

The class will  
start at 16h15



**s i a**

Schweizerischer Ingenieur- und Architektenverein  
Société suisse des ingénieurs et des architectes  
Società svizzera degli ingegneri e degli architetti  
Swiss society of engineers and architects

Dimitrios Terzis



Dr. Dimitrios Terzis

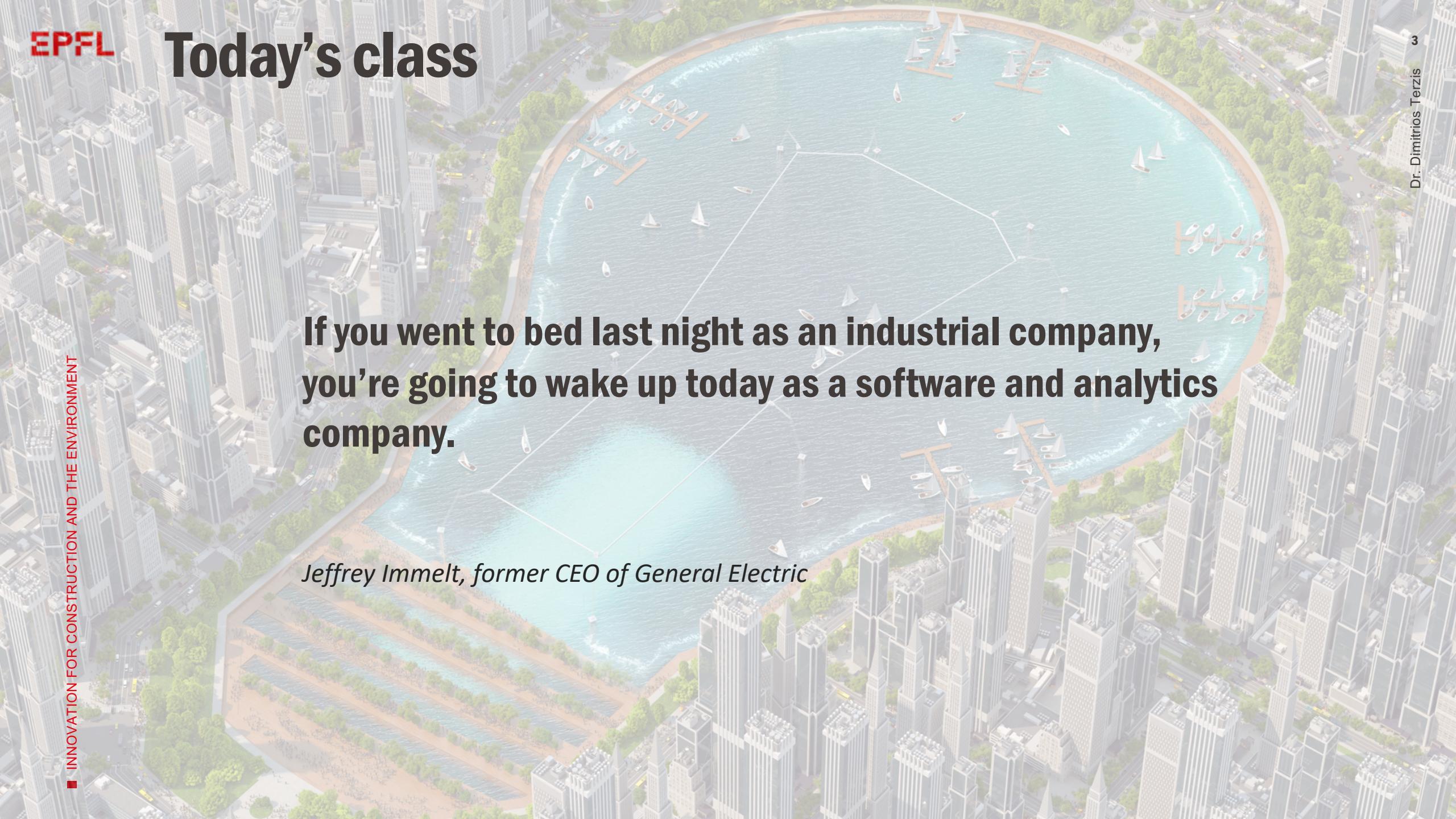
05/11/2024

# Innovation for construction & the environment

# Today's class

- 1) 3D printing and sustainability / Lessons from Mobbots
- 2) S-curves and pivoting while innovating
- 3) Parametric design

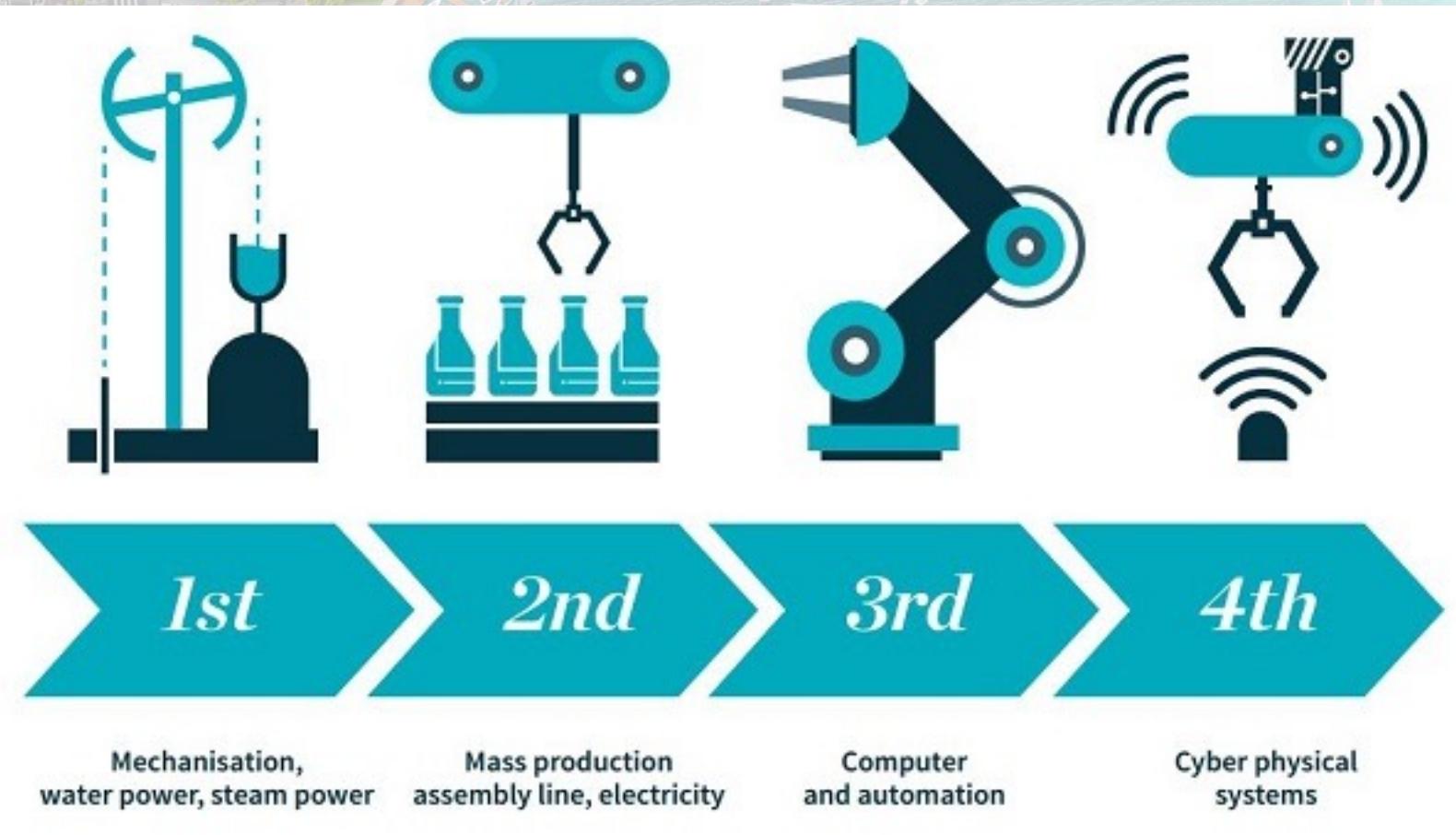
# Today's class



If you went to bed last night as an industrial company,  
you're going to wake up today as a software and analytics  
company.

