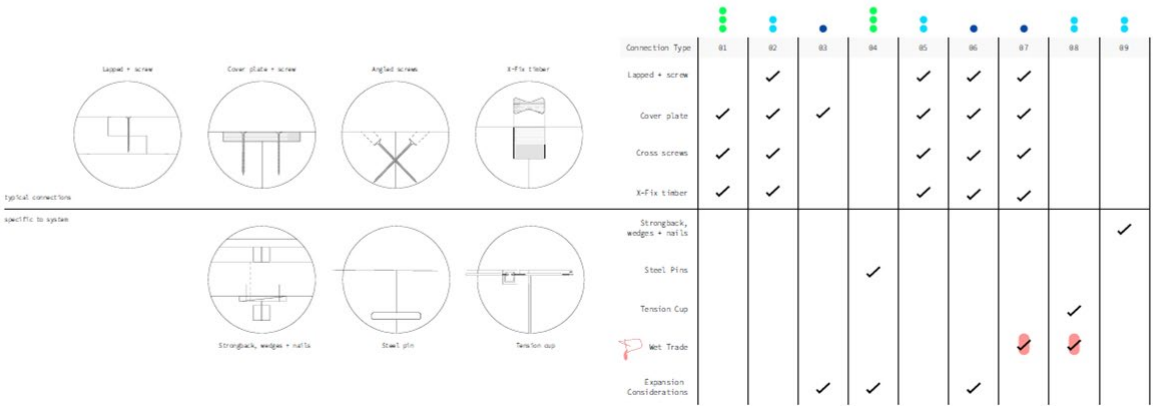
#	System	SLS structural design	ULS structural design
1	Lendlease: Daramu house updated		
2	Stora Enso: CLT Rib Panel Cassette		
3	Kielsteg: Plywood/OSB Curved Web Ribs		
4	Lignatur: Closed Rib-deck		
5	Stora Enso: LVL Closed Rib-Panel		
6	Hasslacher: Glue Laminated Timber Floor System		

method

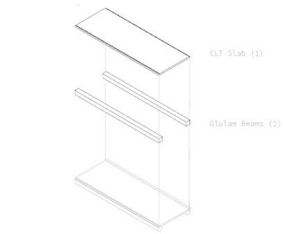


01 02 03 04 05 06 07 08 09

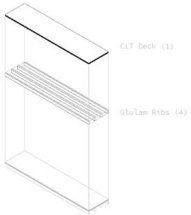




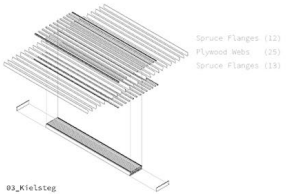
element to element connection



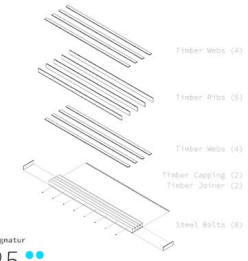
01_Daramu House
3 Components per Element
2 Types of Component



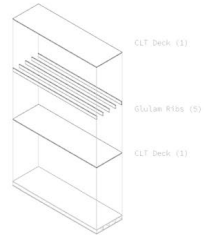
02_StoraEnso CLT
5 Components per Element
2 Types of Component



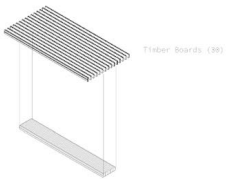
03_Kielsteg
52 Components per Element
3 Types of Component



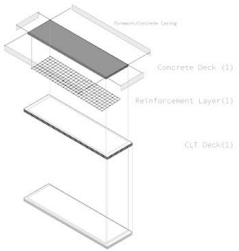
04_Lignatur
25 Components per Element
6 Types of Component



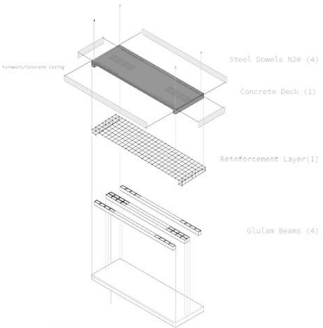
05_StoraEnso LVL
7 Components per Element
2 Types of Component



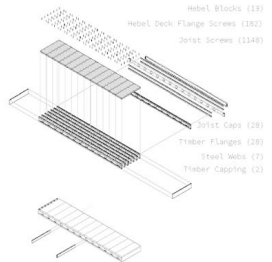
06_Masslacher
30 Components per Element
1 Types of Component



