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Advancing Digital Supply Chains in Construction Products through Standardisation

Finnish Association of Construction Products Industries

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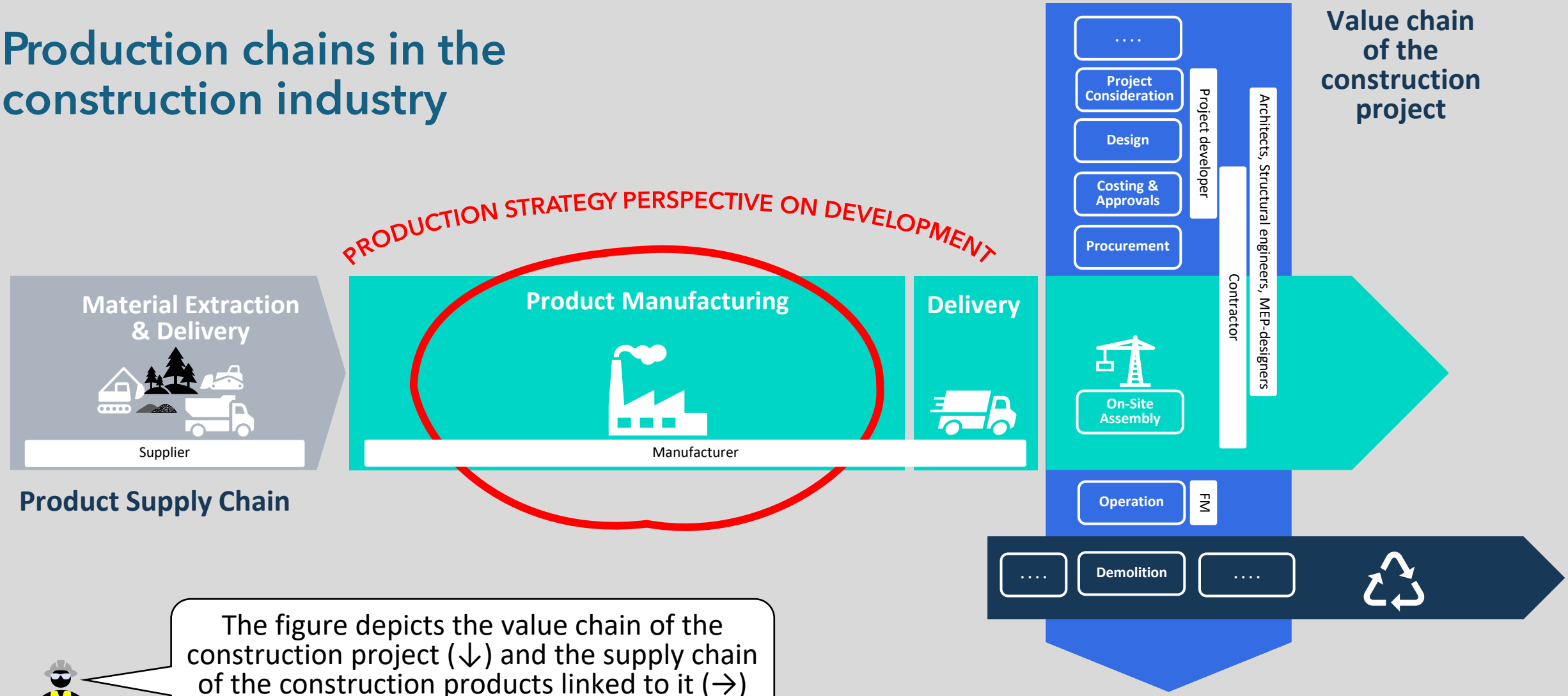
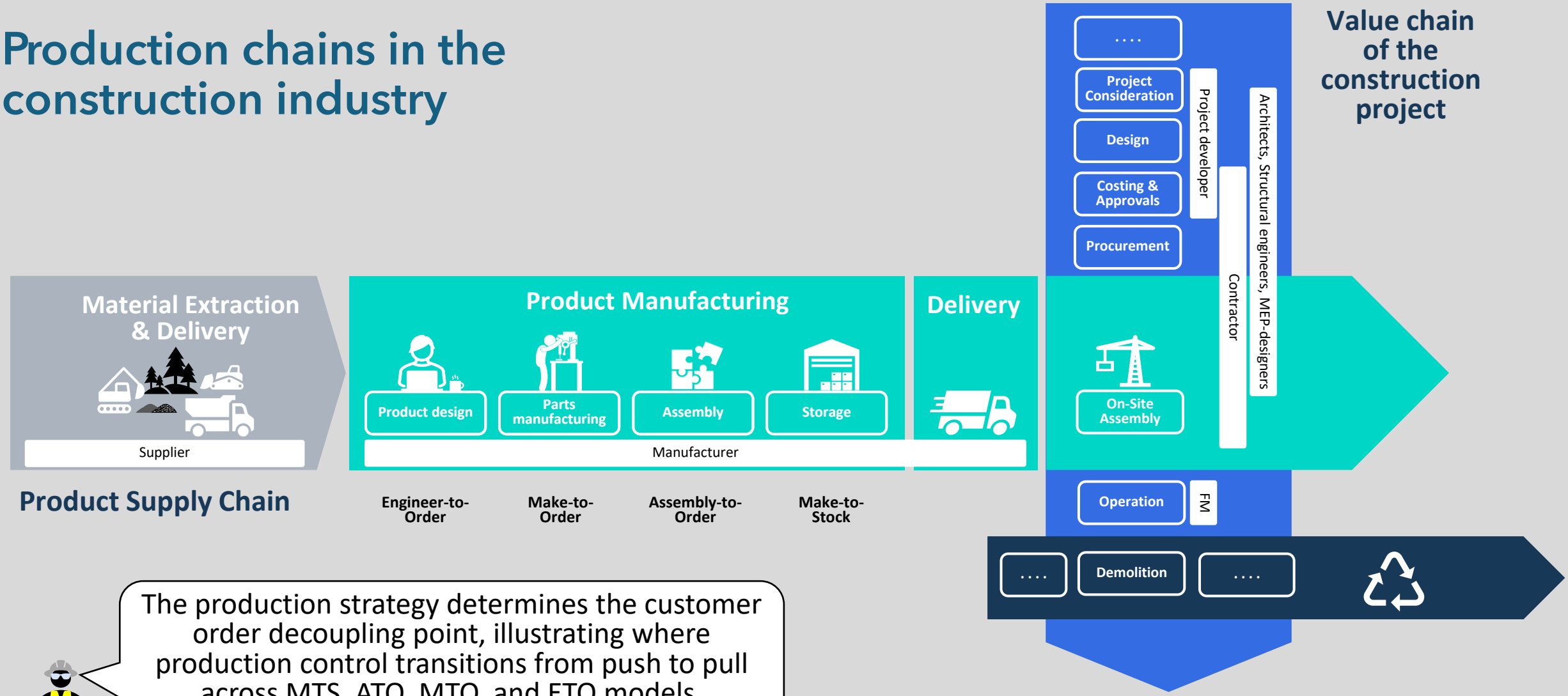
Production chains in the construction industry



