TRANSFORMING
CONSTRUCTION
NETWORK PLUS
THE TRANSFORMING CONSTRUCTION NETWORK PLUS (N+)

Stimulating participation, facilitating collaboration, and encouraging exploration

The N+ unites construction’s academic and industrial communities to create a new research and knowledge base, dedicated to addressing the systemic problems holding back the sector.

More information about the N+ can be find:
THE TRANSFORMING CONSTRUCTION NETWORK PLUS

- The N+ is funded by UK Research and Innovation through the Industrial Strategy Challenge Fund
- It is supported by UK Research & Innovation (UKRI) funding

The aim of the N+ is to provoke, enable and amplify innovation, through four main objectives:

- Knowledge
- Community building
- Business models
- Investment and legacy
RETHINKING THE BUSINESS MODEL FOR OFFSITE CONSTRUCTION

Dr Daniel M. Hall
Assistant Professor of Innovative and Industrial Construction at ETH Zurich.

Dr Wei Pan
Executive Director of Centre for Innovation in Construction and Infrastructure Development and Associate Professor in Construction Engineering & Management at The University of Hong Kong.

Prof Jennifer Whyte
Laing O'Rourke/RAEng Chair in Systems Integration, Department of Civil and Environmental Engineering, Imperial College London.
Co-Investigator of the Transforming Construction Network Plus
New business models for offsite construction
Transforming Construction Network Plus Webinar
29 May 2019

Prof. Daniel M. Hall
Chair of Innovative and Industrial Construction
@daniel_hall_ethz | dhall@ethz.ch | ETH Zürich

(images courtesy nArchitects and MIR studio (left), NCCR dfab (right))
About Me

- PhD Civil Engineering Stanford University 2017
- Founder of Industrialized Construction Forum at Stanford (www.indconstructionforum.com)
- Visitor to Imperial College in Autumn 2016
- 3 years industry experience (contractor)
- Assistant Prof. of Innovative and Industrial Construction @ ETH Zürich since 2018 (http://www.ic.ibi.ethz.ch/)

Prof. Daniel M. Hall
What is Industrialized Construction?

Is it more than just...?
Industrialized Construction

Advanced IT tools
Logistics
Automation
Product Platform
Prefabrication
Customer & Market Focus
Control of Process
Re-use of Experience
US Market: More Investment

IC Investor Funding Each Year Since 2004

(Pullen, Hall & Lessing 2019)

Read more!
www.bit.ly/IC_whitepaper
Construction startup Katerra gets $865M in Softbank’s latest mega-round

Matthew Lynley @mldntype / Jan 24, 2018

There’s another big financing round led by Softbank’s mammoth vision fund today, with the firm this time pouring $865 million into a construction startup called Katerra that’s a one-stop shop for getting a building up off the ground.

Katerra is creating a full-stack provider for, well, buildings. The company runs the process of getting a building up and people inside it from the architectural design components all the way through labor.

Exclusive: Airbnb will start designing houses in 2019

Airbnb wants to get into the housing business in a big way.

Amazon makes first investment in a homebuilder, backing start-up focused on prefabricated houses
How are firms organizing for industrialized construction?
1) Spinoff from project-based firm

DPR Construction
1) Spinoff from project-based firm
1) Spinoff from project-based firm

- Little change to established business
- Structured learning process

- Slower implementation
- Must re-educate supply chain

(Image courtesy digitalbuilding.com)
2) Vertical Integration

- Full-stack product integration
- Speed to capture market share

- Capital-intensive

(Image + video courtesy katerra.com)
3) Digital Systems Integration

(images courtesy projectfrog.com)
3) Digital Systems Integration

(video courtesy http://myprojectfrog.com/videos.html)
3) Digital Systems Integration

- Capital-light, Industry 4.0
- Agile Development

- Less control over product
- Longer co-creation process

Manufacturing
Bill of Materials
Component Model (LOD 400)
Shop Drawings

Permit & Construction
Structural Calculations
Architectural Drawings
Structural Drawings

