MODULAR CONSTRUCTION IN BRAZIL: CHALLENGES AND OPPORTUNITIES FOR IMPLEMENTING MASS CUSTOMIZATION

Prof. Carlos T. Formoso

Building Innovation Research Unit (NORIE)

Federal University of Rio Grande do Sul (UFRGS)

Porto Alegre, Brazil

NORIE
Núcleo Orientado para a
Inovação da Edificação

UFRGS
UNIVERSIDADE FEDERAL
DO RIO GRANDE DO SUL

Summary

- **Modular Construction:** definition and limitations
- **Mass customization :** scope of decision categories
- **Challenges and opportunities of Modular Construction in Brazil**
- **Modular construction and sustainability**

What is Modular Construction?

- Construction process in which **a large share of activities are executed off-site**, in a **controlled environment**, with a **high degree of mechanization**

- **Panels or volumetric modules** are used, and these have a **high degree of completeness**

- **Integration of components** is undertaken in an **industrial environment**

- The **modularity concept** is used

Limitations of Modular Construction

- **The degree of mechanization and automation varies substantially:** many companies do not deliver a combination of highly repetitive standardized modules, produced by semi-automated production lines

- **Degree of completeness of modules produced in manufacturing plants also vary substantially**

- **Many projects that use modular construction also involve non modular activities**, including other prefabricated Building systems and traditional construction site activities

- **Concept of modularity has not been fully explored**, being often poorly adapted to construction

Modular Construction in housing - Brazil

- Recent examples from Brazil

Modular Construction in other types of projects - Brazil

Prisons

Schools

VISIA
CONSTRUÇÃO MODULAR

What is *Mass Customisation*?

- **Competitive strategy that aims to offer products that fulfil customers' specific requirements through flexible processes and structure, within costs and delivery time similar to mass production** (Pine, 1993)

  - Limited customization based on a deep knowledge about customer requirements
  - Based on the assumption that there is a premium price

Why Mass Customization is important for housing?

- Inadequacy of traditional project delivery approaches results in **poor value generation**

- **Diversity of customer profiles** in low-cost housing

- **Changes in life-style**: homework, leisure, respect to minorities, etc.

Couple with kid(s)
37,80%

Couple without kid(s)
21,11%

Adult(s) without kid(s)
18,89%

Adult(s) with kid(s)
11,11%
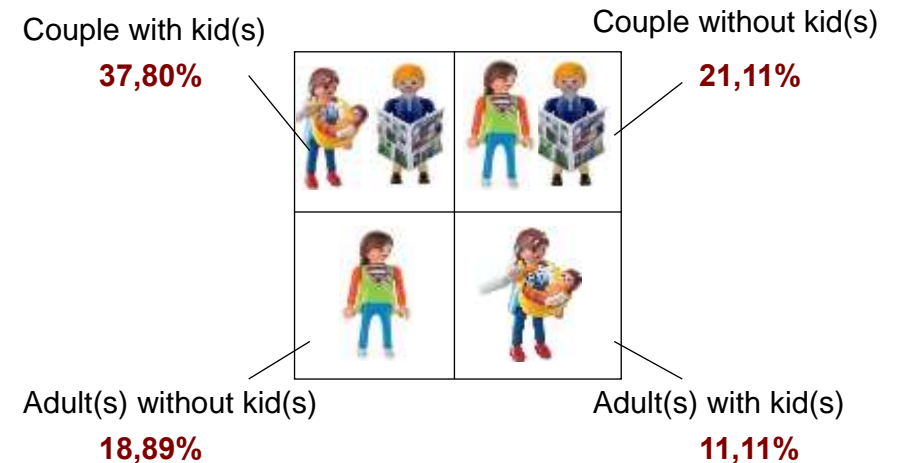
Example from a housing program in Brazil