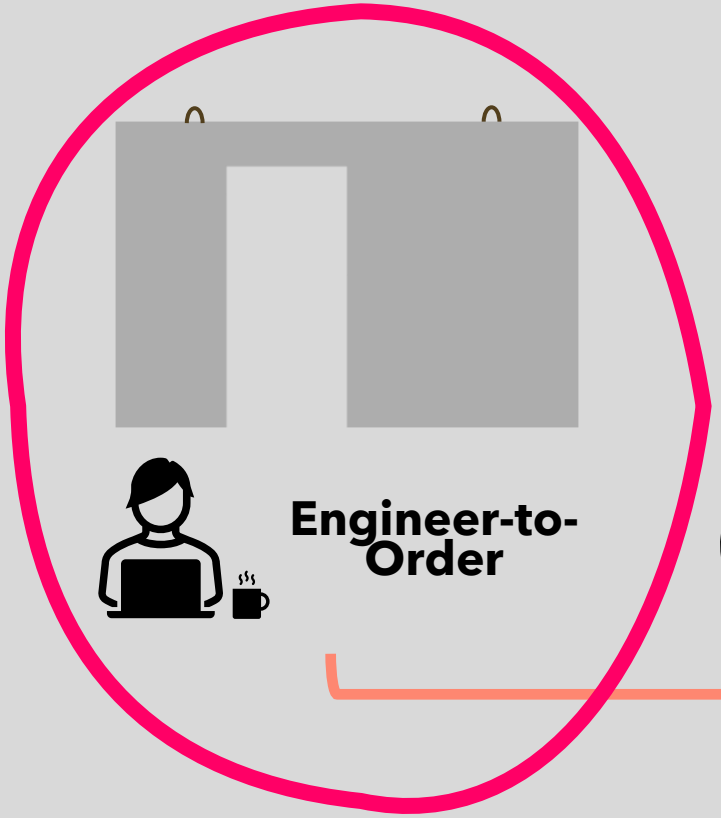
The figure depicts the value chain of the construction project (↓) and the supply chain of the construction products linked to it (→)

Production chains in the construction industry

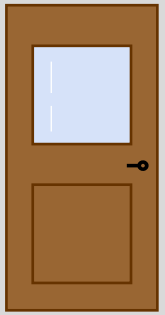


The production strategy determines the customer order decoupling point, illustrating where production control transitions from push to pull across MTS, ATO, MTO, and ETO models.