*Jeffrey Immelt, former CEO of General Electric*

# Construction 4.0



# Understanding the scale of natural resources depletion

50bn tonnes of sand and gravel extracted each year, finds UN study

Calls for international standard on extraction and better monitoring of most-exploited resource after water



▲ A front loader is used to clear an area for sand mining on a dried lake bed in Jiangxi province, China. Photograph: Aly Song/Reuters

Humans extract 50bn tonnes of sand and gravel every year, according to UN research, enough to build a wall 27 metres high by 27 metres wide around the planet.

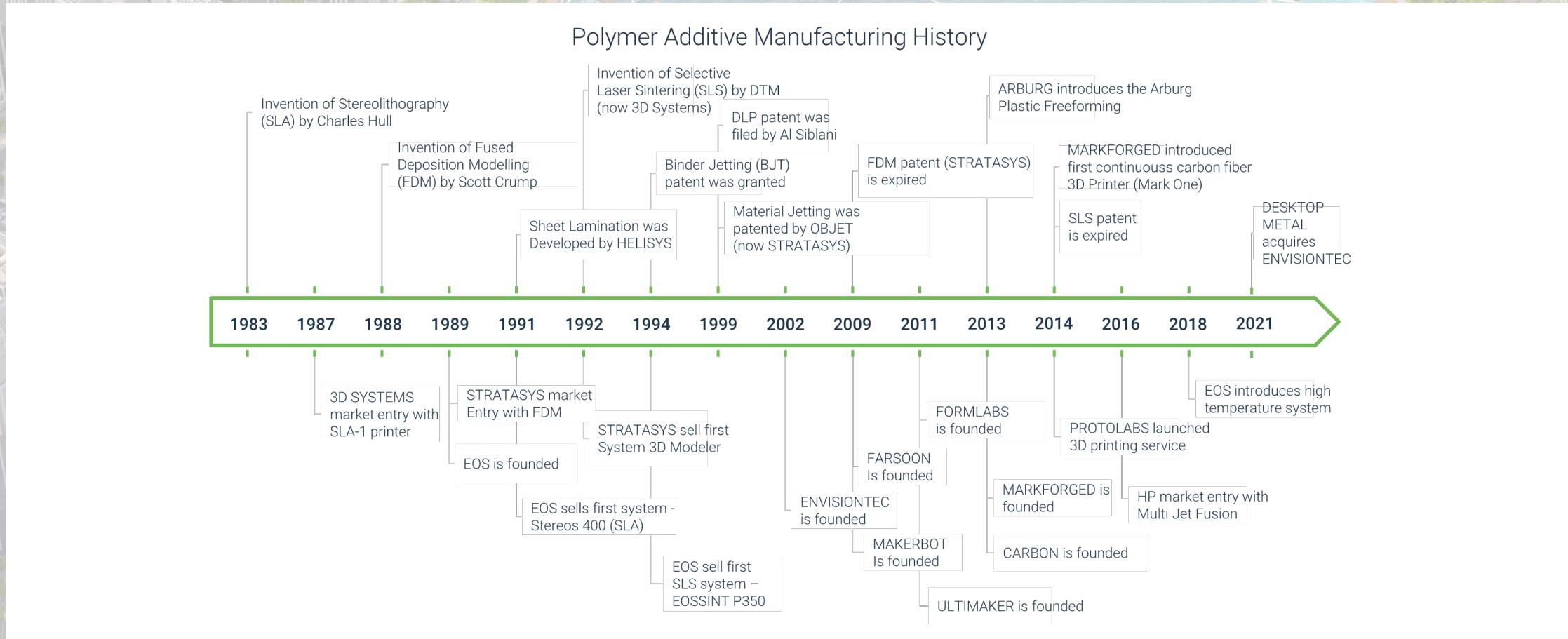
Sand is the most-exploited resource after water. But unlike water, it is not recognised as a key strategic resource by governments and industry, something, the UN says, that must change and fast.

# Understanding 3D printing



Source: <https://parametric-architecture.com/apis-cor-completes-the-dubai-municipality-largest-3d-printed-construction/>

# Understanding 3D printing implies understanding additive manufacturing



Overall, the link between 3D printing in construction and additive manufacturing is that 3D printing is a specific application of additive manufacturing technology within the construction industry. It leverages the principles of additive manufacturing to create customized, efficient, and often innovative building components and structures.

# Understanding 3D printing through a Swiss-made example



## **AUTOMATION AND ROBOTICS OF SPRAYED CONCRETE**

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Using less concrete for  
Sustainable  
infrastructures

# Concrete is the second most consumed material on Earth and is responsible for massive CO<sub>2</sub> emissions

Concrete consists of cement, sand, aggregates, and water.

Cement is responsible for 7% of the global CO<sub>2</sub> footprint.

Beside this the world is running out of crucial commodity which is sand.

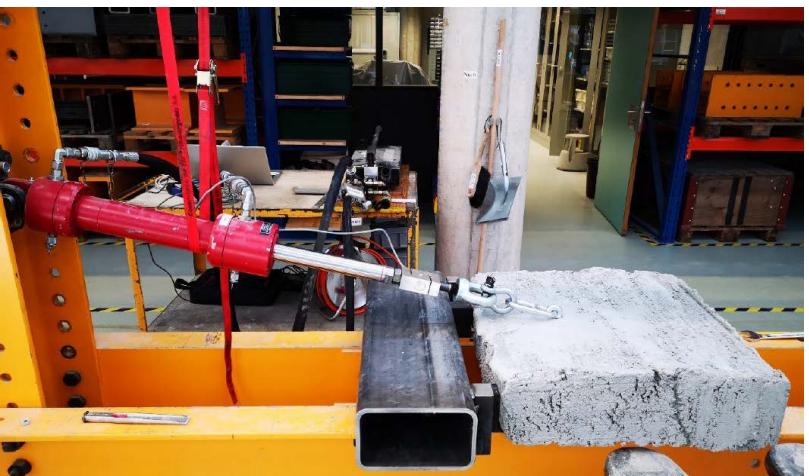
We therefore need to reduce the consumption of concrete on a global scale and use construction materials in a more efficient and sustainable way.