07_MMHolz
50 Components per Element
3 Types of Component



08_CREE
59 Components per Element
4 Types of Component



09_TecSlab
332 Components per Element (1445 Inc. screws)
7 Types of Component

factory production

pr

de

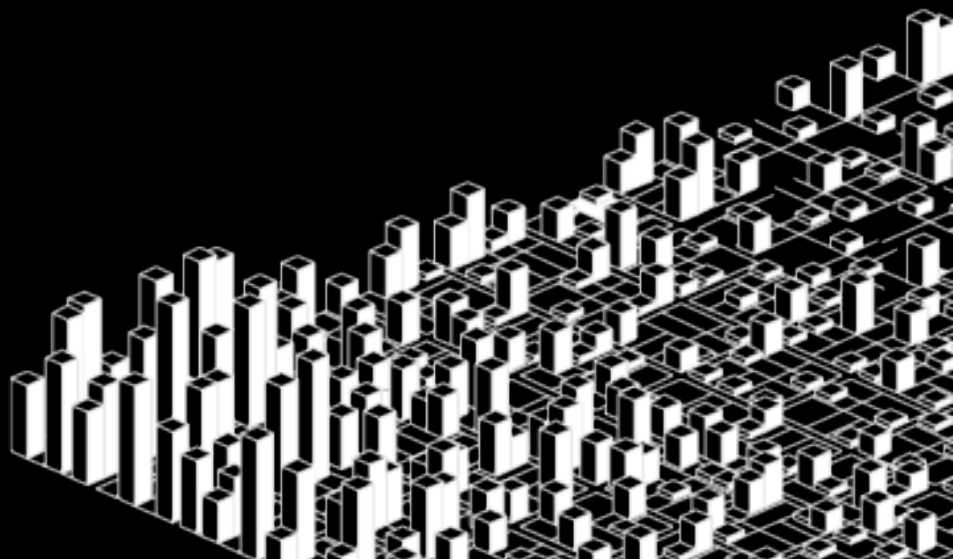
System ID		Quantitative	Quantitative	Quantitative	Quantitative	Quantitative	Quantitative	Mixed (Quant + Qual)	Qualitative	Mixed (Quant + Qual)	Mixed (Quant + Qual)	Mixed (Quant + Qual)	Mixed (Quant + Qual)
		Production	Production	Design	Design	Design	Design	Design	Design	Design	Design	Design	Design
		Floor area per truck delivery	Total lifts 8x8m x 8 storeys (unloading + lifting)	Material volume per 8x8m	Floor Depth with Services (1D reticulation)	Floor Depth with Services (Partial 2D reticulation)	Floor Depth with Services (2D reticulation)	Dimensional + Geometric Flexibility	Aesthetic Potential	Factory Processes	Site Installation	Varied Connection Design	Element to Element Connection
		NORMALISED RANK (1-9)	NORMALISED RANK (1-9)	NORMALISED RANK (1-9)	NORMALISED RANK	NORMALISED RANK	NORMALISED RANK (1-9)	TIERED RANK (1-3)	TIERED RANK (1-3)	TIERED RANK (1-3)	TIERED RANK (1-3)	TIERED RANK (1-3)	TIERED RANK (1-3)
1	Daramu House	6	1	8	3	1	1	1	1	1	1	2	1
2	Stora Enso CLT Open Rib Panel	6	4	3	2	1	1	1	1	1	1	1	2
3	Kielsteg Closed Curved Rib Panel	1	6	4	5	4	4	2	2	3	2	1	3
4	Lignatur Close Rib Panel	4	9	1	1	1	5	2	1	2	3	1	1
5	Stora Enso LVL CLosed Rib Panel	1	2	1	2	2	5	1	2	1	1	1	2
6	Hasslacher Timber Slab	1	8	7	5	4	4	2	2	2	2	1	3
7	MMHolz Timber-Concrete Slab	9	2	9	6	6	6	2	2	2	1	2	3
8	CREE Timber-Concrete	8	1	5	3	4	7	3	1	2	3	3	2
9	TecSlab Cassette	9	4	2	9	9	9	3	3	3	3	2	2