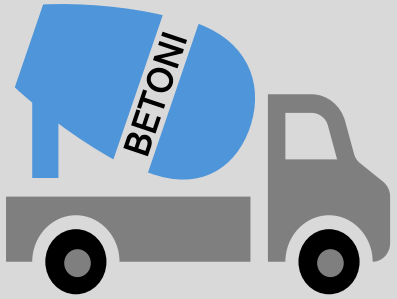
Production strategies for building products



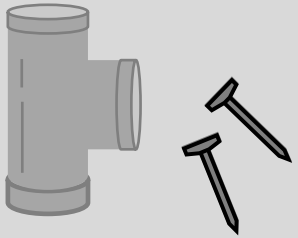
Engineer-to-Order



Make-to-Order



Assembly-to-Order



Make-to-Stock

Project-specific products

Standard products

Delivery

In Finland, we are currently working on the precast concrete supply chain as an Engineer-to-Order reference case

Current State

(Based on preliminary studies & workshops results)

- BIM data is not usable across the supply chain.
- Lack of linked building data prevents seamless information flow between stakeholders.
- Current data architecture is based on closed information exchange systems.
    - Point-to-point, customized integrations are inefficient and costly.
- Lack of interoperability between systems and platforms.
- Unstructured data (PDFs, images, phone calls, emails) dominates communication, making automation and analytics difficult.