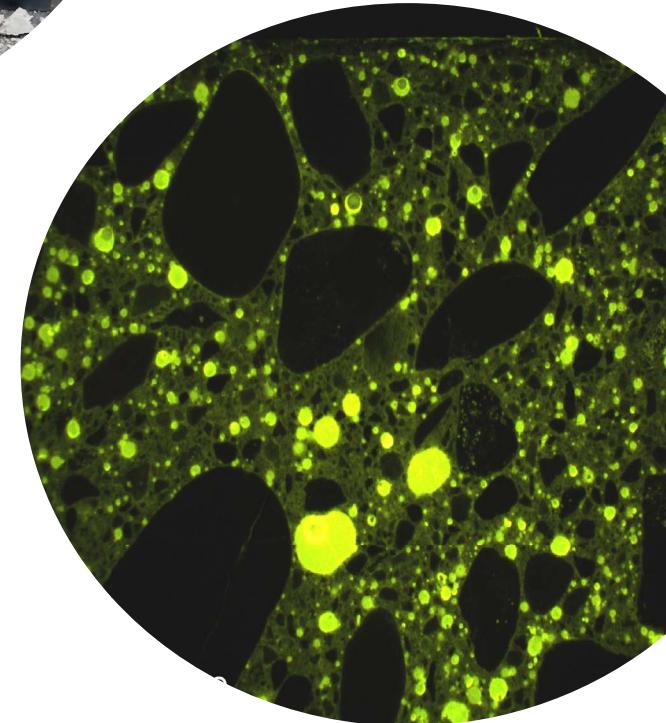
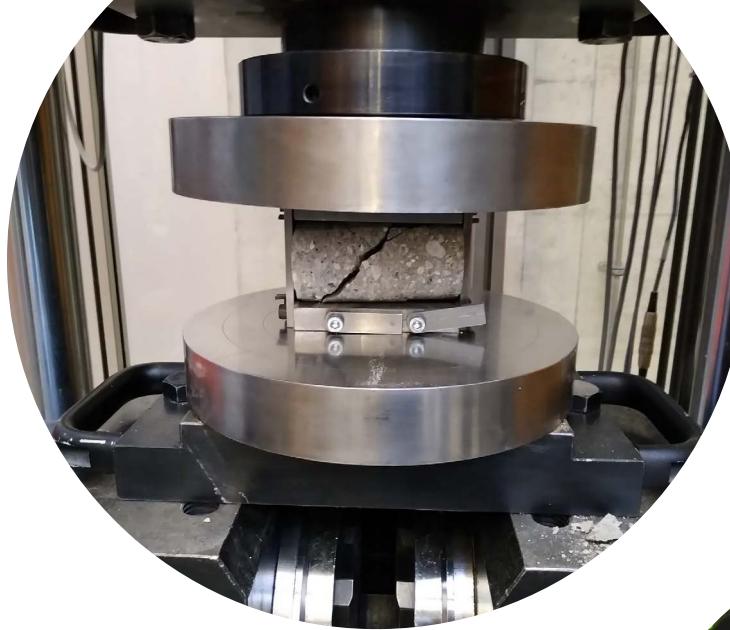


But what about our working processes, are they really efficient and safe ?

# Key features of mobbot 3D printing technology



- Sprayed material
- Aggregates Ø 8mm
- Use of local sand, aggregates, cement
- Waterproof products
- No “cold joints”
- Integration of rebars / reinforcement
- Conventional structural dimensioning
- Integration of anchors
- High durability (Freeze, Thaw, Cl etc)
- Versatile methods



# Comparison of 3D concrete printing

## “traditional 3D concrete printing”

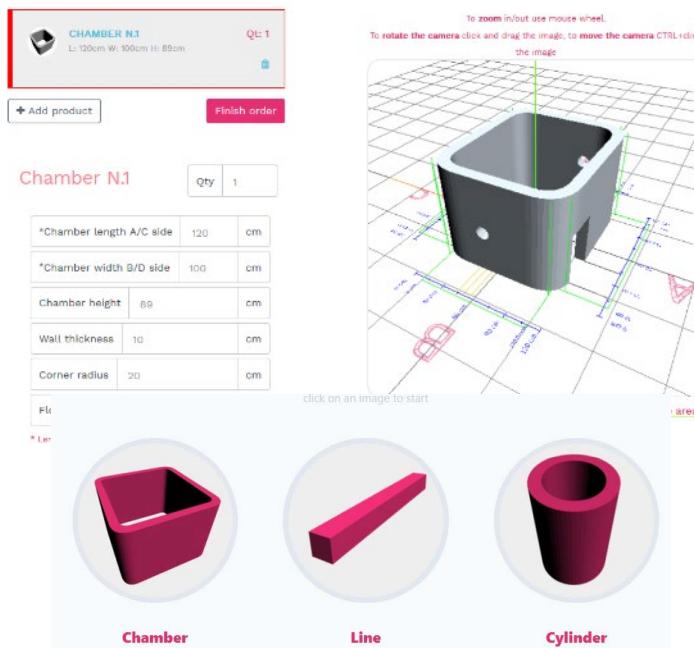


- Extrusion of fine and special mortar Ø 2-4mm
- High price of raw materials
- Weaknesses between the layers = cold joints
- Not compatible with existing standards
- No rebars



- Sprayed concrete Ø 8mm
- Conventional concrete and recycled material up to 45%
- Price of raw material
- Monolithic elements
- Compatible with standards
- Integration of traditional rebars
- Watertight

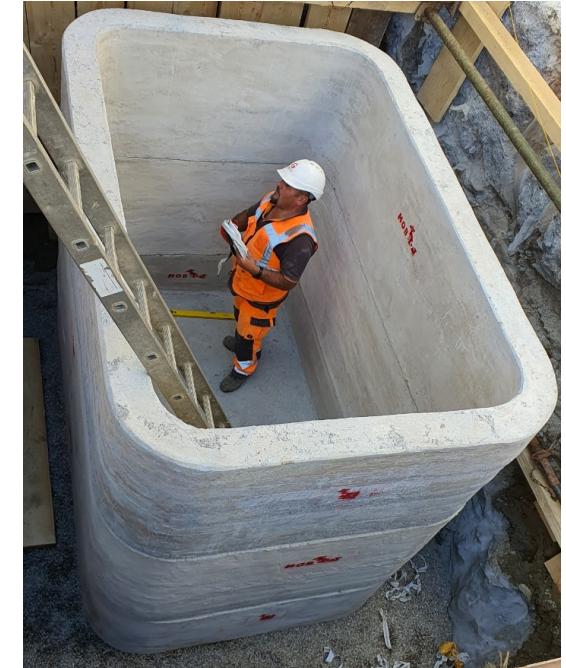
We have developed a robotic system that enables to design, fabricate and deliver concrete elements within 24 hours using less materials



Design



Sprint



Delivery

# Digital design with an online configurator

Order

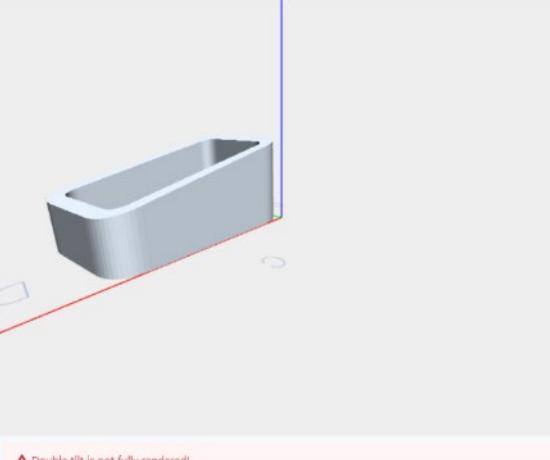
Project: New

**chamber**

Internal length:	188 cm
External length:	218 cm
Internal width:	100 cm
External width:	<b>130 cm</b>
Tilt:	Double tilt
H1 Ext. Height:	50 cm
H2 Ext. Height:	100 cm
H3 Ext. Height:	100 cm
H4 Ext. Height:	50 cm
Wall thickness:	15 cm
Internal corner radius:	31 cm
External corner radius:	<b>31 cm</b>
Bottom thickness:	0 cm
Number of circular slits:	0
Number of rectangular slits:	1
Volume:	633 l
Weight:	1518 kg

Double tilt is not fully rendered!

