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INTERNATIONAL GROUP FOR LEAN CONSTRUCTION
DUBLIN | IRELAND | 1ST - 7TH JULY 2019

# **PERFORMANCE MEASUREMENT IN LEAN PRODUCTION SYSTEMS:** AN EXPLORATION ON REQUIREMENTS AND TAXONOMIES

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# Aim of the study

Propose a set of **requirements** for **Performance Measurement Systems** (PMS) from a **lean production perspective** and a **taxonomy of metrics** for lean production systems.

- Based on the **analysis of the Performance Measurement Systems of 5 South American construction companies** involved in the implementation of the Lean Production philosophy.

# Performance Measurement Systems

- Several previous studies are limited to the **definition of performance measures**
- Focus on Performance Measurement Systems:
  - Uses a set of indicators that **quantify the efficiency or effectiveness** of a process or organization
  - Involves an **effort to fully integrate measures into process management**
  - Defines **procedures for data collection and processing, and protocols for distributing information** (Neely et al., 1996)

# Role of Performance Measurement Systems

| In general (business management) |
| --- |
| Provides the necessary information for **process control** |
| Enables the **establishment of challenging and feasible goals** |
| Helps to **align efforts and resources to the most important aspects of the business** (Lantelme and Formoso 2000) |
| **Facilitates communication** between different managerial levels (Hall et al. 1991) |

# Role of Performance Measurement Systems

| In general (business management) | In the implementation of lean principles |
|---|---|
| Provides the necessary information for **process control** | Produces data that can be used as a reference for **learning** and **process improvement** (Pavlov and Bourne 2011) |
| Enables the **establishment of challenging and feasible goals** | Points out shortcomings as sources of creative tensions for **continuous improvement** (Spear and Bowen 1999) |
| Helps to **align efforts and resources to the most important aspects of the business** (Lantelme and Formoso 2000) | Provides focus on the lean goals, such as eliminate waste, reduce variability, and improve value generation (Koskela 1992) |
| **Facilitates communication** between different managerial levels (Hall et al. 1991) | Rendering **invisible attributes** of the process visible through measurements (Koskela 1992) |

# Drawbacks of Performance Measurement Systems

**In general (business management)**

- Use metrics strongly related to the **traditional project management approach**: cost deviation, productivity and utilization rates (Bhasin 2008; Maskell 1991)
- Compare task completion and quality data to the plan or budget - **Thermostat model** (Koskela and Howell 2002);
- Put to much effort on **lagging indicators**, **ineffective to support timely decision making** (Kennerley and Neely 2003; Sarhan and Fox 2013);
- **Lack of prioritization** regarding critical processes: **too many measures** (Bourne et al. 2000).

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- **Lack of prioritization** regarding critical processes: **too many measures** (Bourne et al. 2000).

**In the implementation of lean production**

- Most companies use only Last Planner related metrics (España et al. 2012; Sacks et al. 2017);
- Lack of intermediate metrics to **assess the changes taking place in the effort to introduce lean production** (Sánchez and Pérez 2001);
- Lack of measures **regarding supply chain integration** (Nudurupati, Arshada and Turner 2007);
- **Too much effort on the application of tools** that generate metrics, rather than considering them as **countermeasures** (Spear and Bowen 1999).

# Types of **Performance Measures in lean systems**

| Karlsson and Åhlström (1996) | Sánchez and Pérez (2004) and Rivera and Manotas (2014) | Koskela (1992) |
|---|---|---|
| **Elimination of waste** | **Elimination of waste** | **Waste reduction** |
| **Continuous improvement** | **Continuous improvement** | **Continuous improvement** |
| Zero defects | | Variability reduction |
| Just In Time (JIT) | Continuous flow and Pull-driven systems | |
| Pull instead of push | | |
| Multifunctional teams | Multifunctional teams | |
| Decentralized responsibility | | |
| Integrated functions | | |
| Vertical Information Systems | Information systems | |
| | | Adding value |
| | | Cycle time |
| | | Simplification and Transparency |
| | | Focus on complete process |