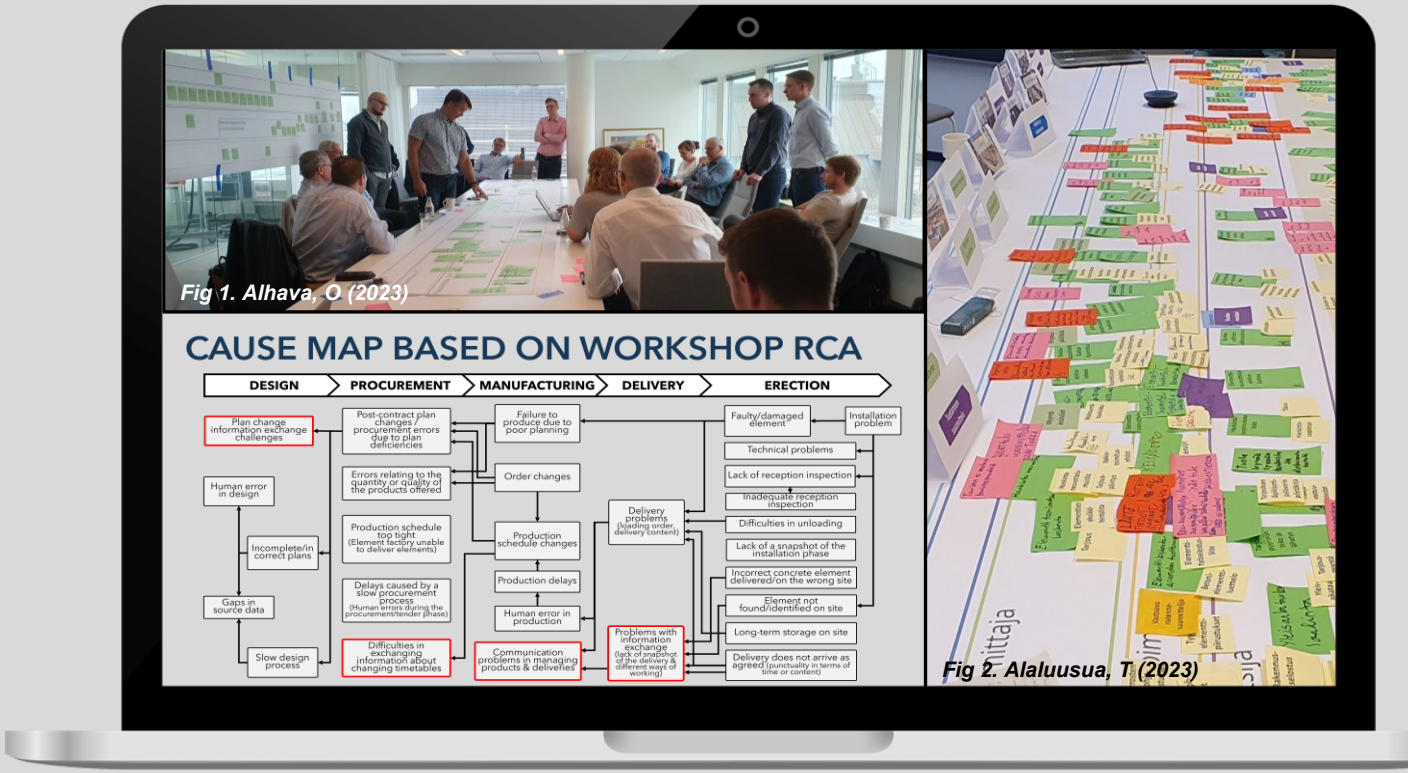


Fig 1. Alhava, O (2023)

Fig 2. Alaluusua, T (2023)

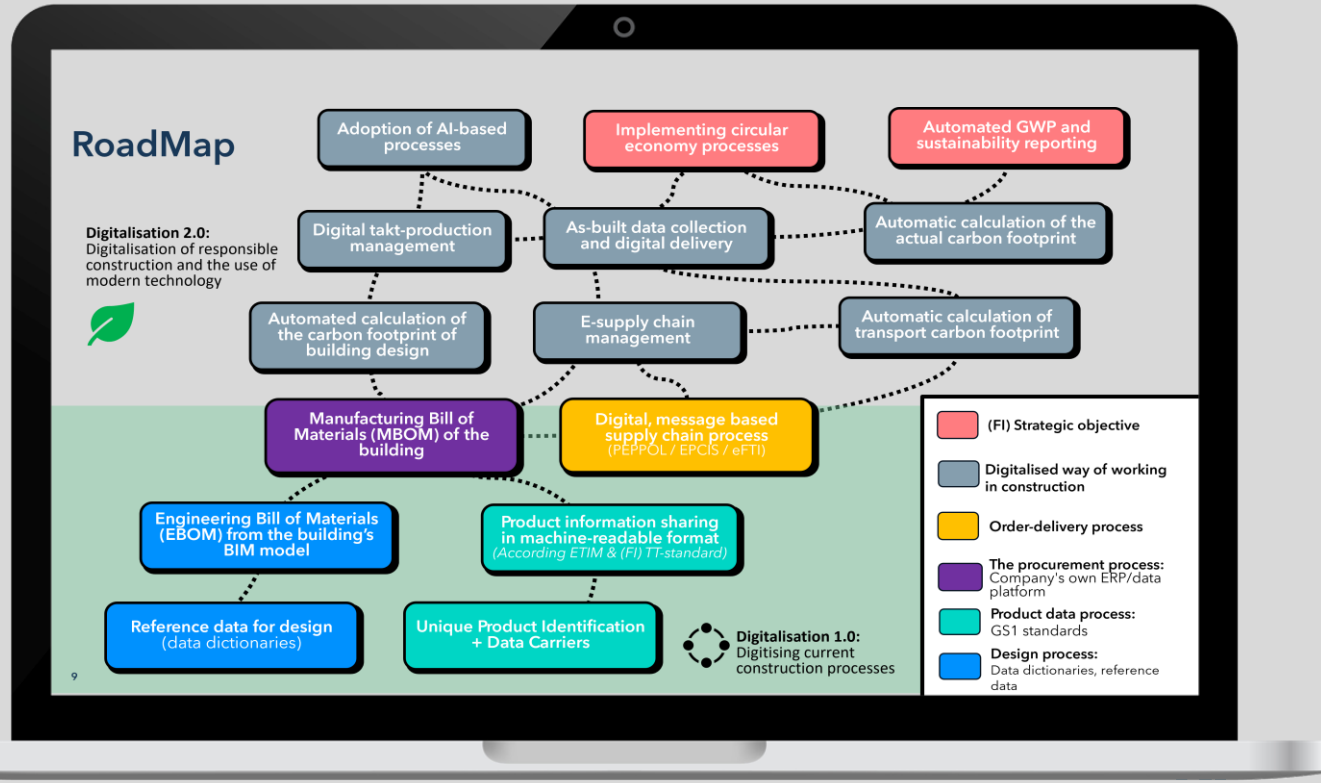
Current State → **Development roadmap** → **Future State**

Ref. *Alaluusua, T. (2023) Digital management of information exchange in takt production supply chains*

Ref. *Alhava et al. (2024) Challenges and Opportunities in Digitalising Concrete Element Supply Chain: Proposed National Model*

Development Roadmap

- Based on the current state analysis, we developed a general development roadmap that covers all production strategies.
- Our findings show that advancing digital supply chains requires the comprehensive development of operations, information management, and technology systems.
- To achieve the best results, we collaborate with experts from various organizations, including academia, industry practitioners, non-profit associations, public authorities, and IT companies.