**3D Configurator** v2.0.37 Beta



Autodesk 105335 -

**Details**

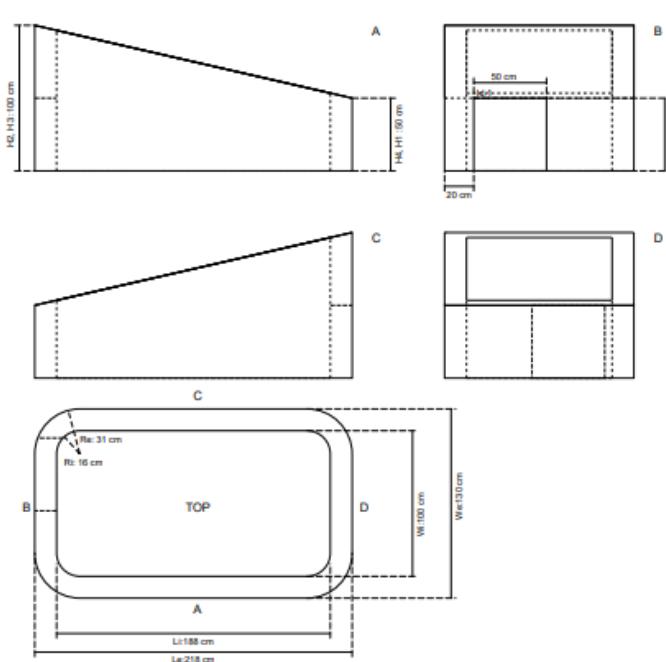
Dimensions Slits U-shape Tilt Options

**Tilt**

This is under development and will be available soon!

Double tilt

H1 Ext. Height (cm) 50  
H2 Ext. Height (cm) 100  
H3 Ext. Height (cm) 100  
H4 Ext. Height (cm) 50



**S09 –London, Hyde park**

Generated by themobbot.com

Note: Tilt data are not fully represented in drawing

**Measurements**

- External Height: 100 cm
- Internal Width: 100 cm
- External Width: 130 cm
- Internal Length: 188 cm
- External Length: 218 cm

**Other**

- Wall Thickness: 15 cm
- Internal Radius: 16 cm
- External Radius: 31 cm
- Number of circular slits: 0
- Number of rectangular slits: 1

**Options**

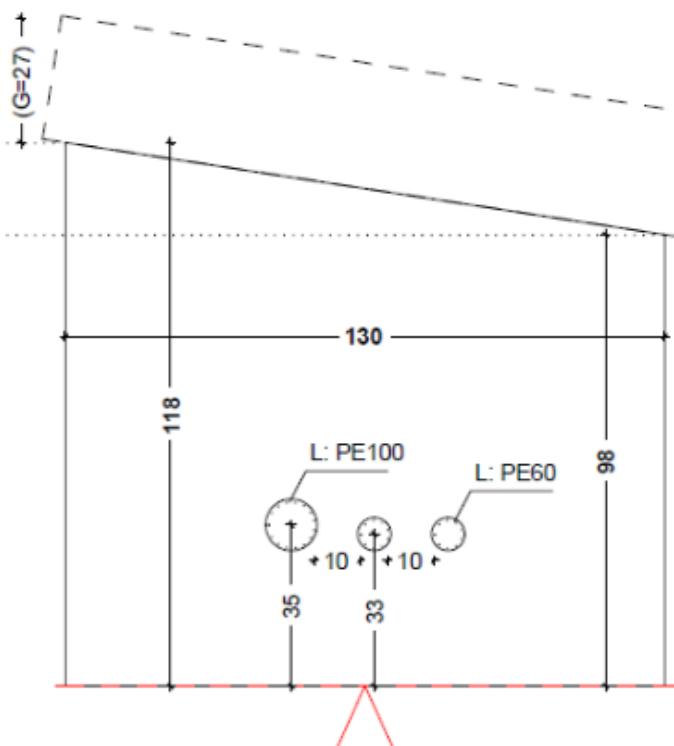
- Tilt AD:50cm, AB:100cm, BC:100cm, CD:50cm
- Rebars
- Volume: 633 l
- Weight: 1518 kg

PDF generated on July 22nd 2021, 10:53

v.a.0.1.8.3

[PRODUCT CONFIGULATOR | themobbot.com](http://themobbot.com)

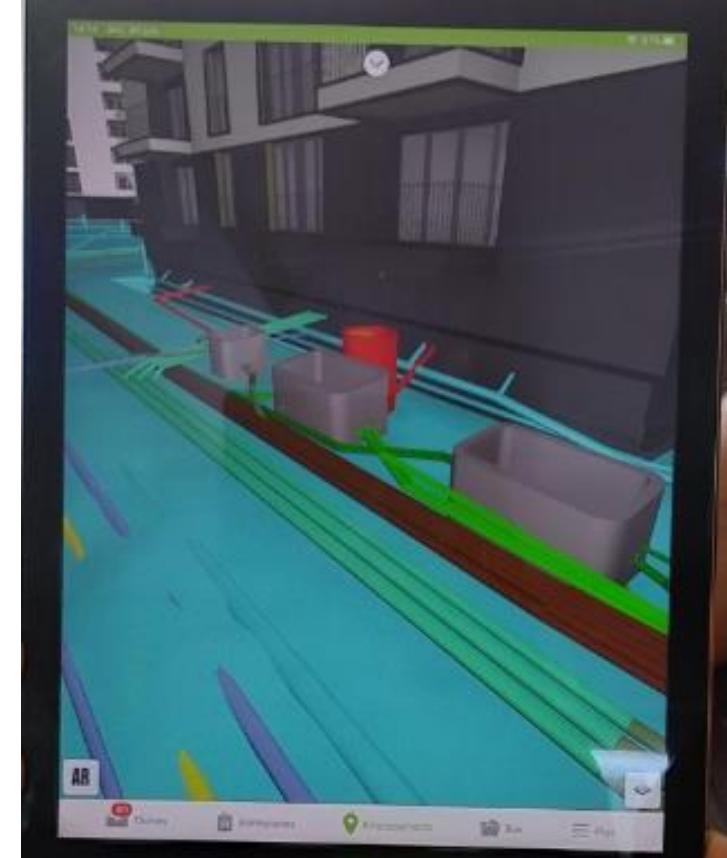
# But we can use and generate BIM model



Project owner:



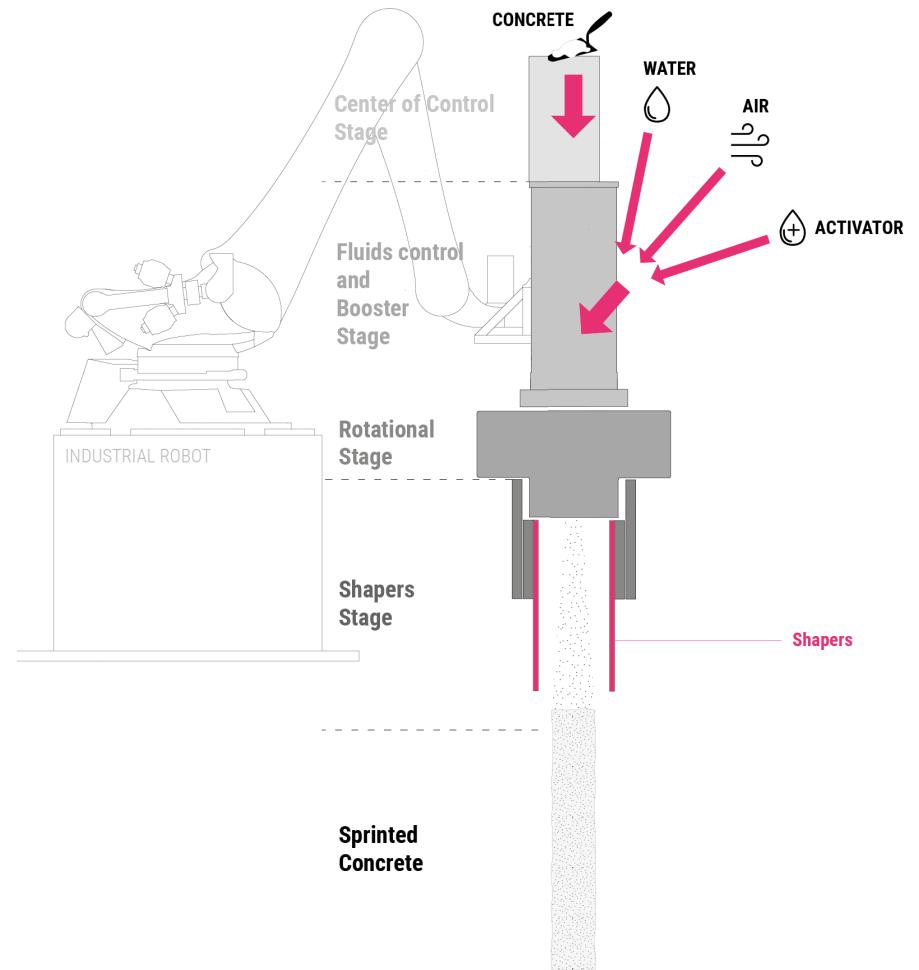
Contractor:



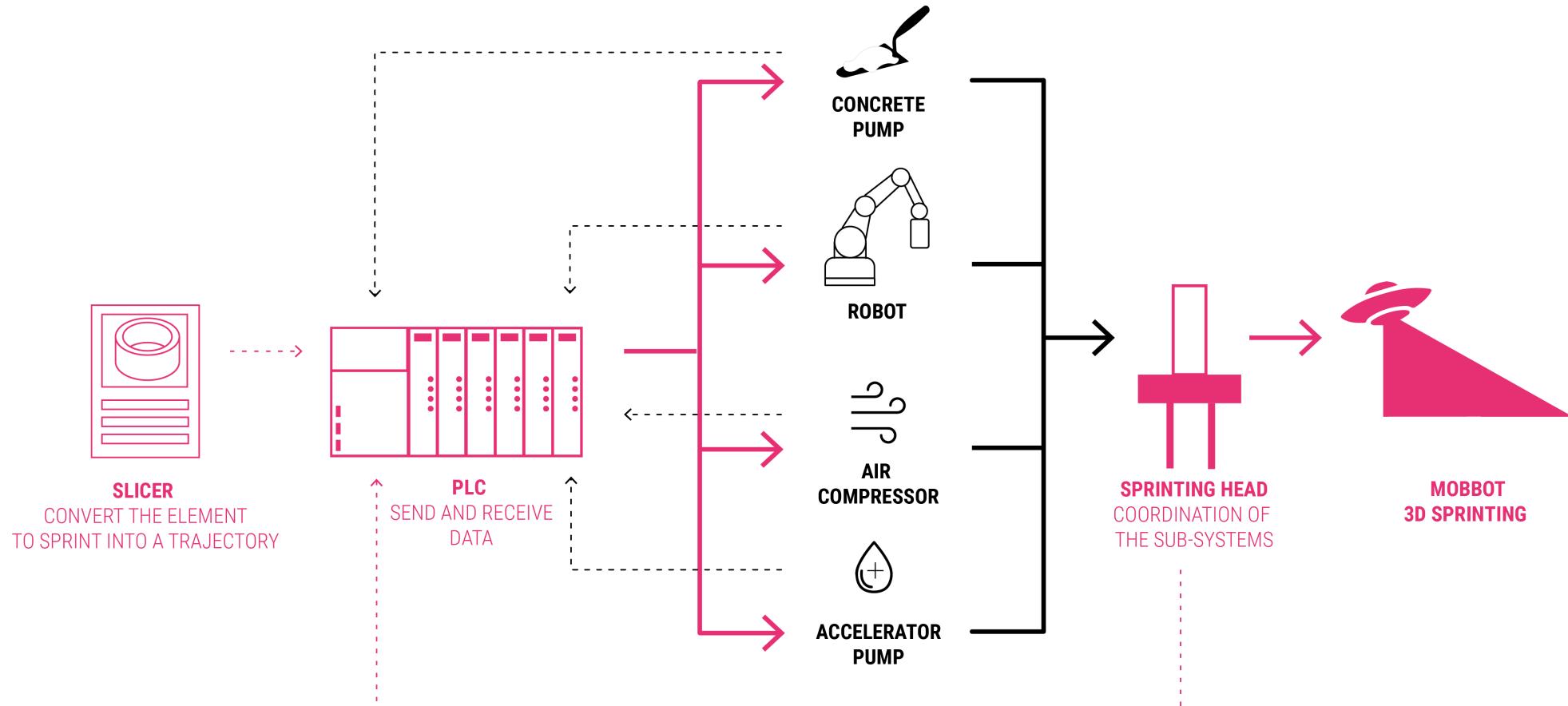
Benefits :

- Solution « Plug & Play »
- Integration in BIM and georeferenced
- Ergonomic and safe for workers

# So how does the system work ?



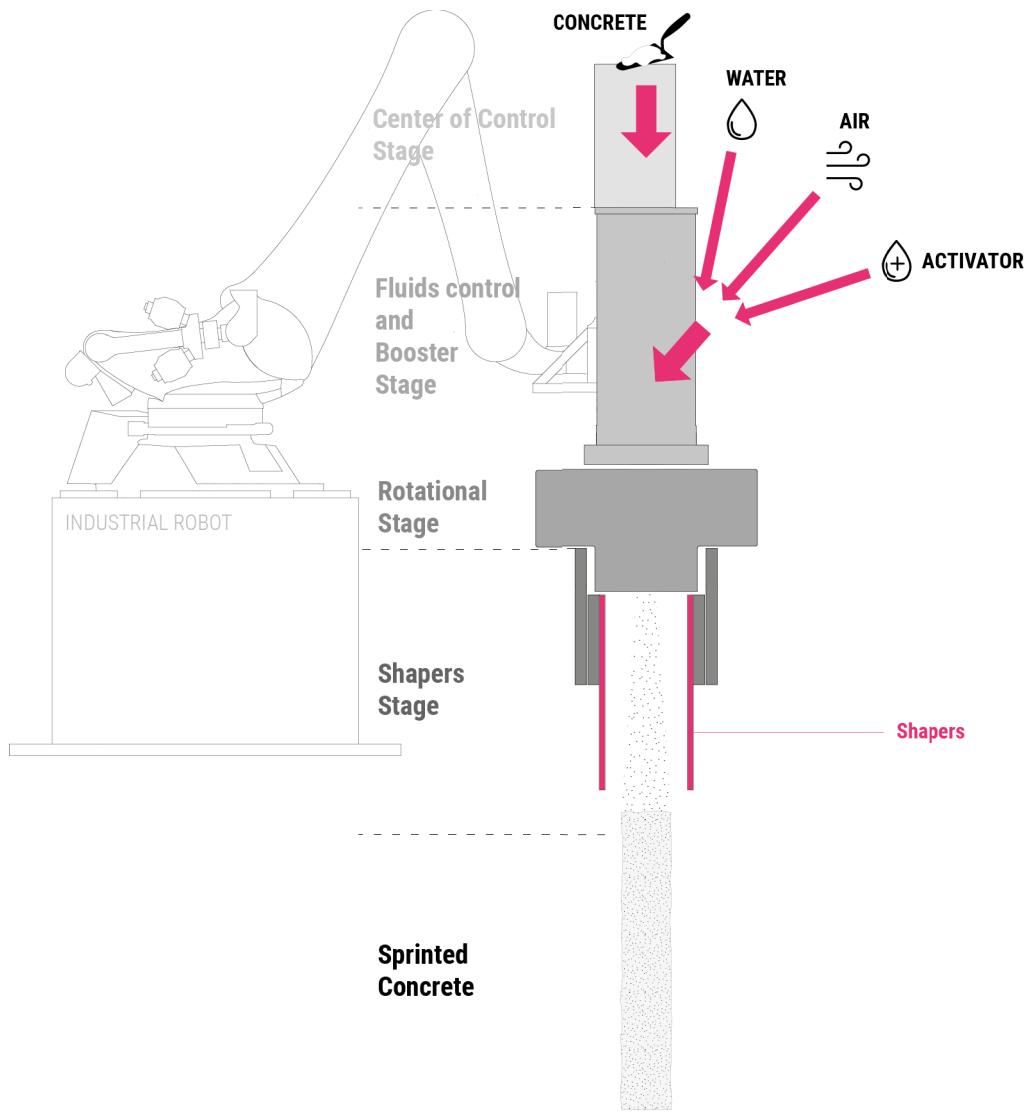
# How does it work ?