# Companies studied





| | Company A | Company B | Company C | Company D | Company E |
|---|---|---|---|---|---|
| **Company size** | Large | Large | Small | Large | Large |
| **Main characte-ristics** | Benchmark in Lean Construction, **30 years** lean implementation | Multinational Company, complex projects, **20 years** lean implementation | Family company, **3 years** lean implementation | **3 years** lean implementation | Works as a contractor, various projects, **5 years** lean implementation |
| **Main lean practices adopted** | - **Last Planner**<br>- Kanban<br>- 5S<br>- Prototyping<br>- Visual management<br>- Standardized work | - **Last Planner**<br>- Kanban<br>- Multi-function teams<br>- Visual management<br>- Standardized work<br>- Value Stream Mapping | - **Last Planner**<br>- Visual management<br>- Task completion control<br>- Takt-time planning | - **Last Planner**<br>- Visual Management<br>- 5S<br>- Task completion<br>- Takt-time planning | - **Last Planner**<br>- Visual Management<br>- Takt-time planning |

# Performance Measures used by the Companies

| Indicators | Company A | Company B | Company C | Company D | Company E |
|---|---|---|---|---|---|
| Last Planner Metrics | x | x | x | x | x |
| Effectiveness of LPS Implementation | x | | x | x | |
| Daily OTP (On Time Performance) | | x | | | |
| Gemba Walk Wastes | | x | x | | |
| Number of Kaizen Ideas | | x | | | |
| Sequence and WIP | | | x | x | |
| HeatMap | | | | x | |
| Batch Adherence Control | | | | x | x |
| Cycle Time | | | | x | x |
| Control of Batch Deliverable Rhythm | x | | x | x | x |

# Performance Measures used by the Companies

Last Planner related measures

| Indicators | Company A | Company B | Company C | Company D | Company E |
|---|---|---|---|---|---|
| Last Planner Metrics | **x** | **x** | **x** | **x** | **x** |
| Effectiveness of LPS Implementation | x | | x | x | |
| Daily OTP (On Time Performance) | | x | | | |
| Gemba Walk Wastes | | x | x | | |
| Number of Kaizen Ideas | | x | | | |
| Sequence and WIP | | | x | x | |
| HeatMap | | | | x | |
| Batch Adherence Control | | | | x | x |
| Cycle Time | | | | x | x |
| Control of Batch Deliverable Rhythm | x | | x | x | x |

# Performance Measures used by the Companies

Waste and Reliability measures

| Indicators | Company A | Company B | Company C | Company D | Company E |
|---|---|---|---|---|---|
| Last Planner Metrics | x | x | x | x | x |
| Effectiveness of LPS Implementation | x | | x | x | |
| Daily OTP (On Time Performance) | | x | | | |
| Gemba Walk Wastes | | x | x | | |
| Number of Kaizen Ideas | | x | | | |
| Sequence and WIP | | | x | x | |
| HeatMap | | | | x | |
| Batch Adherence Control | | | | x | x |
| Cycle Time | | | | x | x |
| Control of Batch Deliverable Rhythm | x | | x | x | x |

# Performance Measures used by the Companies

Takt time and batch related measures

| Indicators | Company A | Company B | Company C | Company D | Company E |
|---|---|---|---|---|---|
| Last Planner Metrics | x | x | x | x | x |
| Effectiveness of LPS Implementation | x | | x | x | |
| Daily OTP (On Time Performance) | | x | | | |
| Gemba Walk Wastes | | x | x | | |
| Number of Kaizen Ideas | | x | | | |
| Sequence and WIP | | | x | x | |
| HeatMap | | | | x | |
| Batch Adherence Control | | | | x | x |
| Cycle Time | | | | x | x |
| Control of Batch Deliverable Rhythm | x | | x | x | x |