Simplified views of Mass Customization

Flexible technologies

finishings

layout

- • Familienhäuser - Klassisch/Modern/Landhaus

- • Bungalows - Klassisch

- • Doppel/Reihenhäuser - Klassisch

Type of house

Choice menu (e.g. website)
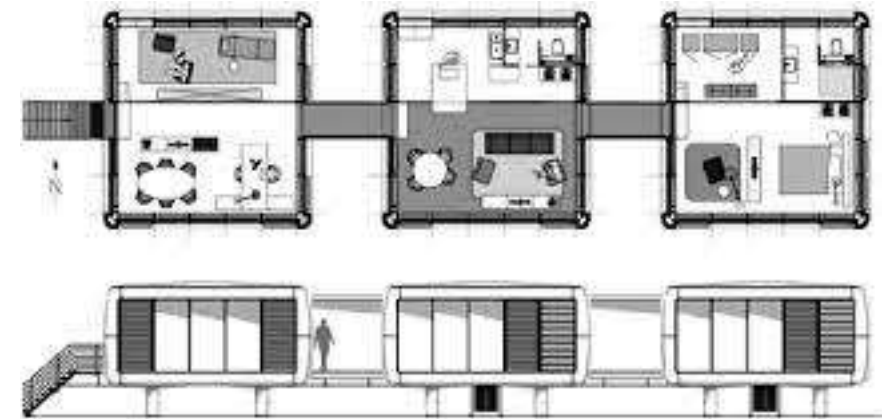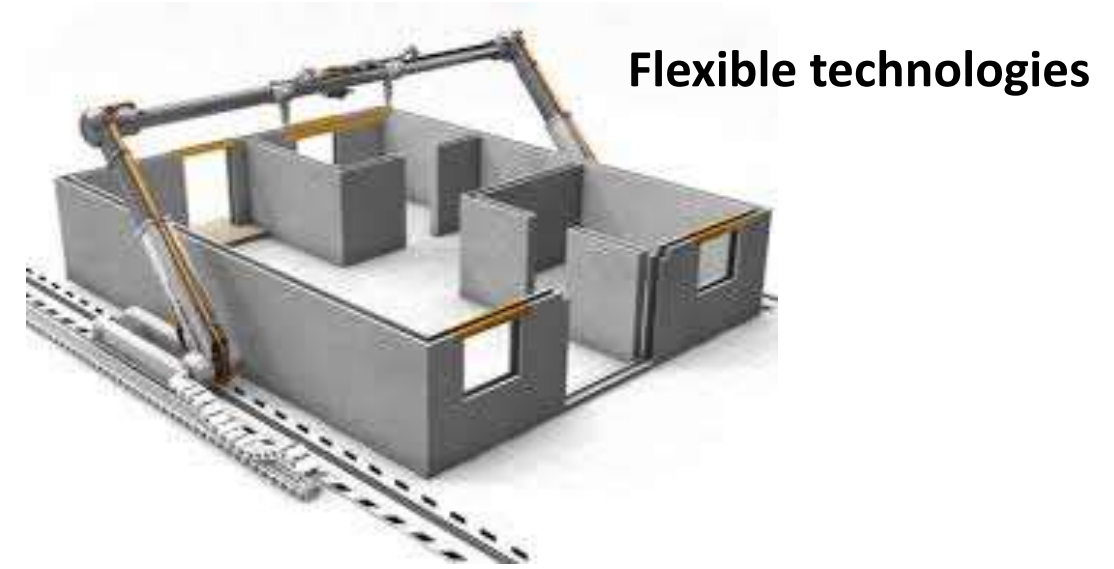
Flexible design

Decision categories in Mass Customization

Competitive Environment

Clients

Which are the attributes to be customized and product variants?

Customer integration
Requirements capture, processing

Operations
Production
Logístics
Supply chain

Product design

Company

How to deliver product variants?

1   2

How the product variants are translated into product designs?