# We combine additive and subtractive methods

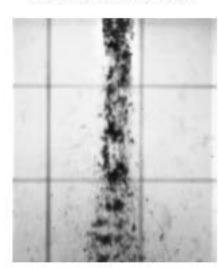
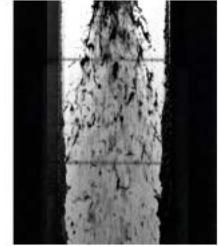
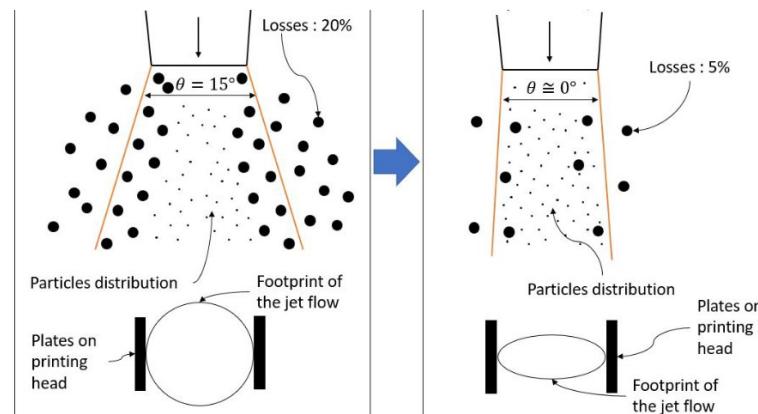


# Why does it work well?



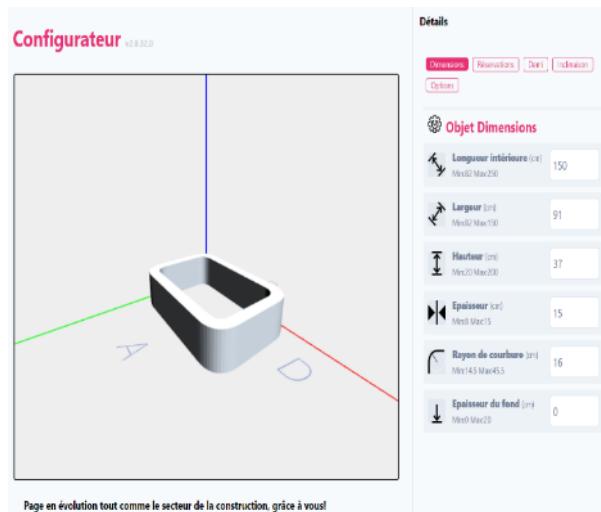
**Our know-how lies in the modelling, simulation and prediction of the concrete flow to have optimum strength performance. To do so, we control:**