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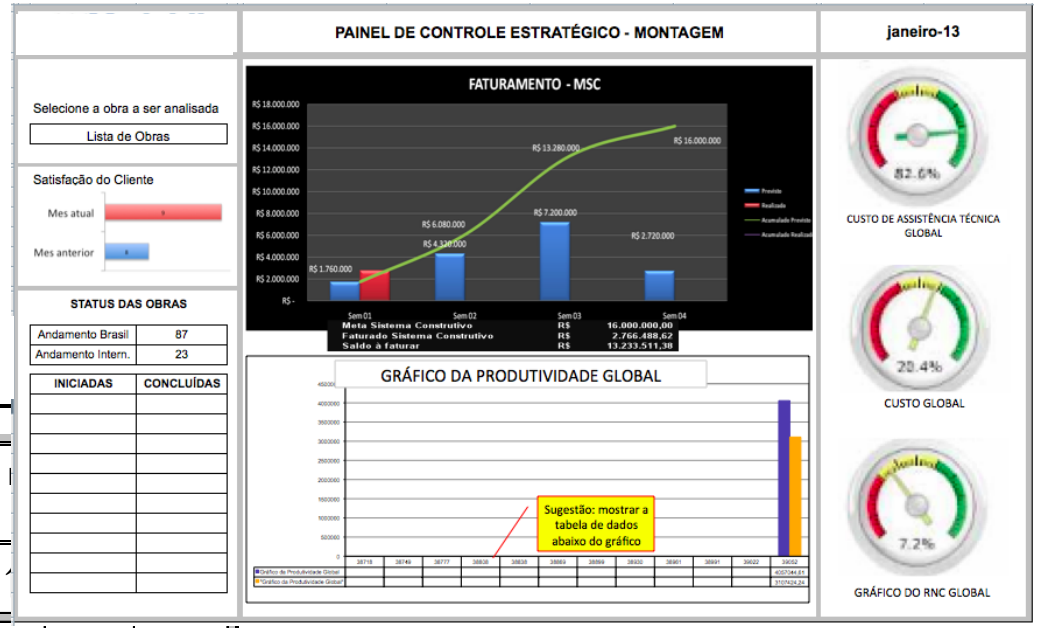
# Best practices identified in the Companies

## Performance Dashboards

### Strategic Dashboard




### Tactical Dashboard

FOTOS

| mês | LOGOTIPO EMPRESA | | LOGOTIPO OBRA 1 | | | |
|---|---|---|---|---|---|---|
| abr/07 | | | | | | |
| IDC (índice de desvio de custo) | ↑ | 0,84 IDC mês | 1,03 IDC 2007 | ↑ | 0,92 IDC mês | 0,97 IDC 2007 |
| meta < ou = 1 | | | | | | |
| IDP (índice de desvio de parzo) | ↓ | 0,92 IDP mês | 1,01 IDP global | ↓ | 0,91 IDP mês | 0,96 IDP obra |
| meta > ou = 1 | | | | | | |
| PPC (percentual de planos concluídos) | ↑ | 89% PPC médio global | | → | 92% PPC mês | 90% PPC obra |
| meta 75% | | | | | | |
| INR18 | ↓ | 85% INR18 média mês globa | | ↓ | INR18 mês | 65% |
| meta > ou = 80% | | | | | | |
| NNCA | ↑ | 5 NNCA médio | | ↑ | 8 NNCA | |
| meta < 5 | | | | | | |

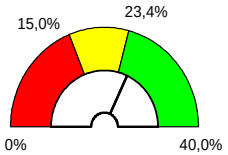
| | | | | | |
|---|---|---|---|---|---|
| | | | | 1,05 IDP mês | 0,92 IDP obra |
| | | | | 85% PPC mês | 83% PPC obra |
| | | | | INR18 mês | 60% |
| | | | | 2 NNCA | |