Adaptado de Rocha (2011)
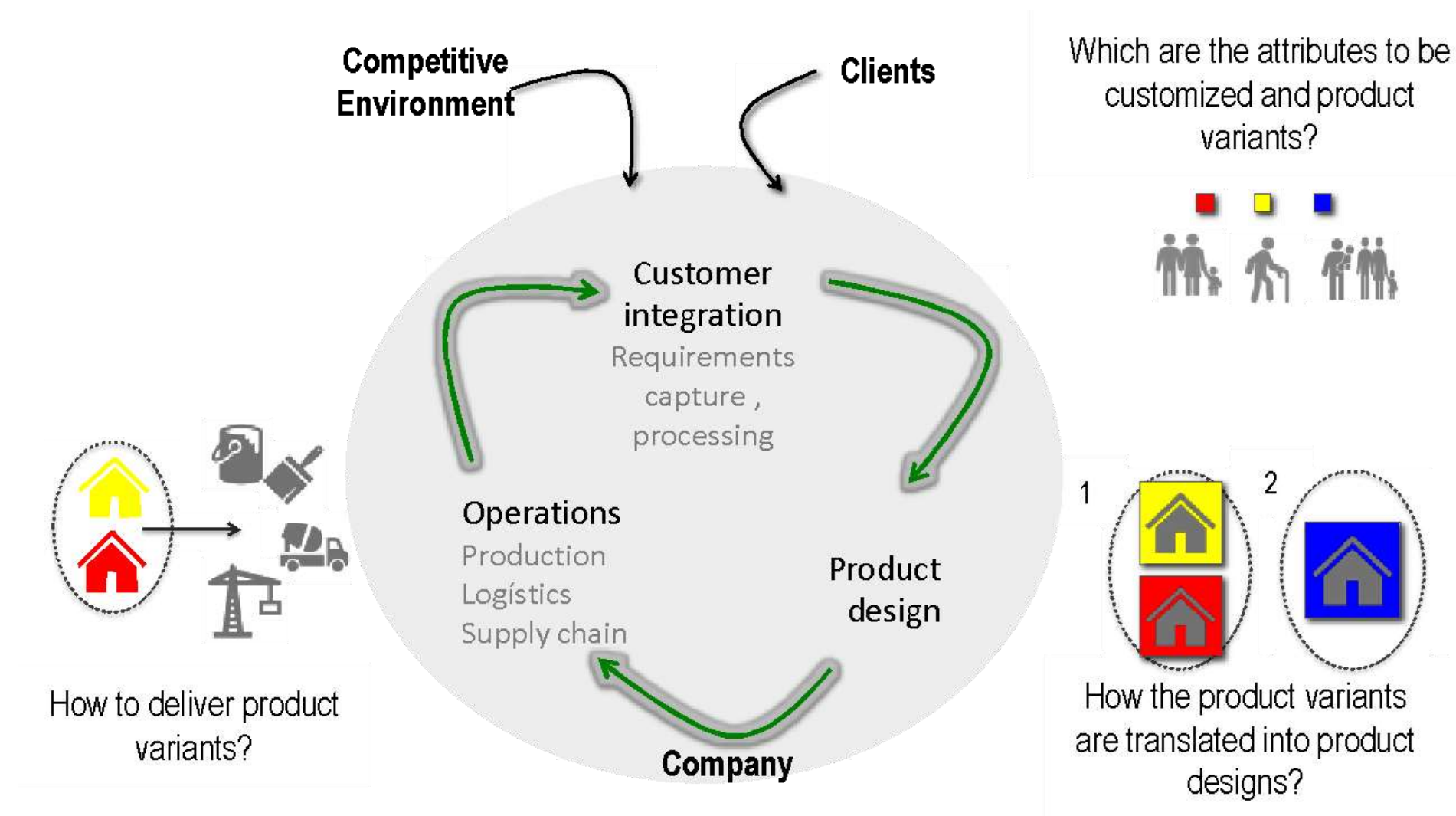
Body of knowledge involved in Mass Customization

Client requirement modelling

Client requirement management

Willingness to pay

Choice menu

Customer interface

Co-design

Process modularity

Pull production

Visual management

Small batch size

Customer integration
Requirements capture, processing

Operations
Production
Logístics
Supply chain

Product design

Product-service systems

Product architecture

Product modularity

Mass Customisation in housing - Brazil

- ## Traditional projects

Management of decoupling points

Customization points

Standard unit
Customization by selection of pre-defined alternatives

Decoupling point

Finishing materials
Customization by additional work
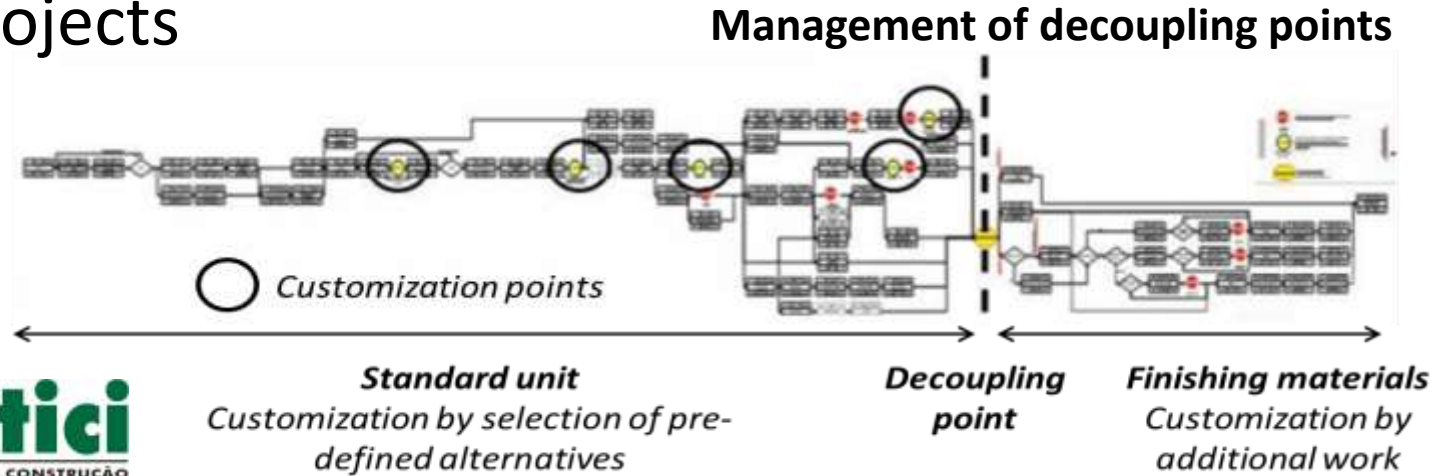
Choice menu