- Spraying angle control
- Speed control
- Flow and pressures



# The benefits for the customers

## Online design



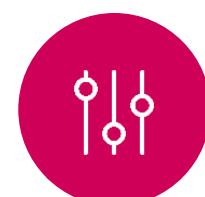
## Offsite production



## New value chain



## Installation



Flexible



2 hours  
instead of 2  
days



> 30-50%  
less CO<sub>2</sub>

# Today the method is used for telecom, railway, energy and water utilities

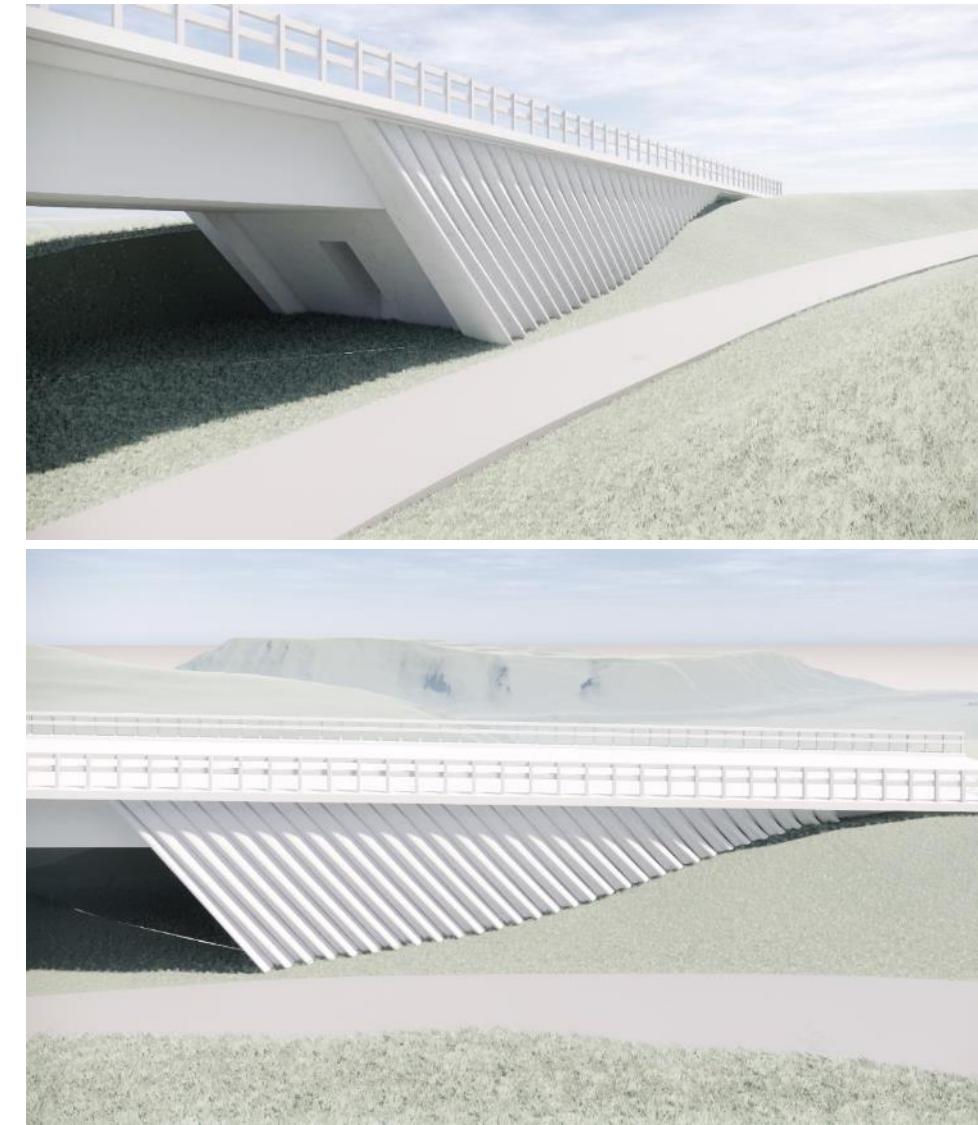
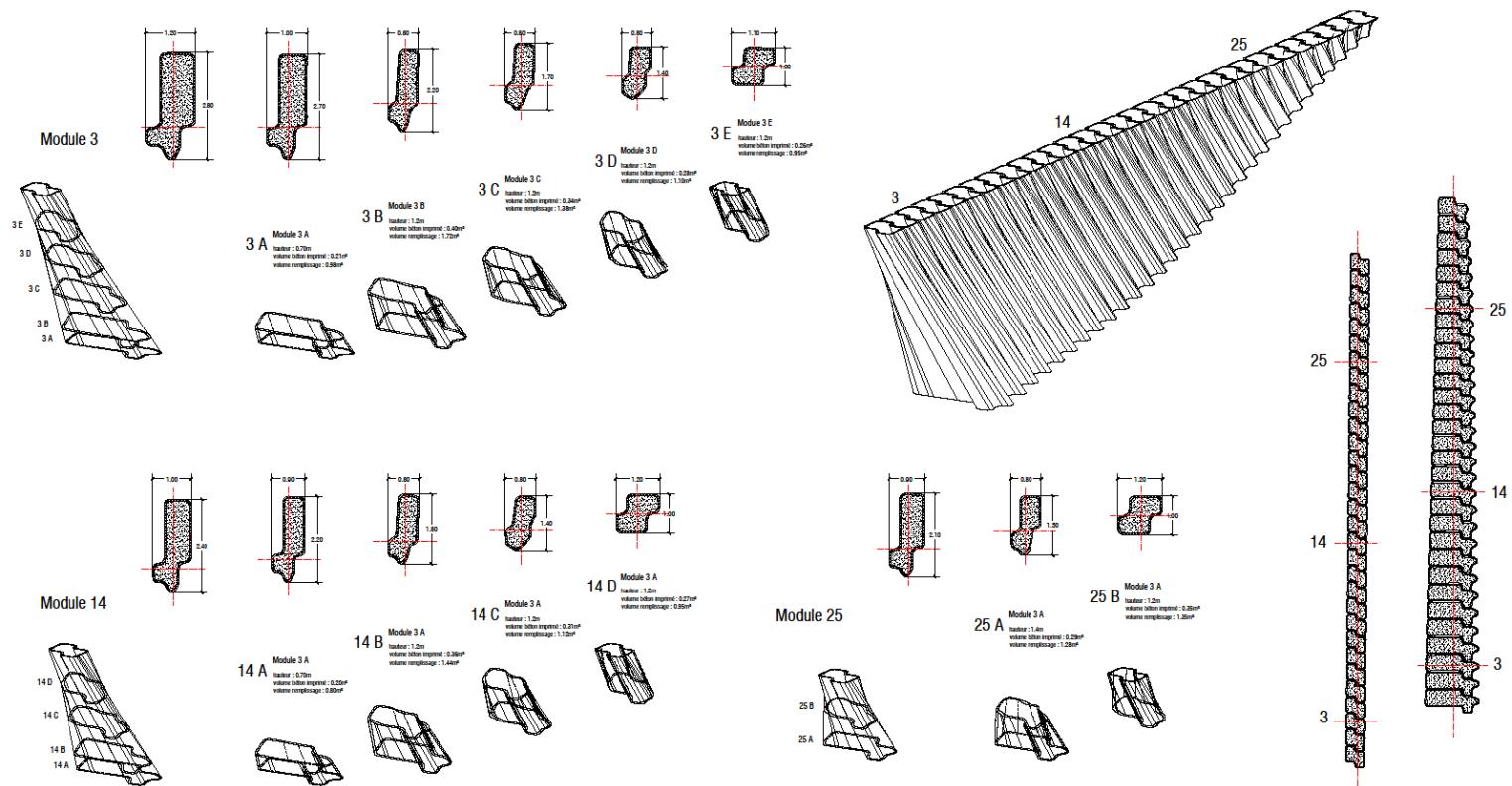


GROUPE GRISONI



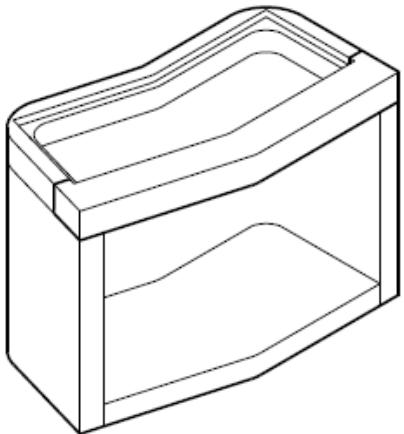
# Chesalles Bridge – Fribourg -CH

**MARC MIMRAM** | ARCHITECTE DPLG  
INGÉNIEUR ENPC



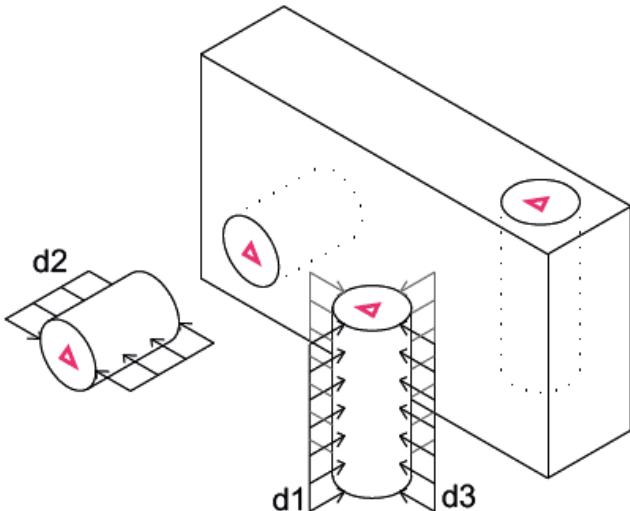


# Other possibilities



# What is unique with MOBBOT

## Isotropic performances



\*Brazilian splitting test

## Conventional concrete & Local raw materials



## Rebars integration



# How 3D printing integrates into circular economy



Renovation of  
existing  
infrastructures



Renovation /  
building by-  
products

Recycled  
Materials /  
Demolition waste

Enhanced  
properties with  
sprayed materials



# Unique value proposition



Digital design and personalised elements



Optimized concrete performances



Precast offsite production



Recycled materials



# compatible with a large amount of raw materials type

Temperature: 4 – 30 °C

Humidity 37-70%

MOBBeton

0 – 4/8 mm

Local raw materials

RMX Fribourg

0 – 8 mm

CEM II 42.5 N

Premix A

0 – 2 mm

High Sulfate  
resistant  
C3A<8%

Customer

0 – 8mm  
grey / white

Local raw material  
CEM I 52.5 N/R  
CEM II 52.R

Customers

0 – 8mm  
Grey

Up to 45% recycling  
aggregates

Susteno





We turn data into  
sustainable construction



# Our vision

At Mobbots, we **empower the construction** industry to build the required **next generation sustainable infrastructures.**

Using our unique **digital construction technology and data** our clients have a way to build robust and innovative construction elements with a climate-first priority for all.