### Operational Dashboard

EMPREENDIMENTO -

Período - 12/06

**PAINEL DE CONTROLE OBRA**




**Margem Operacional**

**X %**

MO Real: X %

MO Orçada: Y %

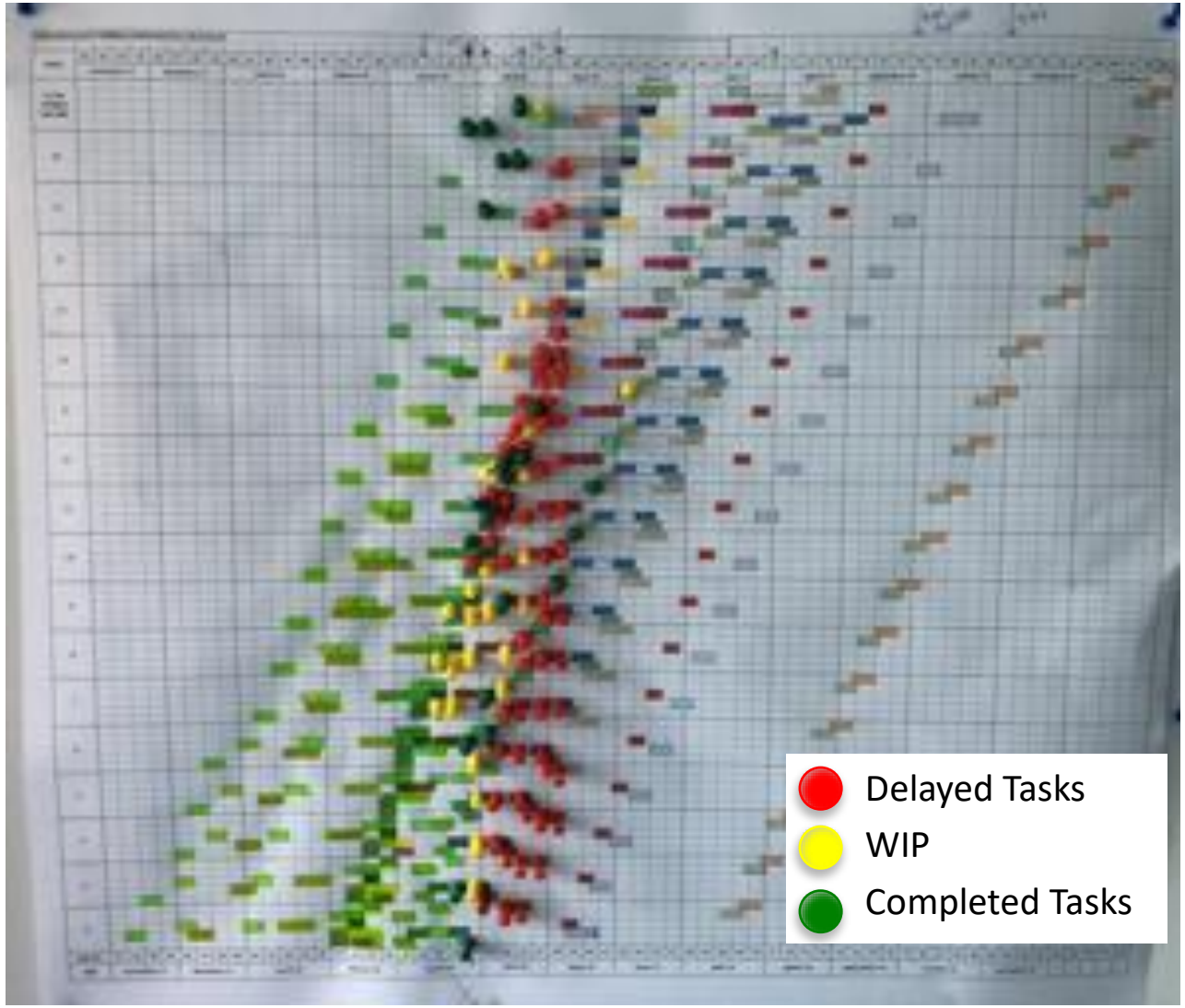
MO Meta obra > ou = Z %

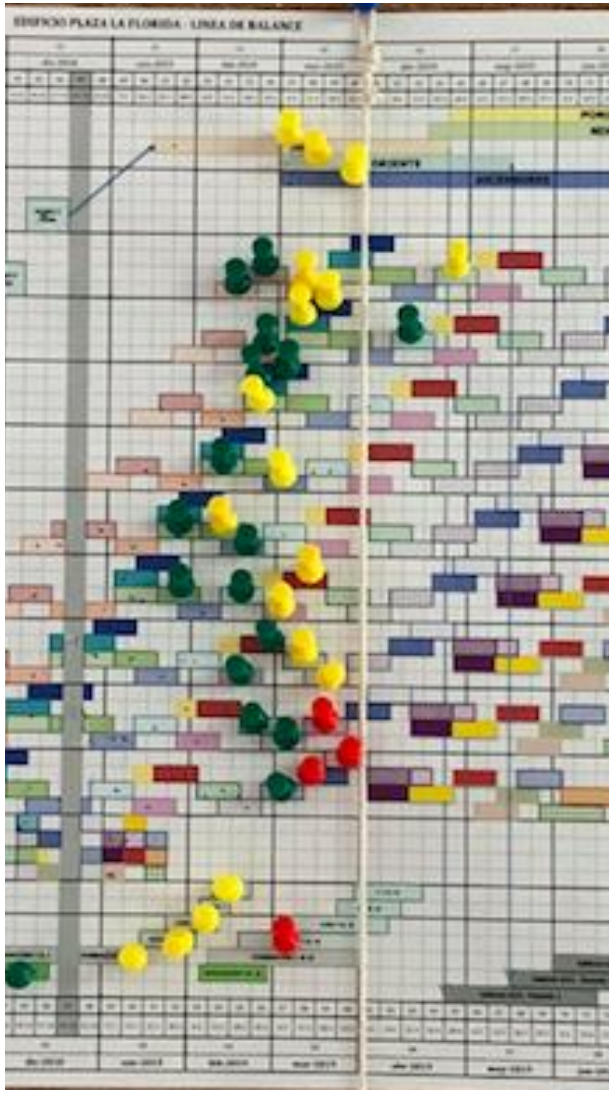
| Indicador | Resultado | Status |
|---|---|---|
| Desvio de custo da obra | -5,03% | |
| | Mês anterior | Meta < ou = 0 |
| Desvio de prazo da obra | -16,67% | |
| | Mês anterior | Meta < ou = 0 |