Visual management

Kits prepared by suppliers

IDENTIFICAÇÃO UNIDADES PERSONALIZADAS

PP.01.00

Application of Mass Customisation in housing - Japan

Very advanced off-site (modular) production systems

Several mechanisms for capturing customer requirements

Customer integration practices

- **Choice menu**
- **Consumer experience**
- **Digital integration**
- **Feed-back mechanisms**
- **Monitoring adaptations and upgrading**
- **Etc.**

Japen

Brazil (Conte, 2020)

Quantitative techniques for assessing customization options


Assessment of willingness to pay

Choice menu

Hentschke (2021)

Product modularity

Definition: result of the division of a product in subsystems which have different functions, and are connected by standard interfaces

Modular architecture products: there is a direct relationship between components and functions. It is the opposite of integral architecture products
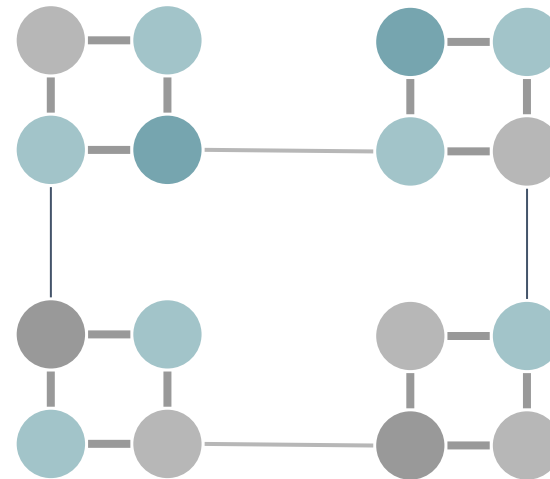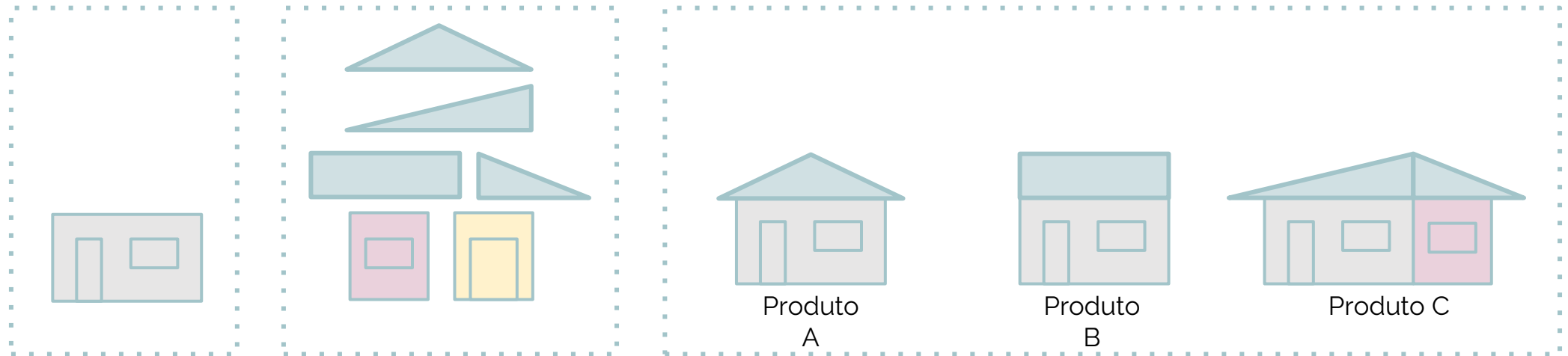