Current State → Development roadmap → Future State

Development Roadmap

Digitalisation 2.0:
Digitalisation of responsible construction and the use of modern technology

Digitalisation 1.0:
Digitising current construction processes

Redrawn from: CC-BY 4.0: Arola, T., Alhava, O., June 12, 2024: Digitalization of the Construction Industry: Supply Chain Digitalization, RYHTI and Interoperability (presentation)

Standards to Follow in Supply Chain Digitalization

IFC
Data model –schema and format
EN ISO 16739:2024

IFD classification, SML
Data dictionaries, classification, linked data
EN ISO 12006-2:2020
EN ISO 12006-3:2022

GUID / UUID
ISO/IEC 9834-8:2005
ISO/IEC 11578:1996

Data templates, properties
EN ISO 23386:2020
EN ISO 23387:2020
EN ISO 22057:2022

LOIN
Level Of Information Need
EN ISO 7817-1:2024

Information management
Processes – how to work in the project using BIM
EN ISO 19650-1:2018
EN ISO 19650-2:2018
EN ISO 19650-3:2020
EN ISO 19650-4:2022
EN ISO 19650-5:2020
CEN/TR 17439:2020

EU DPP
XXXX XXXXX

EPD
EN ISO 14025:2018

Order-delivery process

Peppol / UBL
EN ISO/IEC 19845:2015
EN ISO/IEC 16931-1:2017

EPCIS (GS1)
GS1 EPCIS Standard:2022
GS1 CBV Standard:2022
GS1 EPCIS & CBV Guideline:2023

eFTI (EU)
CELEX 32020R1056

GS1 Standards

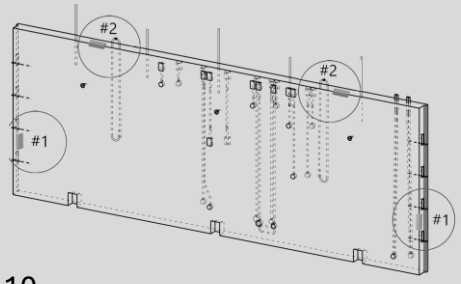
Identification
GS1 GTIN
ISO/IEC 15459-6
ISO/IEC 6523
GS1 GLN
ISO/IEC 6524
GS1 SSCC
ISO/IEC 15459-1
ISO/IEC 6523
GS1 GIAI
ISO/IEC 15459-4 & 5
ISO/IEC 6523
GS1 GSRN
ISO/IEC 15418
GS1 GRAI
GS1 GDTI

Data Capture
EAN/UPC barcode
ISO/IEC 15420
GS1 Data Matrix
ISO/IEC 16022
GS1 QR Code
ISO/IEC 18004
EPC Tag Data Standard
ISO/IEC 15962:2024

Implementation Guideline:

Unique Product Identification and Data Carriers for ETO Products

- Previously based on manufacturers' non-standardised internal codes
- A GTIN alone identifies a general product category, not a unique item
- Precast elements (ETO products) require a different approach for identification:
  - GTIN → identifies the base product type
  - MTO variant → identifies the specific variation
  - Serial number → distinguishes identical units

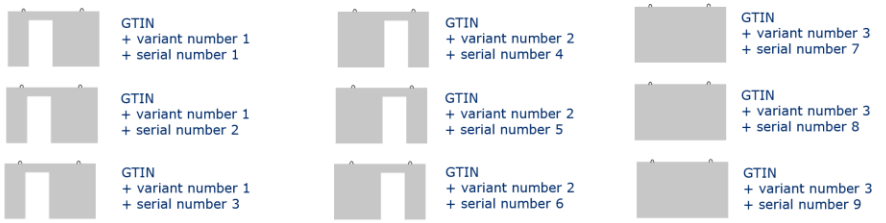


LEVELS OF PRODUCT IDENTIFICATION

Level 1
Product identification (GTIN)

Level 2
Product variation identification (GTIN + MTO Variation number)

Level 3
Individual product identification [SGTIN] (GTIN + MTO Variation number + Serial number)