| Percentual de Pacotes Concluídos (PPC) | 76,50% | |
| | Mês anterior | Meta > 79% |
| Percentual de Boas Práticas de Planejamento (PBPP) | 84,38% | |
| | Mês anterior | Meta > 79% |
| Índice NR18 (INR18) | 98,60% | |
| | Mês anterior | Meta > 79% |

- Translate strategy into goals
- Metrics are analyzed as a set, in a single interface

# Best practices identified in the Companies

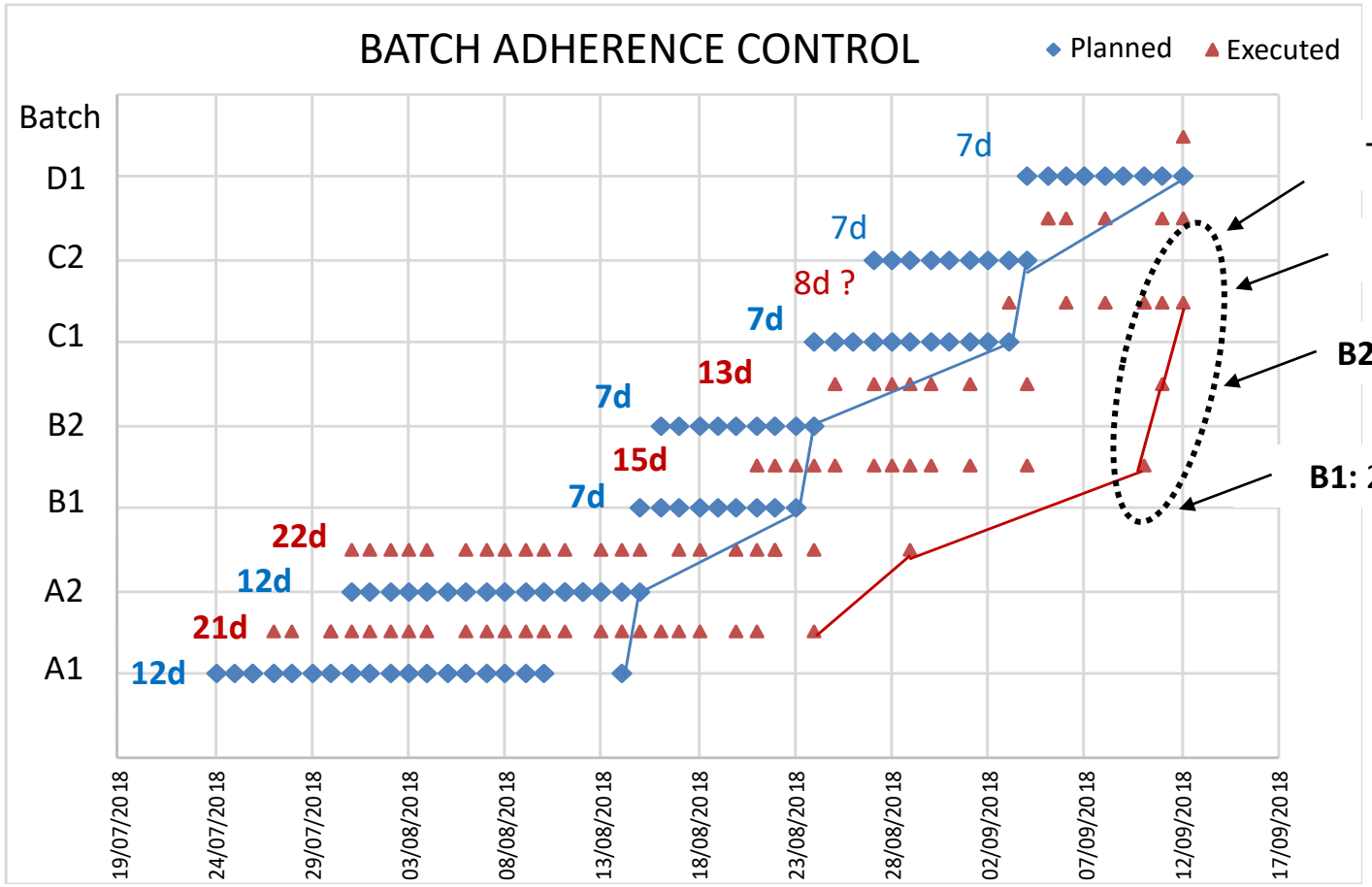
**Visual monitoring of WIP by using the Line of Balance**