modular
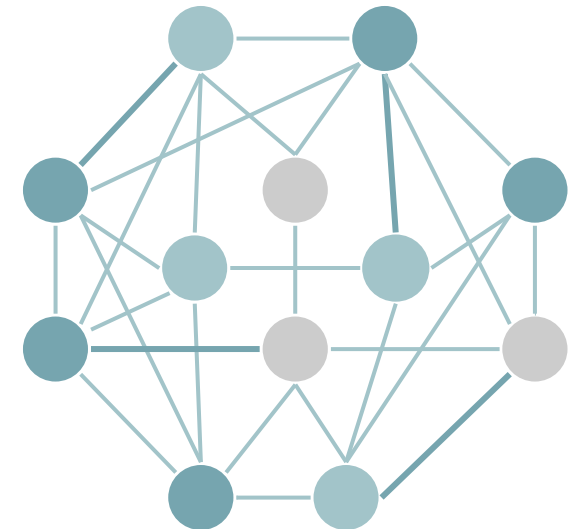
integral

Platform and platform product family

- **Platform**: set of modules that are used for several different products (or for a family of products), with the aim of increasing repetition

  - Platform product: most of the products of the family use the same modules

Plataform   **Modules**   **Product family**

Home design catalogues

- Often adopted by companies that do not know much about customer requirements

- Contributes to increase the number of options

- Creates burden of choice

# Application of the concept of product modularity

Application of the concept of product modularity

Different hierarchical levels of product modularity

- **KITS:** set of elements or components that are supplied in a specific workstation

- **COMPONENTS:** pre-fabricated elements that are used for the assembly of volumetric modules (e.g. columns, beams, panels, slabs)

- **CHASSIS:** tri-dimensional (3D) structural component that allows other components to be precisely positioned

- **3D MODULE WITHOUT FINISHINGS:** tri-dimensional module that contains only the structure and panels (walls, ceiling, floor)

- **3D MODULE WITH FINISHINGS:** tri-dimensional module that is produced in the manufacturing plant (includes also plumbing, electrical fittings, some finishings, etc.)

- **SITE ASSEMBLY MODULE :** combination of models PA that are connected and finished at the construction site
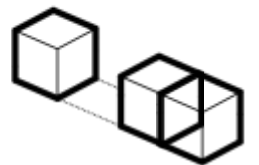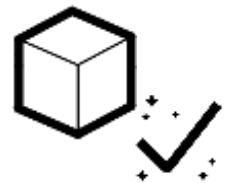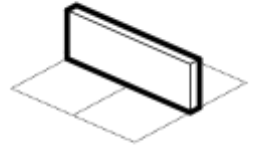
Process modularity: reduction of batch size

- A process is divided in batches that have some degree of repetition, although product modules are not identical

