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BIM-BASED CONSTRUCTION PROGRESS MEASUREMENT OF NON-REPETITIVE HVAC INSTALLATION WORKS

by

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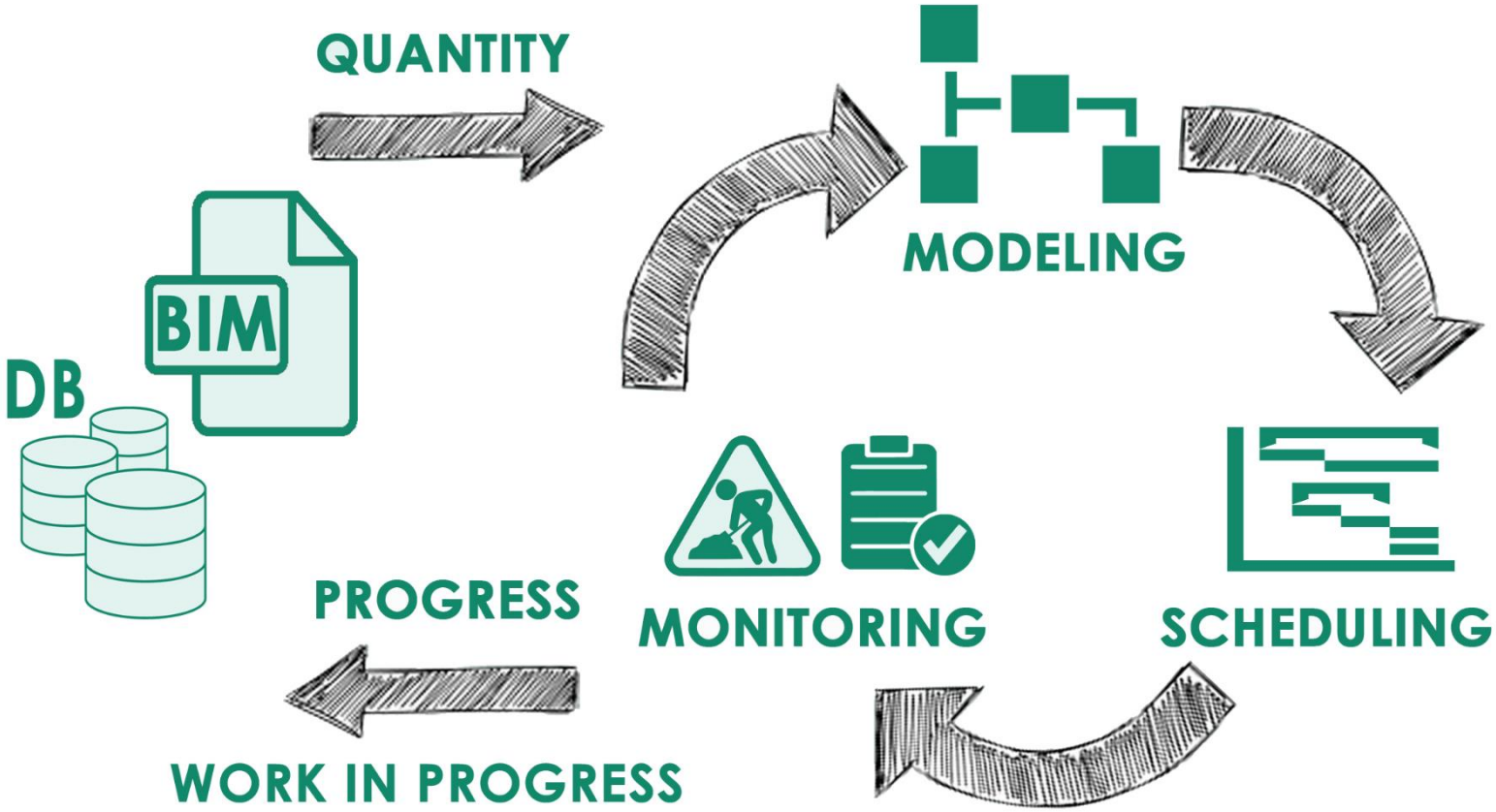
Introduction