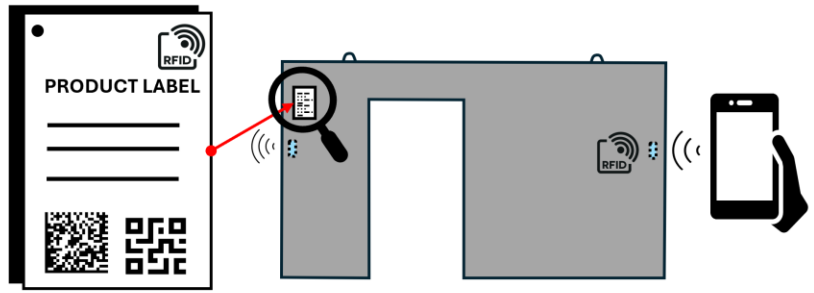


GS1 APPLICATION IDENTIFIERS (AI) TO IDENTIFY ENGINEER-TO-ORDER PRODUCT

Minimum information requirements for the identification	
(01) GTIN-koodi	06400001000247 Example
(242) Made-To-Order (MTO) variation number	123456 Example
(21) Serial number	12345678910 Example
***Additional information for precast concrete elements use case**	
(91) Finnish element classification	V1001 Example
(92) GUID	ba34cf17-0c4b-4c6f-9295-cae05aa74ad4 Example
(99) Domain name	id.rt.fi Example

DATA CARRIERS

GS1 Digital Link (2D Barcode)	**GS1 DataMatrix** (2D Barcode)	**EPC/RFID** (radio frequency remote sensing method)



Industry-specific Peppol Implementation guidelines

(Pan-European Public Procurement Online)

- **Peppol** is a **network**, not a standalone system.
- It aims to **optimize the supply chain**, not create a single central point.
- **Based on the international standard ISO/IEC 19845:2015** (UBL).
- **Already used in the construction industry** in several Nordic countries.
- **Each country may have its own Peppol Authority** responsible for national governance.
- To **connect to the Peppol network**, organizations need an **authorized Peppol service provider** and a **compatible system** (e.g., order management or ERP system).

Work in progress...

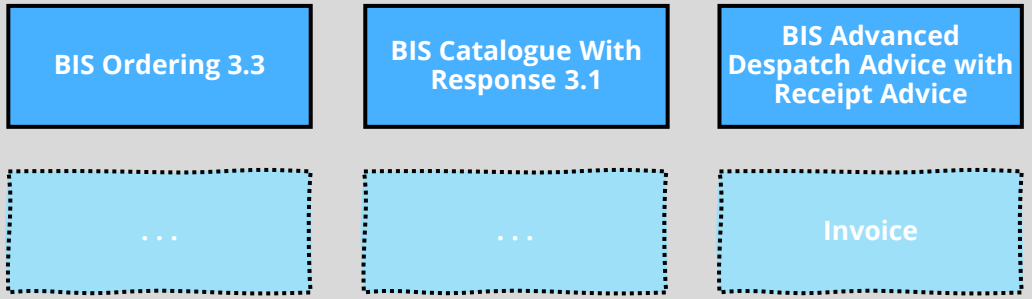
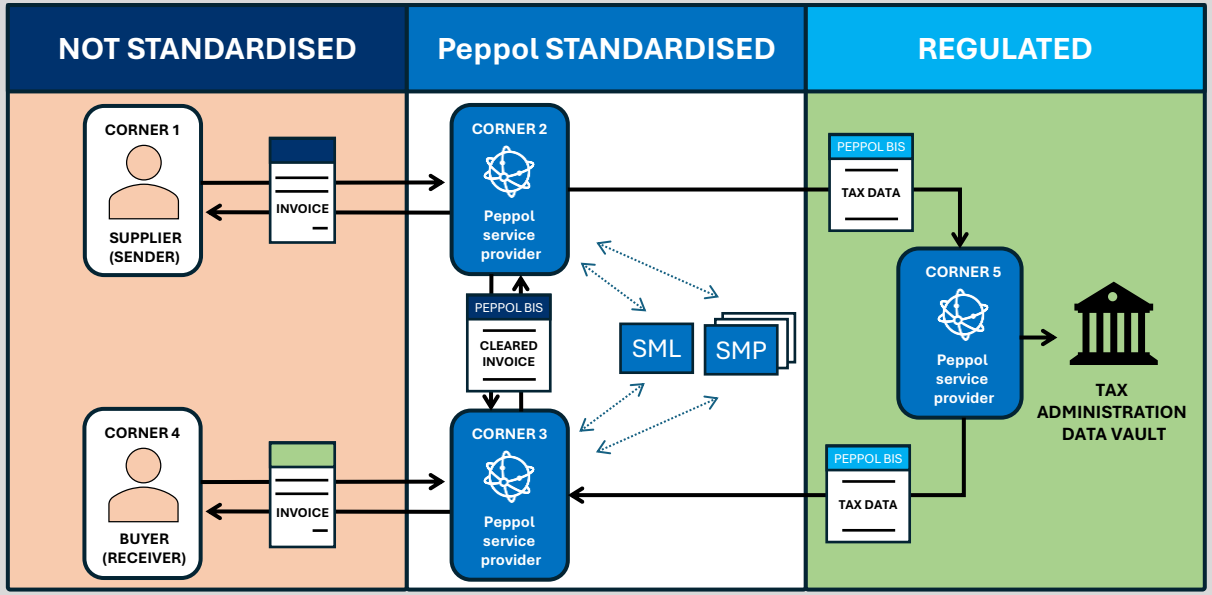