- Each batch has a similar set of tasks and work density

- Applicable also for production lines with a high level of automation

Etapa

Process modularity: case of Porto Alegre Airport

17 similar pregabricated concre structure batches
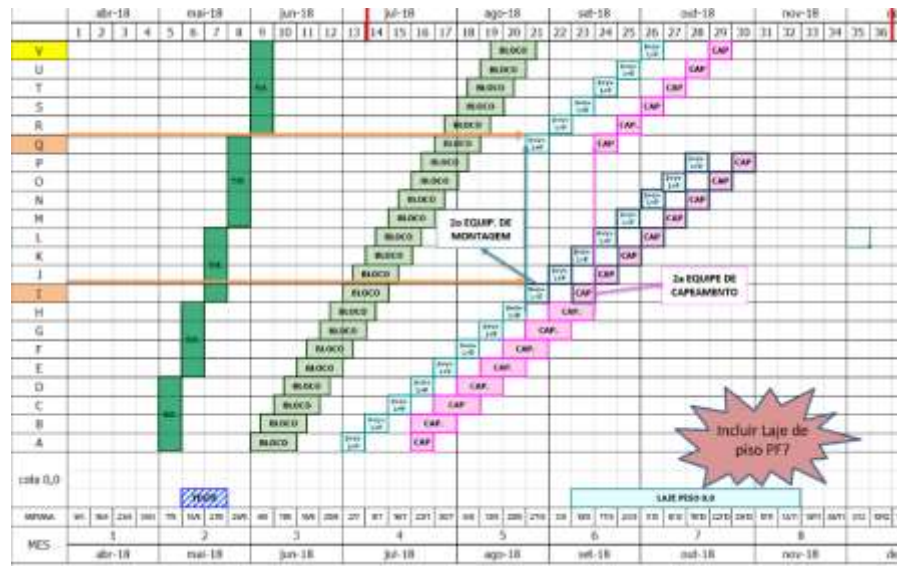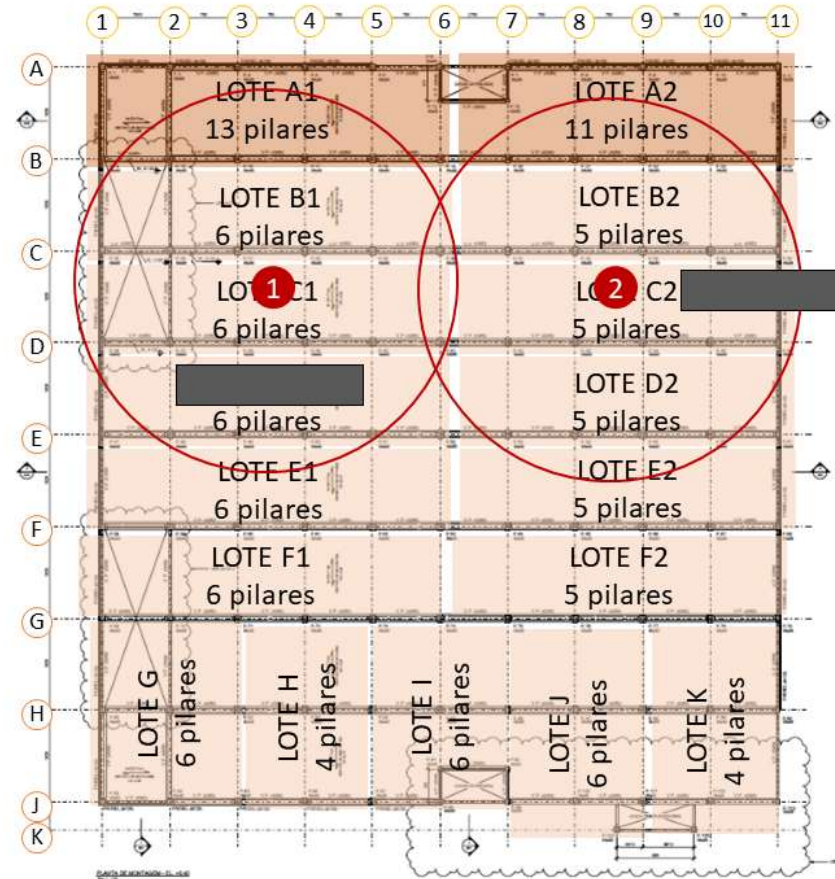
Location based plan: takt time, similar cycle times

Opportunities for gradual implementation of off-site modular construction

Pre-fabricated façades

Modular toilet

Opportunities for gradual implementation of off-site modular construction

On-site pipe shop

Ready to install electrical wiring

URBIC (2022)