# Best practices identified in the Companies

## Control of Batch Adherence and Cycle Time



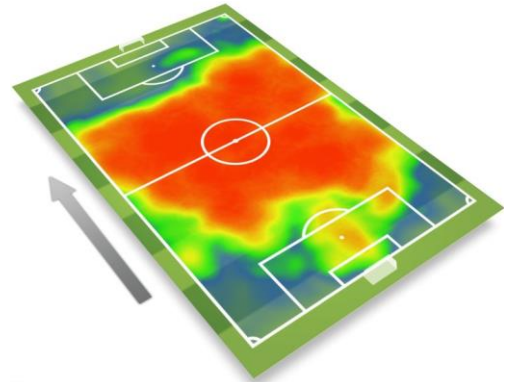

Tend to end simultaneously

**C1:** 3/9 to 12/9 (7 days of delay)

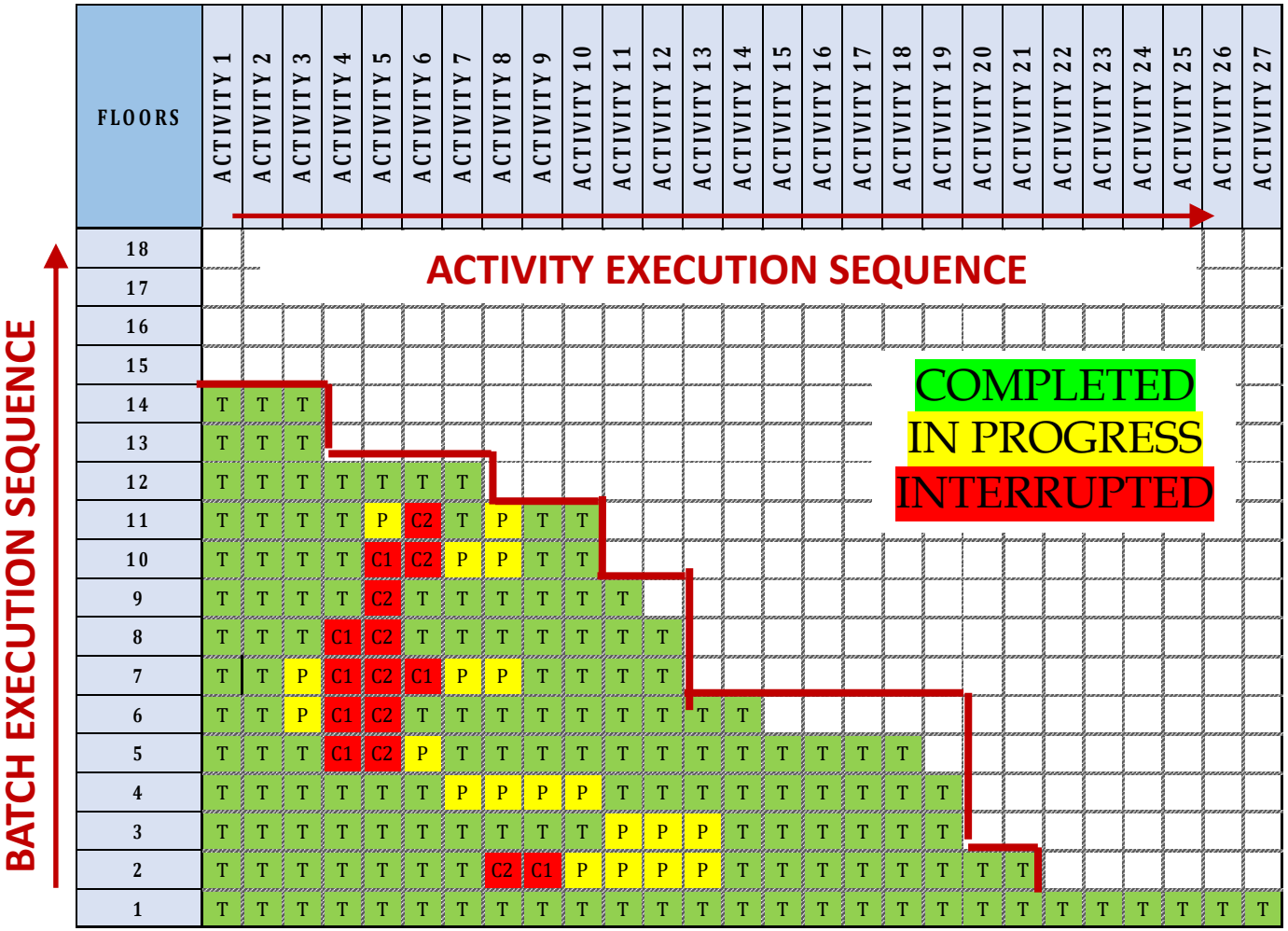
**B2:** 24/8 to 11/9 (12 days of delay)

**B1:** 23/8 to 10/9 (12 days of delay)

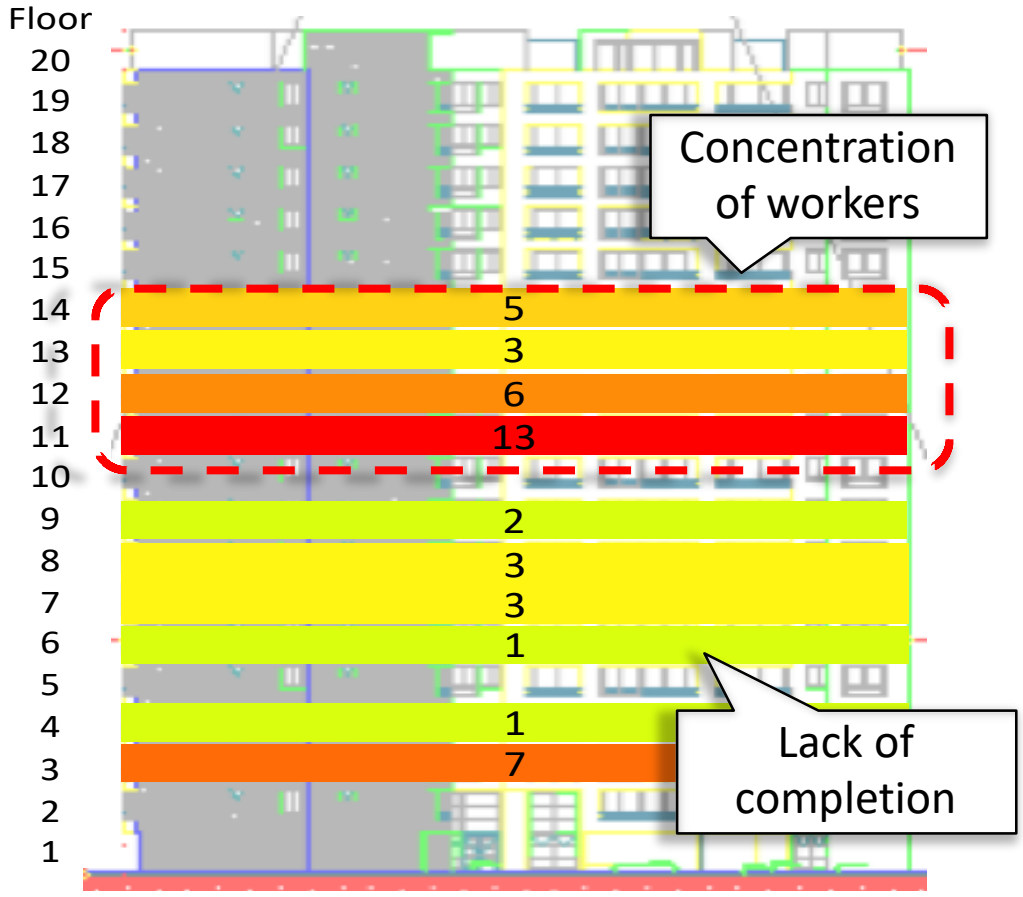
# Best practices identified in the Companies