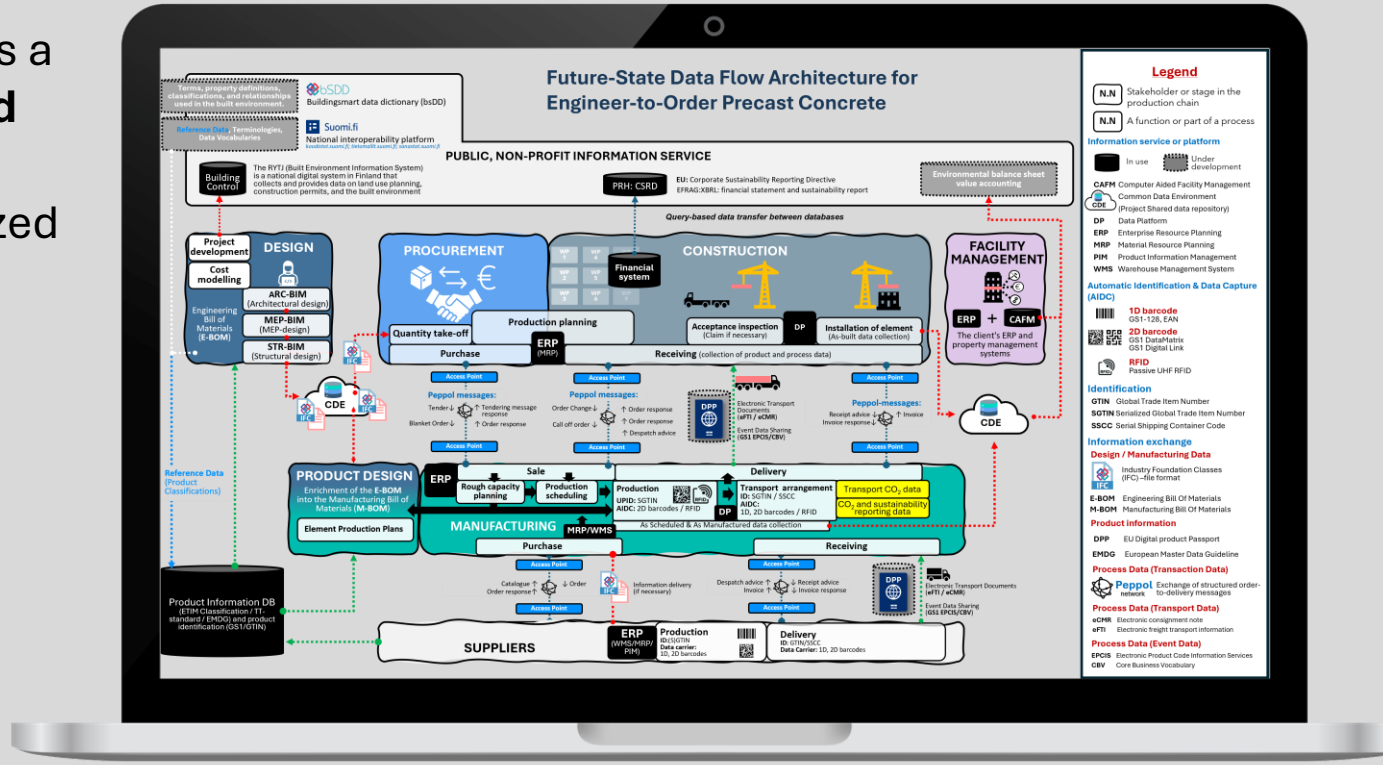
Fig. *Peppol, 5-corner model for e-invoicing (2021).*



*Service Metadata Provider (**SMP**), Service Metadata Locator (**SML**)*

Future State Data Flow Architecture for Engineer-to-Order Precast Concrete

- Our development work follows the **TOGAF framework** and the **national JHS-179 architecture principles** to build an **industry-level architecture** for different production strategies.
- The **Future State Data Flow Architecture** serves as a key representation combining **process (action) and data architecture**. It illustrates **data repositories, interfaces, and core process functions** of a digitized supply chain.
- The **data architecture diagram** functions as an **evolving artefact** throughout the development project.