Lean concepts in production management: small batches, WIP control, visual management, etc.
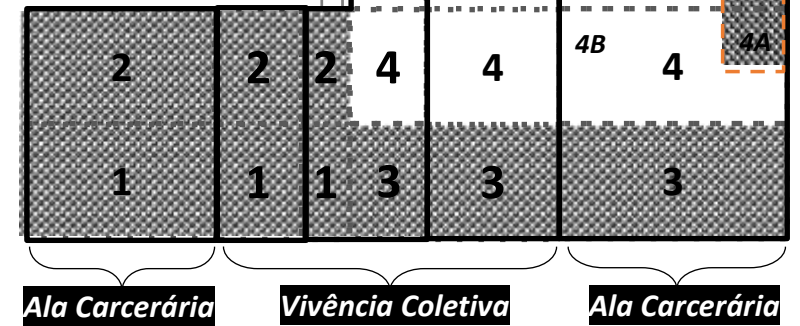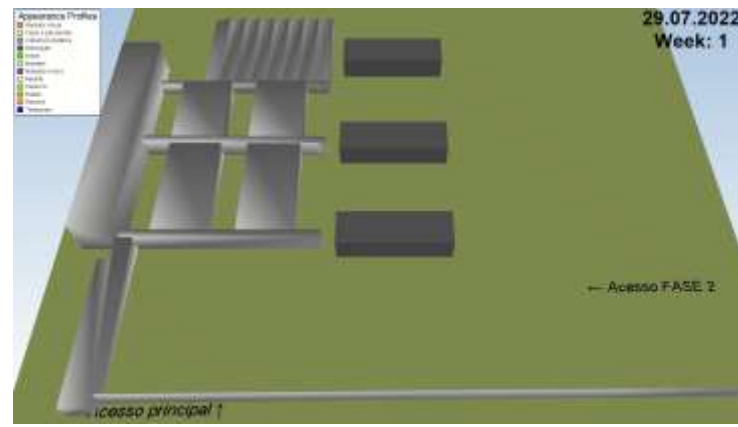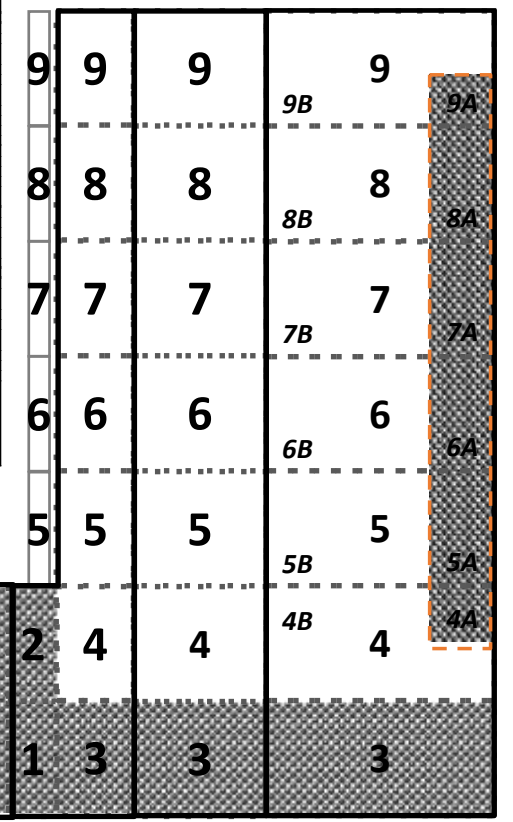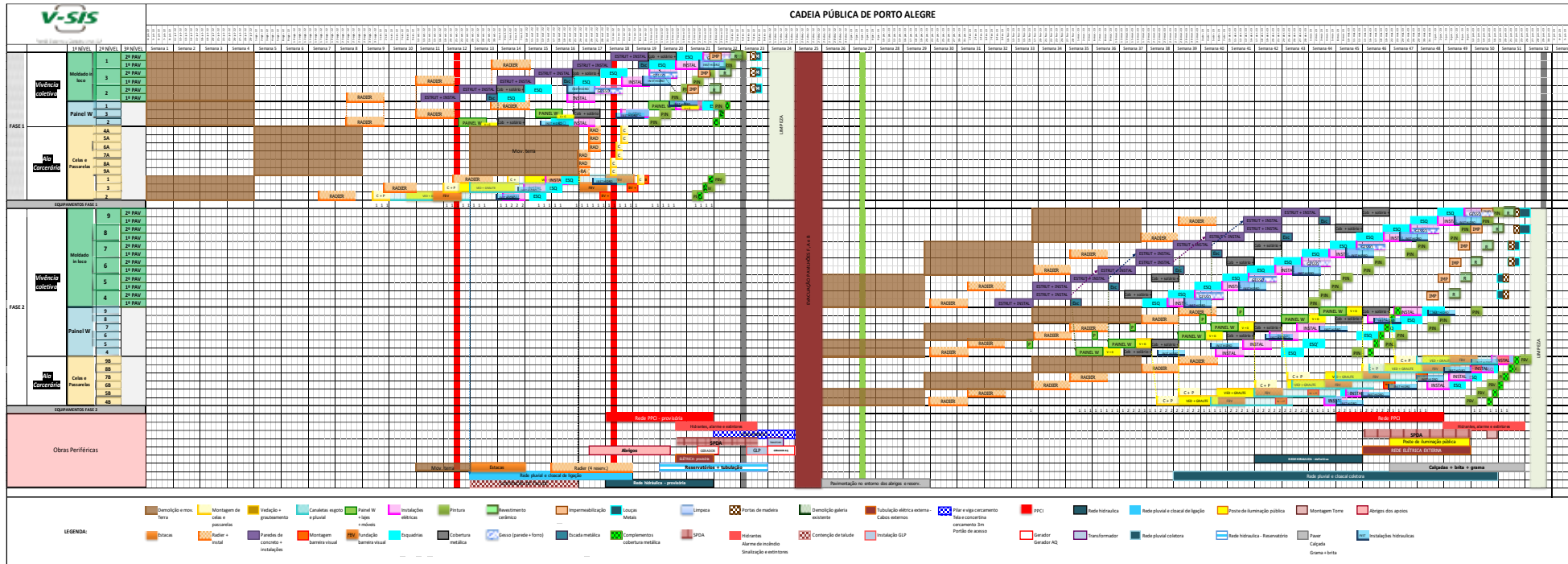
Metrics for controlling status of the system