- Budget overruns are often identified only in a late phase of a construction project when intervention options become limited
- Main causes according to the authors:
  1) Insufficient consideration of important information during the planning phase
  2) Inability to track the construction progress on-site in real-time
- Important information included in the BIM model are often not used anymore after design
- The potential of BIM to support planning, scheduling and monitoring of HVAC construction works is presented
- Practical application in an HVAC supplier company from Northern Italy by using as case study a medium sized hospital construction project.

Approach


QUANTITY
BIM
DB
MODELING
SCHEDULING
MONITORING
PROGRESS
WORK IN PROGRESS

Approach

- The **Pitch** is used to normalize workloads for uniform scheduling and measurement of different construction tasks

$$Pitch_{CA_i,Task_j,Crewsize_k} = \frac{Quantity_{ij}\,[MU_j]}{time\ interval}$$

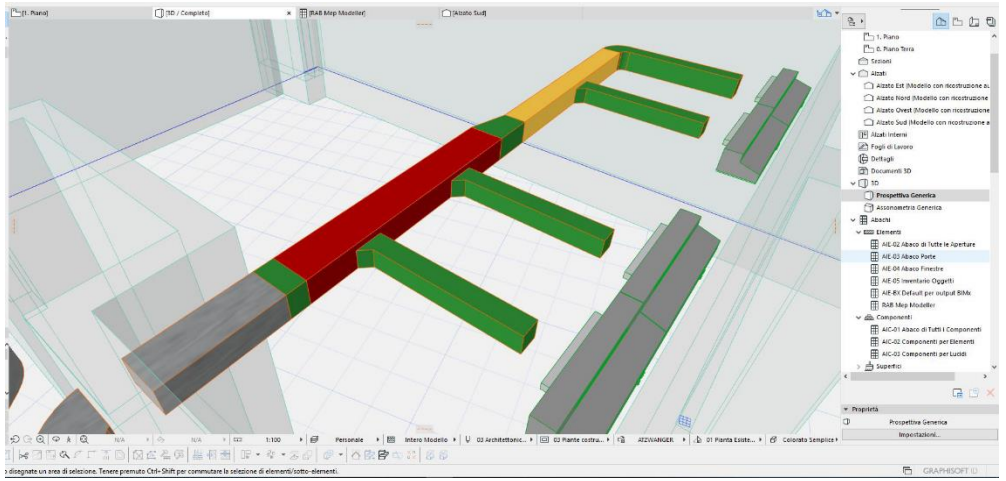
- Task-related quantities are derived from the BIM model for accurate estimation of the Pitch during the ***modelling*** phase

- During ***scheduling***, task related quantities and pitches are used to calculate the task durations and serve as orientation for the progress monitoring (e.g. task needs 100 pieces to install, pitch of 20 pieces per day with 2 workers results in a duration of 5 working days).

- In ***monitoring***, the pitches provide orientation about the goal to be achieved in terms of quantities. The amount of actual installed pieces is fed back into the BIM model in order to visualize the reached construction progress.

BIM and Lean Construction

- **Intuitively visualization** of the construction progress
- **Improved collaboration** within and between trades thanks to a quick understanding of progress issues
- Progressive refinement of the pitch value allows a **higher reliability** of the short-term scheduling.
- **Improved transparency** and scheduling and therefore an improved overall installation **workflow**