## Sequence and WIP




## Heatmap: shows number of workers



# Requirements: initial propositions for PM Systems

## Based on literature and practice

1. **Have a direct alignment with higher goals** (e.g. company strategy or lean ideals)
2. **Combine leading and lagging indicators**
3. **Create local control systems**: local concepts (e.g. kaizen ideas) and adapted to specific contexts
   PM system should be revised in order to meet the requirements of each situation.
4. **Be updated from time to time** (as result of learning)
   PM system must keep pace with changes in the production system.
5. **Be simple** (easy to understand) **and provide quick feedback to users**
   Clear and simple information **facilitates problem detection**, allowing decision-making and actions to be performed shortly.
6. **Promote improvement and learning**, e.g. by increasing process transparency.

# Critical analysis

## Analysis of the Propositions in the companies studied

| Requirements Proposed | Company A | Company B | Company C | Company D | Company E |
|---|---|---|---|---|---|
| Have a direct alignment with higher goals | +/- | + | +/- | +/- | +/- |
| Combine leading and lagging indicators | + | + | +/- | + | +/- |
| Create local control systems | +/- | +/- | - | - | +/- |
| Be updated from time to time | + | +/- | +/- | - | - |
| Be simple and provide quick feedback to users | + | + | + | + | + |
| Promote improvement and learning | + | + | +/- | + | +/- |

# Proposed Taxonomy for Performance Measurement in LPS

## Based on literature and practice

| Lean main objectives | Means |
|---|---|
| Waste Elimination | Continuous Improvement and learning |
| | Just In Time |
| | Process Reliability (Quality and Time) |
| Value Generation | Resilience (Safety) |
| | Supply Chain Integration |
| | Collaboration and empowerment |

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Last Planner Metrics
Daily OTP (On Time Performance)
WIP and Sequence
HeatMap
Rhythm Deviation
Batch Adherence Control
Cycle Time

Number of Kaizen Ideas

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Cycle Time

Number of Kaizen Ideas

# Conclusion and further work

- Previous studies have proposed metrics for Lean Production Systems, but **most of them do not suggest guidelines for devising Performance Measurement Systems**
- There is a **tension between improving Performance Measurement, and increasing the effort involved** in data collection and processing (non-value-adding, and may cause dissatisfaction)
- A **set of requirements have been proposed** for making Performance Measurement Systems more effective (rather than simply increasing the number of metrics)

  - Some improvement opportunities were identified**:** e.g. **alignment with higher goals, creating local control systems, and keeping the PMS updated**
- Performance Measurement for production control in some construction companies is often **limited to Last Planner or Takt Time Planning** (process reliability)

  - Based on the proposed taxonomy, some gaps were identified: e.g. **Value Generation, Resilience, JIT, Collaboration and empowerment, Supply Chain Integration**


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# Thank you!