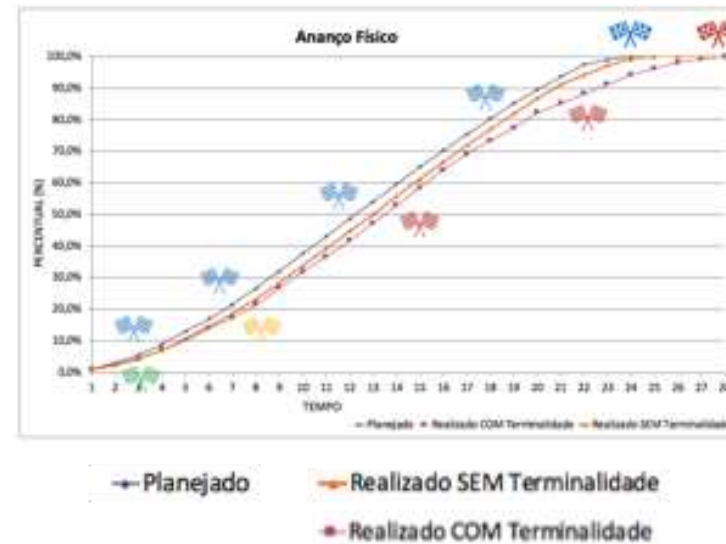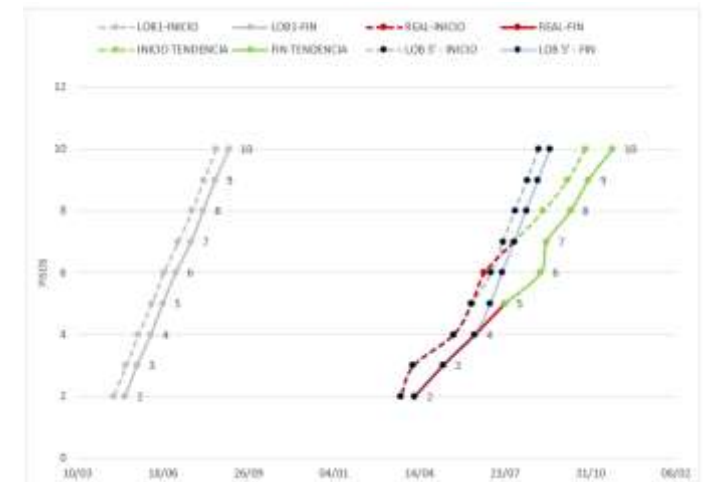**Matrix for status control**

Takt time control

Cycle time
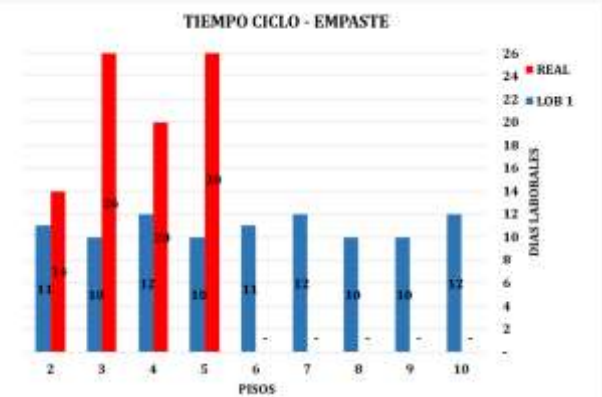
Project progress and completeness

Adherence to batch

Technologies for controling the status of production units

Andon

Câmara 360º

Transmissão wireless

RFID

KANBIM
Digital Twin (Sacks, 2020)

Final comments

- **Major changes are happening in the construction industry**:
  - New generation of industrialized construction technologies
  - Widespread use of digital technologies
  - New business models
- **Mistakes from the past must not be repeated**: focusing on technological solutions, without improving managerial models
- **Understanding the diversity in client demands plays an important role in some market segments:** product customization, short lead-times, product-service systems, etc.
- *Lean* **concepts and methods and digital technologies have played key roles in modular construction**