Case study: context

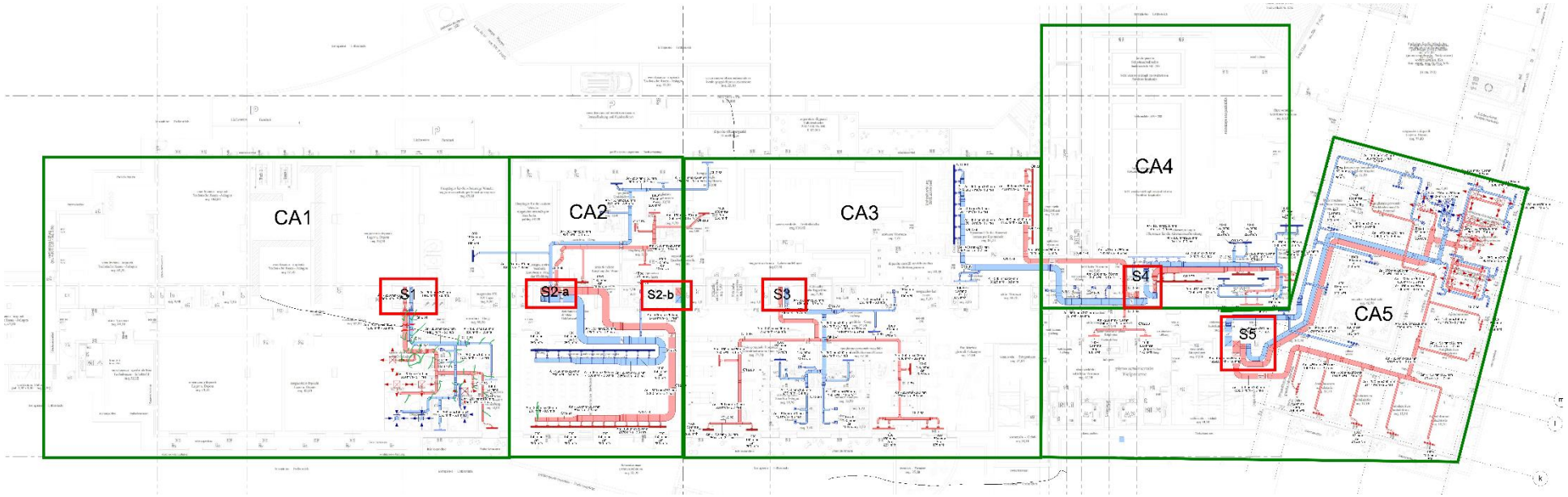
- **Private healthcare facility** specialised in rehabilitation and located in Northern Italy.
- Footprint of about **3500 sqm** and composed of **4 levels aboveground** and **1 level underground**
- Living rooms and medical rooms containing advanced technological equipment → HVAC system with **little repetition**
- HVAC installation from October 2018 up to June 2019 (9 months)

Case study: context

- Case study company **subcontracted** the **HVAC installation** task to another company
- Subcontracted company provides the **billing in a monthly frequency** according to the reached progress measured in square meters (sqm) installed
- A difficult and important task of the project manager is to understand whether **the progress reported corresponds** to the **real reached progress on-site**
- Analysis if BIM could be used to support the quantitative measurement of the construction progress

Case study: definition of the Location Breakdown Structure

- Subdivision in levels (-1 until +4)
  - Horizontal: Subdivision in Construction Areas (CA1 until CA5)
  - Vertical: Definition of the risers (S1 until S5)