normalised ranks per criteria + qualitative tiered system

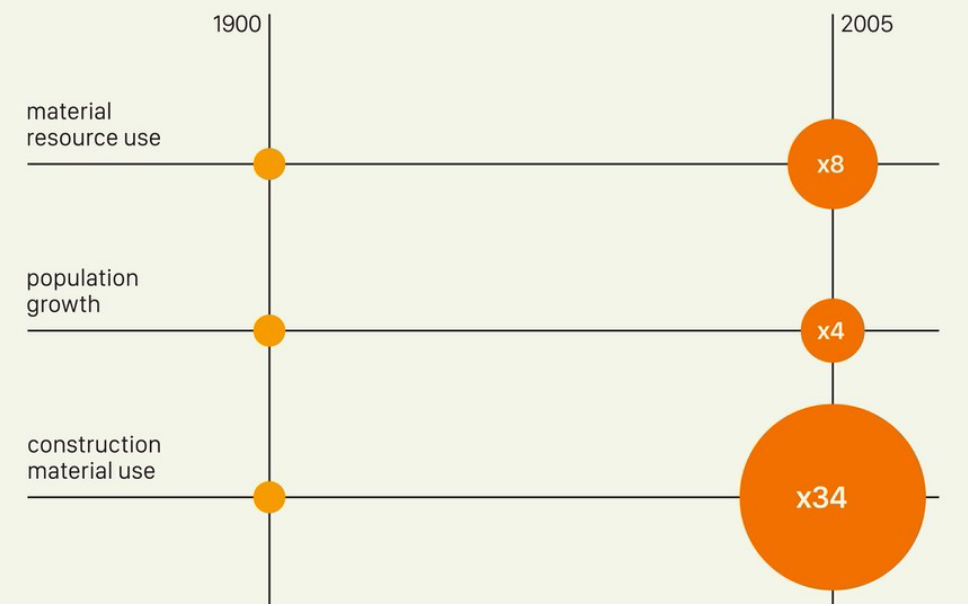
fbi

Circular Economy Roadmap for the Construction Industry

- Project #48



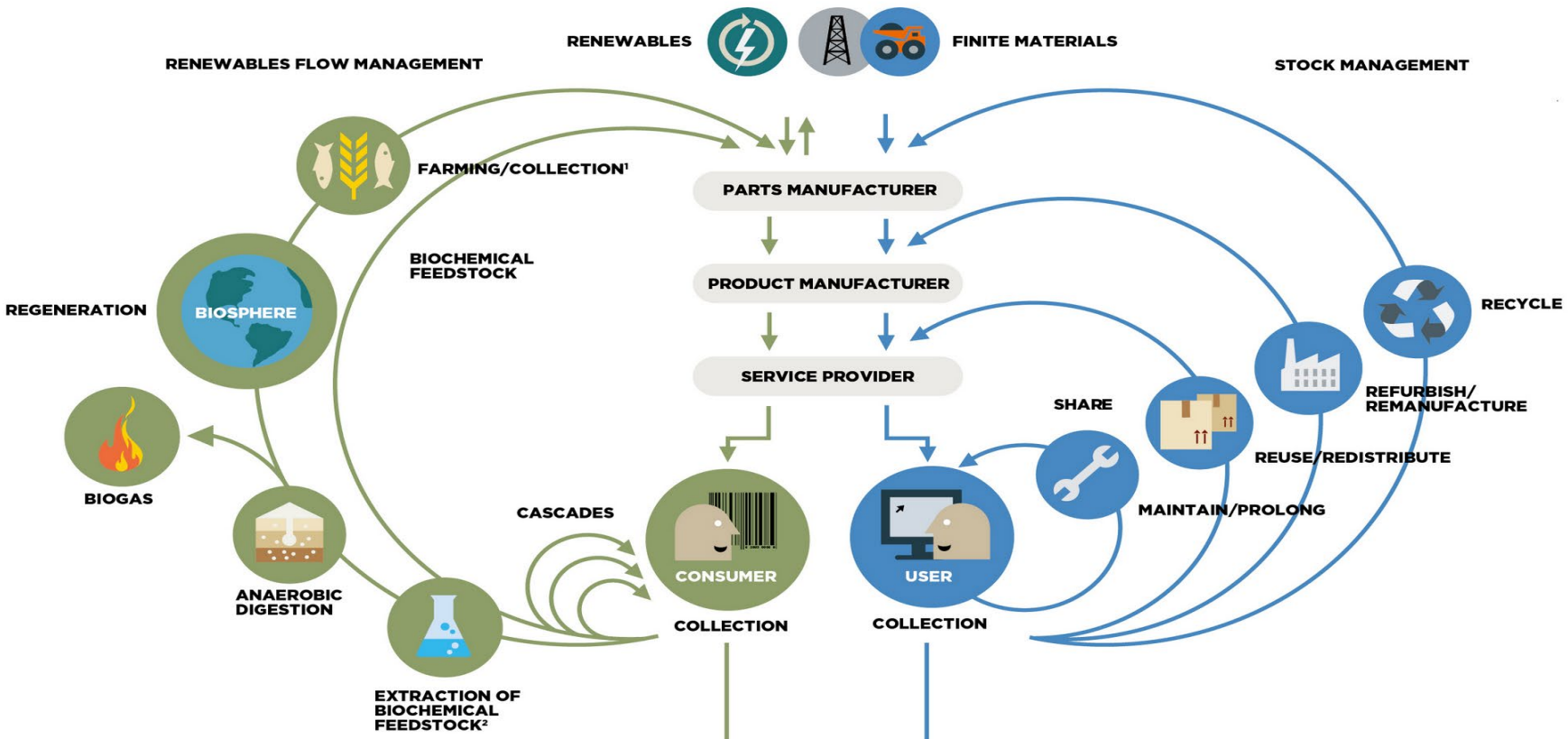
BUILDING AND CONSTRUCTION IMPACT



Sources: OECD, World Bank, UN websites, GlobalABC, One Planet SBC

RMIT UNIVERSITY

One planet build with care



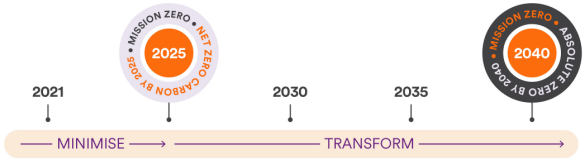
1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input

SOURCE
Ellen MacArthur Foundation
Circular economy systems diagram (February 2019)
www.ellenmacarthurfoundation.org
Drawing based on Braungart & McDonough, Cradle to Cradle (C2C)