Current State → Development roadmap → Future State

Future-State Data Flow Architecture for Engineer-to-Order Precast Concrete

Terms, property definitions, classifications, and relationships used in the built environment.

bSDD
Buildingsmart data dictionary (bsDD)

Reference Data, Terminologies, Data Vocabularies

Suomi.fi
National interoperability platform
koodistot.suomi.fi; tietomallit.suomi.fi; sanastot.suomi.fi

PUBLIC, NON-PROFIT INFORMATION SERVICE

Building Control

The RYTJ (Built Environment Information System) is a national digital system in Finland that collects and provides data on land use planning, construction permits, and the built environment

PRH: CSRD

EU: Corporate Sustainability Reporting Directive
EFRAG:XBRL: financial statement and sustainability report

Environmental balance sheet value accounting

Query-based data transfer between databases

DESIGN
Project development
Cost modelling
Engineering Bill of Materials (**E-BOM**)
ARC-BIM (Architectural design)
MEP-BIM (MEP-design)
STR-BIM (Structural design)

PROCUREMENT
Quantity take-off
Production planning
Purchase
ERP (MRP)

CONSTRUCTION
WP 1 WP 4 WP 7
WP 2 WP 5 WP 8
WP 3 WP 6 WP 9
Financial system
Acceptance inspection (Claim if necessary)
DP
Installation of element (As-built data collection)
Receiving (collection of product and process data)

FACILITY MANAGEMENT
ERP + **CAFM**
The client's ERP and property management systems

IFC

CDE

Access Point

Peppol messages:
Tender↓ ↑ Tendering message response
Blanket Order↓ ↑ Order response

Peppol messages:
Order Change↓ ↑ Order response
Call off order↓ ↑ Order response
↑ Despatch advice

DPP
Electronic Transport Documents (**eFTI / eCMR**)
Event Data Sharing (**GS1 EPCIS/CBV**)

Peppol-messages:
Receipt advice↓ ↑ Invoice
Invoice response↓

CDE

Reference Data (Product Classifications)

PRODUCT DESIGN
Enrichment of the **E-BOM** into the Manufacturing Bill of Materials (**M-BOM**)
Element Production Plans

ERP
Sale
Rough capacity planning
Production scheduling
Delivery

MANUFACTURING
MRP/WMS
Production
UPID: SGTIN
AIDC: 2D barcodes / RFID
DP
Transport arrangement
ID: SGTIN / SSCC
AIDC: 1D, 2D barcodes / RFID
Transport CO_2 data
CO_2 and sustainability reporting data
As Scheduled & As Manufactured data collection
Purchase
Receiving

Access Point

Catalogue ↑ Order response ↑ ↓ Order
Information delivery (if necessary)

Despatch advice ↑ Invoice ↑ ↓ Receipt advice ↓ Invoice response

DPP
Electronic Transport Documents (**eFTI / eCMR**)
Event Data Sharing (**GS1 EPCIS/CBV**)

Product Information DB
(ETIM Classification / TT-standard / EMDG) and product identification (GS1/GTIN)

SUPPLIERS
ERP (WMS/MRP/PIM)
Production
ID:(S)GTIN
Data carrier: 1D, 2D barcodes
Delivery
ID: GTIN/SSCC
Data Carrier: 1D, 2D barcodes

Legend

N.N Stakeholder or stage in the production chain

N.N A function or part of a process

Information service or platform

In use
Under development

CAFM Computer Aided Facility Management
CDE Common Data Environment (Project Shared data repository)
DP Data Platform
ERP Enterprise Resource Planning
MRP Material Resource Planning
PIM Product Information Management
WMS Warehouse Management System

Automatic Identification & Data Capture (AIDC)

1D barcode
GS1-128, EAN

2D barcode
GS1 DataMatrix
GS1 Digital Link

RFID
Passive UHF RFID

Identification

GTIN Global Trade Item Number
SGTIN Serialized Global Trade Item Number
SSCC Serial Shipping Container Code

Information exchange

Design / Manufacturing Data

IFC Industry Foundation Classes (IFC) –file format
E-BOM Engineering Bill Of Materials
M-BOM Manufacturing Bill Of Materials

Product information

DPP EU Digital product Passport
EMDG European Master Data Guideline

Process Data (Transaction Data)

Peppol network Exchange of structured order-to-delivery messages

Process Data (Transport Data)

eCMR Electronic consignment note
eFTI Electronic freight transport information

Process Data (Event Data)

EPCIS Electronic Product Code Information Services
CBV Core Business Vocabulary

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