(video courtesy http://myprojectfrog.com/videos.html)
## Comparison

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<tr>
<td><strong>Spinoff</strong></td>
<td>• Little change to business</td>
<td>• Slower implementation</td>
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<td></td>
<td>• Structured learning process</td>
<td>• Re-educate supply chain</td>
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<tr>
<td><a href="#">Digital Building Components</a></td>
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<td><strong>Vertical</strong></td>
<td>• Full-stack integration</td>
<td>• Capital-intensive</td>
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<tr>
<td><a href="#">KATERRA</a></td>
<td>• Speed to capture market</td>
<td></td>
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Product Platforms

Rules and Restraints Transferred Upstream

- Design & Customer Acquisition
- Configuration Engineering
- Manufacturing & Production
- Assembly & Logistics

Information Transferred Downstream

(Adapted from Malmgren et al. 2011)
Kit of Parts

Platform

Project Kit

Projects
From BIM-as-input to BIM-as-output

- **BIM**
  - Coordination
  - Information loss
  - .IFC Model(s)
    - Coordination
    - Information loss
    - Shop Drawings for Fabrication
      - Information loss
- **Other Project Constraints**
  - Permit & Coordination (manual)
    - Structural Calcs
    - Arch. Drawings
    - Structural Drawings
  - Construction Sequencing
    - 4D BIM / VICO / Synchro

Information loss
From BIM-as-input to BIM-as-output

- BIM
  - .IFC Model(s)
    - Shop Drawings for Fabrication
      - Construction Sequencing
      - Structural Calculations
      - Architectural Drawings
      - Structural Drawings
    - Coordination
  - Other Project Constraints
    - Permit & Coordination (manual)
      - Structural Calcs
      - Architectural Drawings
      - Structural Drawings
    - Information loss
  - Permit & Coordination (automated)
  - Cloud-based Design Platform / Configurator (embedded Manufacturing & Assembly constraints)
    - Manufacturing
      - Bill of Materials
      - CNC or other digital Fab. script
    - Assembly
      - Construction Sequencing
      - Robotic Assembly script
  - BIM design studio (Revit)

Information loss
Factory bespoke prefabrication

(courtesy NCCR dfab YouTube channel)
DFAB HOUSE, a Building-scale Demonstrator of Digital Fabrication

Img.: K. Graser, NCCR Digital Fabrication
Digital Fabrication & Robotics

Offsite / Industrialized Construction
Digital Fabrication & Robotics

Platforms and Mass Customization
Digital Fabrication & Robotics

Platforms and Mass Customization
Thank you!

Connect: dhall@ethz.ch OR @daniel_hall_ethz

Group page: http://www.ic.ibi.ethz.ch/
Modular Integrated Construction (MiC):
Hong Kong Perspective and Strategy

Dr Wei Pan
Executive Director, Associate Professor
Centre for Innovation in Construction and Infrastructure Development (CICID)
Department of Civil Engineering
The University of Hong Kong
29 May 2019

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CICID (Centre for Innovation in Construction and Infrastructure Development)

- Established in 2002
- Vision: To achieve excellence and innovation in construction and infrastructure research with a desire to contributing to the advancement of the practice and improvement of performance of the construction and infrastructure sector in Hong Kong and around the world
- 40 post-doc/doctrinal researchers (over 100 trained)
- Over 80 research projects
Background & Motivations

High-rise high-density

Health & Safety Issues

Increasing tender price
(Courtesy of RLB, 2017)

High construction cost

Aging workforce

<table>
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<tr>
<th>Year</th>
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<th>30 to 39</th>
<th>40 to 49</th>
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</table>
Modular & Offsite Construction: Concepts Flooding

Offsite Manufacture
- Modular Construction
- Modular Building
- Preassembly
- Offsite Construction

Prefabs
- Prefabricated Prefinished Volumetric Construction

Offsite Production
- Modern Methods of Construction
- System Building
- Modern Integrated Construction (MiC)

Prefabrication
- Modular Integrated Construction (MiC)

Industrialised Building
- Volumetric Construction
- Offsite Fabrication
- Design for Demolition
- Design for Maintenance

Non-traditional Building
- Design for Manufacturing & Assembly
### Categorisations of Offsite Terminologies by Affix