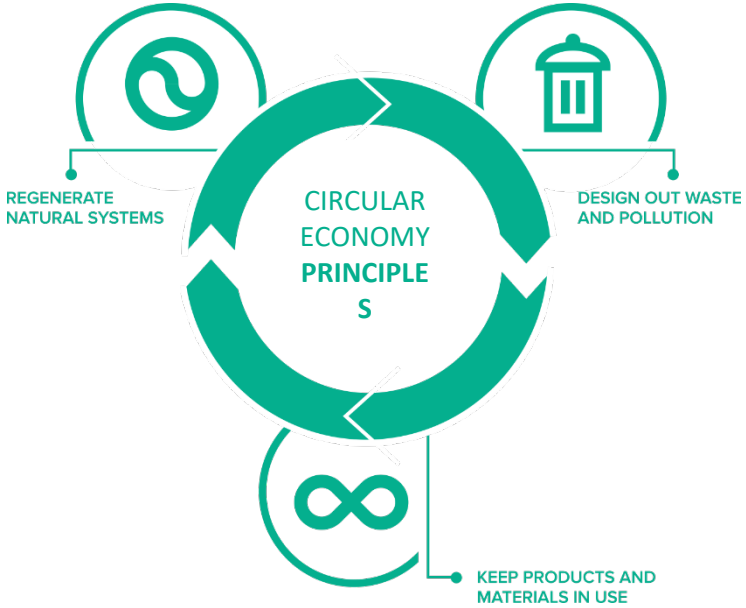
ELLEN MACARTHUR FOUNDATION

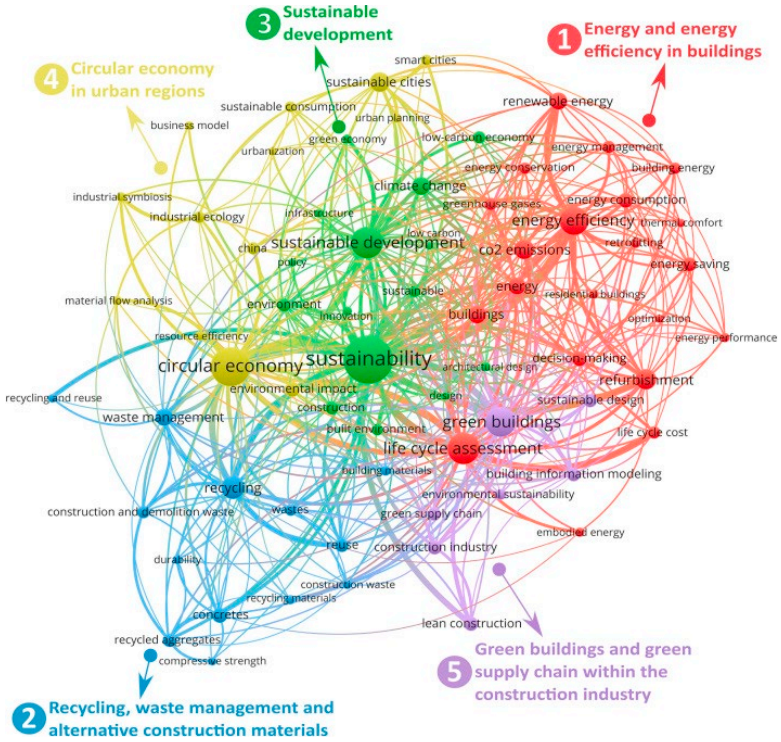
MISSION ZERO ROADMAP

LENDLEASE AUSTRALIA
SUMMARY



	INITIATIVES	OUTCOMES
Fuels we burn SCOPE 1	Use alternative fuels in and electrify construction activities	Zero use of fossil fuels in construction
	Remove reliance on fossil fuels in building services design	100% all electric designs for Lendlease developments
	Retrofit assets under management to remove reliance on fossil fuels	100% base build fossil fuel free assets
	Minimise and set strategy for zero emissions from refrigerants	Zero emissions from refrigerants by 2040
Power we consume SCOPE 2	Drive energy efficiency & set energy use intensity targets	Achieve energy intensity targets
	Optimise onsite renewable energy generation	All developments, assets & off grid sites with onsite renewables
	Optimise energy storage and smart grid analytics	All developments, assets & off grid sites with energy storage
	Purchase and / or generate offsite renewable electricity	100% renewable electricity purchase or dedicated generation
Materials and services we buy SCOPE 3	Collaborate with suppliers & designers to eliminate embodied carbon	Lead industry transformation in embodied carbon in materials
	Set annual embodied carbon standard using circular economy principles	100% of projects meeting zero embodied carbon design standard
	Request embodied carbon reduction & elimination from suppliers	All supplier contracts include zero carbon requirements
	Measure and report scope 3 emissions	Publish scope 3 emissions from 2025
Tenant emissions SCOPE 3	Work with residents & tenants to purchase renewable electricity	100% renewable electricity use by 2030 (tenants) 2040 (residents)
	Progressively remove fossil fuels for tenant & residents in existing assets	100% fossil fuel free assets