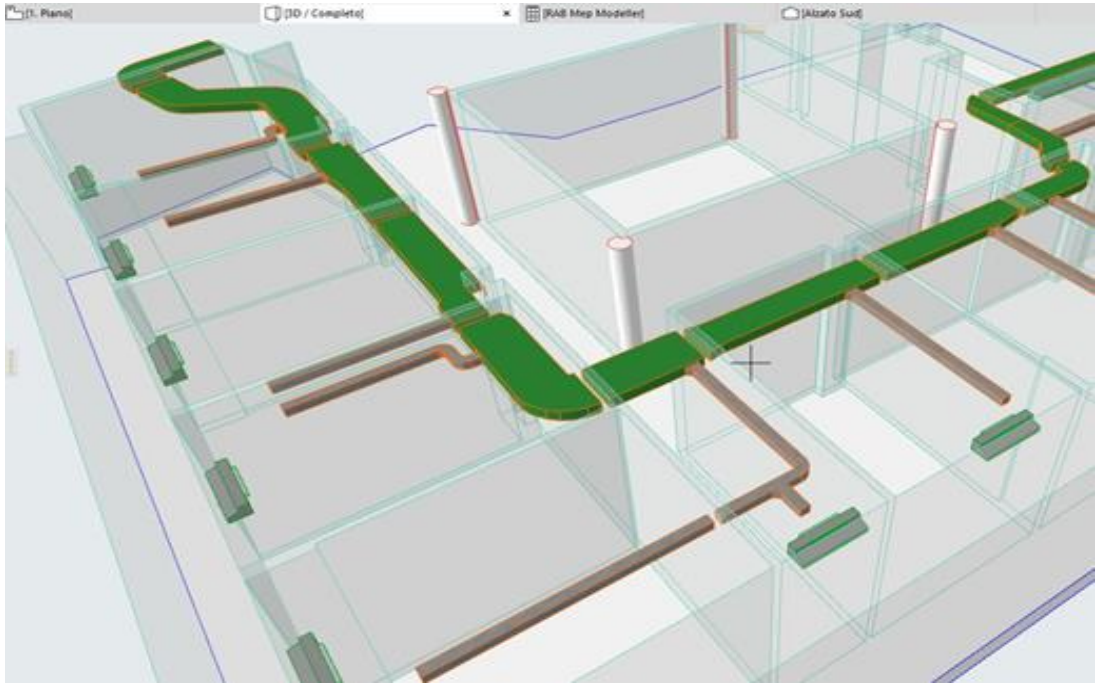
Case study: Pitch for straight and curved channels

$$Pitch_{CA_i,Task_j,Crewsize_k} = \frac{Quantity_{ij}\,[MU_j]}{time\ interval}$$

Task	Total lateral surface [m²]	Duration [d]	Pitch [m²/2workers/day]
Straight and curved channels (pipes)	9,680	280	34.57

- Duration according to project schedule
- Crew size according to the foreman

Case study: monitoring of construction progress



- Progress monitoring CA 5 in level 3:
  - Fridays: 11/01/2019 (week 1), 18/01/2019 (week 2), and 15/02/2019 (week 3)

Case study: calculation deviation from Pitch

	Pitch budget [m²/man-hour]	Time worked [man-hour]	Quantity budget [m²]	Quantity built [m²]	Deviation [m²]	Deviation [man-hour]
week1	2.1875	4.42	9.67	8.056	-1.61	-0.74
week2	2.1875	7.98	17.45	43.298	25.85	11.82
week3	2.1875	0.49	1.07	15.666	14.60	6.67

- Installation of pipes: over budget (week 1) and under budget (week 2 and 3)
- Subcontracted installation company did not work exclusively on level 3 CA5 in week 3 the man-hours were not sufficient to reach a reliable calculation
- First feedback from the project manager: "*approach provides **early warning signals** to **identify delays** and deviations **in time** and as such to **increases budget security** throughout the construction project execution.*"

Conclusion and outlook

- Installation of air ducts is a **highly non-repetitive task** that makes the **construction progress monitoring** a **challenging** activity
- The paper shows the **potential of BIM** to support **planning**, **scheduling** and **monitoring** of non-repetitive HVAC installation tasks
- Preliminary results showed that the approach allows a **weekly measurement of the reached progress** and an evaluation if the project is **over or under budget**.
- The **graphical visualization** of the reached progress in the BIM model, allows an immediate and intuitive understanding of the **status of a construction project**, which may help **easing planning**, **rescheduling** and **collaboration** among the actors involved in the HVAC operations.
- Future research:
  a) Validation of the approach with more case studies
  b) Extension to consider other parts like water pipelines (challenging for a visual recognition);