<table>
<thead>
<tr>
<th>Terminology *</th>
<th>Representative literature</th>
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<td>Offsite Production (OSP)</td>
<td>Gorgolewski <em>et al.</em> (2002); prOSPa *</td>
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<td>Offsite Manufacturing (OSM)</td>
<td>Ong (2004); Venables <em>et al.</em> (2004)</td>
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<td>Offsite Fabrication (OSF)</td>
<td>Gibb (1999); Housing Forum (2002);</td>
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<td>Parry <em>et al.</em> (2003)</td>
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<td>Sparksman <em>et al.</em> (1999)</td>
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<td>Prefabrication</td>
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<td>White (1965)</td>
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<td>Prefabulous</td>
<td>Birkbeck and Scoones (2005)</td>
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<td><strong>MM-category terms</strong></td>
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<td>Modern Methods of House Construction</td>
<td>Ross (2005)</td>
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<td>System Building</td>
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<td>Non-traditional Building</td>
<td>Ross (2002)</td>
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<tr>
<td>Industrialised Building</td>
<td>CIDB (2003); McCutcheon (1989); Sarja (1998)</td>
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#TCNPlus
A Model of Concepts of Modular and Offsite Construction

MiC: The Highest Level of the Spectrum

Level 4

Offsite 60-90%
Modular building form the actual structure and fabric of buildings

Level 3

Offsite 30-50%
Volumetric pre-assembly Installed within or onto another building

Level 2

Offsite 15-25%
Non-volumetric preassembly panelised elements that do not create usable space

Level 1

Offsite 10-15%
Material, component and subassembly Always made in factories

(Developed after Pan, 2006; Gibb and Isack, 2003; Lawson et al., 2014; MBI, 2019)


#TCNPlus
Modular Integrated Construction

• The process of modularising fragmented site-based construction elements, components and facilities to integrated prefinished modules to best suit value-driven production and assembly; should not be simply understood as 3D volumetric modules.

• The process of integrating different construction activities and players in the vertical design and supply chains and of integrating various functions and stakeholders in the lateral institutional settings.

• The life cycle based whole process covering planning, design, production, construction, facility management, but not site construction per se

• So as to allow pre-site virtual building engaging BIM for mitigated risks and post-site smart feedback engaging IoT for enhanced accountability.

Definition of MiC: A game-changing disruptively-innovative approach to transforming fragmented site-based construction of buildings and facilities into integrated value-driven production and assembly of prefinished modules with the opportunity to realise enhanced quality, productivity, safety and sustainability.

High-rise Modular Buildings: The Worldwide Trend


#TCNPlus
An Analytical Framework of MiC Innovating Higher

High-rise MiC Buildings
Structural Analysis (up to 40 storeys)

> Structural stability


> Connection analysis

Lab Test

Original as-built RC structural scheme (exclude podium)
High-density MiC Smart Logistics: BIM-GIS Integration

BIM model

Collada file

Building GIS model

IFC extraction

Installation schedule in BIM

Color-coded Building GIS model

High-density MiC Smart Logistics: Vehicle Routing Planning

The platform consists of four layers:

1. **city 3D model layer** for visualizing the city landscape and the built environment,
2. **project 3D layer** for visualizing the modular buildings and the installation status of modules,
3. **road network layer** for visualizing the road network, and
4. **logistics route layer** for visualizing the optimized traveling route of trailers to transport modules from storage yards to sites.
Higher Co-Creation via MiC Pilot Projects

Student Residence at Wong Chuk Hang Site for The University of Hong Kong

Innocell - Hong Kong Science and Technology Park

Disciplined Services Quarters for the Fire Services Department at Pak Shing Kok, Tseung Kwan O

MiC Display Centre – Construction Industry Council

Courtesy of HKU EO, ArchSD, STP and CIC
Modularisation for Modernisation (MfM)
A Strategy Paper Rethinking Hong Kong Construction

A Five-fold Systems Framework of MiC Research

Modular Integrated Construction (MiC): Hong Kong Perspective and Strategy

Thank You!

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