	Provide onsite renewable electricity & storage to residents & tenants	All assets include resident & tenant onsite renewable energy & storage
	Provide electric vehicle charging points at assets under management	EV charging available at all assets & developments
	Measure, report and reduce waste	Zero emissions from waste to landfill


REGENERATE
NATURAL SYSTEMS
CIRCULAR
ECONOMY
PRINCIPLE
S
DESIGN OUT WASTE
AND POLLUTION
KEEP PRODUCTS AND
MATERIALS IN USE


3 Sustainable development
1 Energy and energy efficiency in buildings
4 Circular economy in urban regions
2 Recycling, waste management and alternative construction materials
5 Green buildings and green supply chain within the construction industry
sustainable development
sustainability
circular economy
energy efficiency
green buildings
life cycle assessment
recycling
waste management
sustainable cities
renewable energy
climate change
co2 emissions
buildings
lean construction
construction industry
concretes
recycled aggregates
compressive strength
construction and demolition waste
material flow analysis
industrial symbiosis
industrial ecology
business model
urbanization
sustainable consumption
green economy
urban planning
smart cities
energy conservation
energy management
building energy
energy consumption
thermal comfort
retrofitting
energy saving
residential buildings
optimization
energy performance
decision making
refurbishment
sustainable design
life cycle cost
building information modeling
environmental sustainability
embodied energy
green supply chain
construction waste
recycling materials
durability
reuse
resource efficiency
recycling and reuse
environmental impact
construction
built environment
building materials
wastes
design
architectural design
innovation
environment
policy
china
low carbon
greenhouse gases
infrastructure

THANK YOU

C.KNAPP@BUILDING40CRC.ORG