# Our company in a nutshell

## **Mobbot**

- ❖ Founded in 2018 in Switzerland
- ❖ Headquarters in Fribourg, Switzerland
- ❖ 8 employees

## **Awards**

- ❖ Winner 1st Prize - Swisscom IoT Climate Award 2022
- ❖ Top 100 Swiss Startups 2020, 2021



**Successful market  
introduction and  
development potentials**

Hundreds of civil engineering elements executed  
according to the swiss construction and safety standards

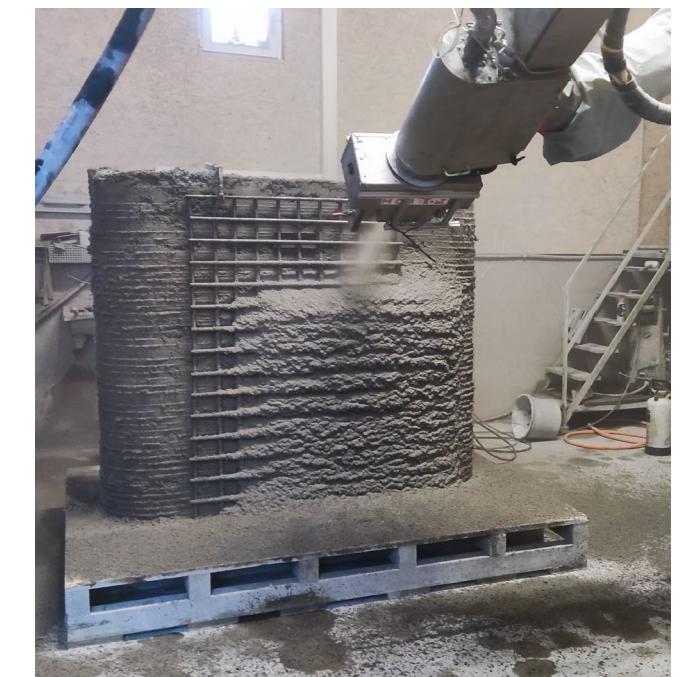
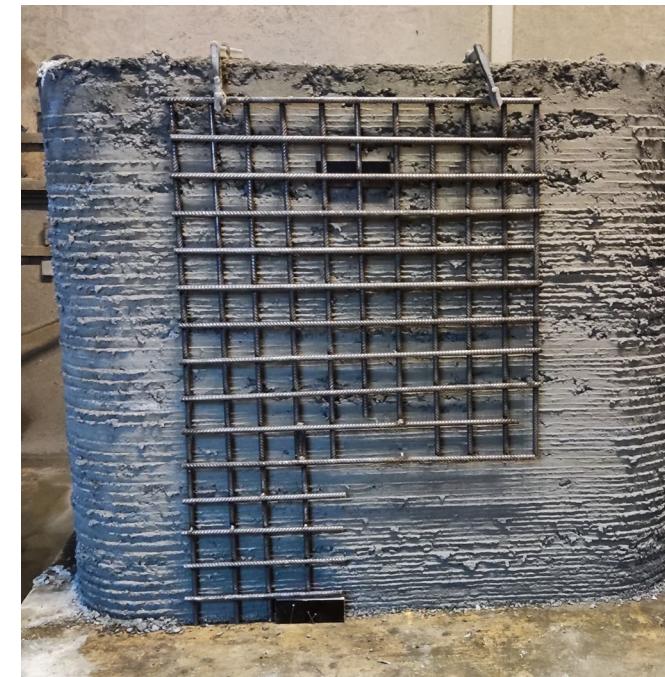


# The method offers unique possibilities to integrate structural reinforcement

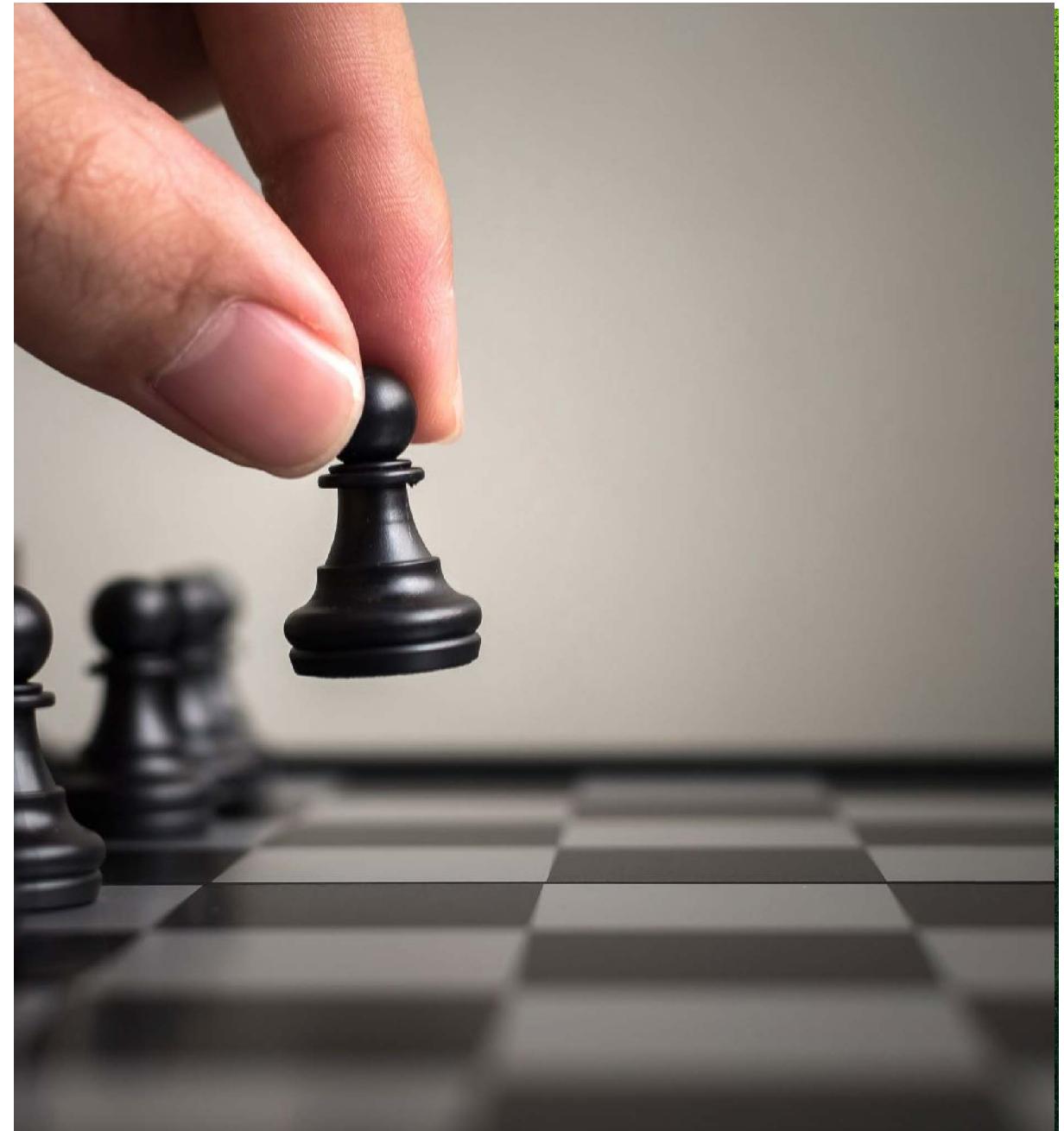
Rebars Ø 14-16mm, sp. = 10cm

No rebar phantoms

Rebound: < 5%



Is the business scalable ?  
Is the market ready ?



**Are there  
opportunities in  
other segments?**

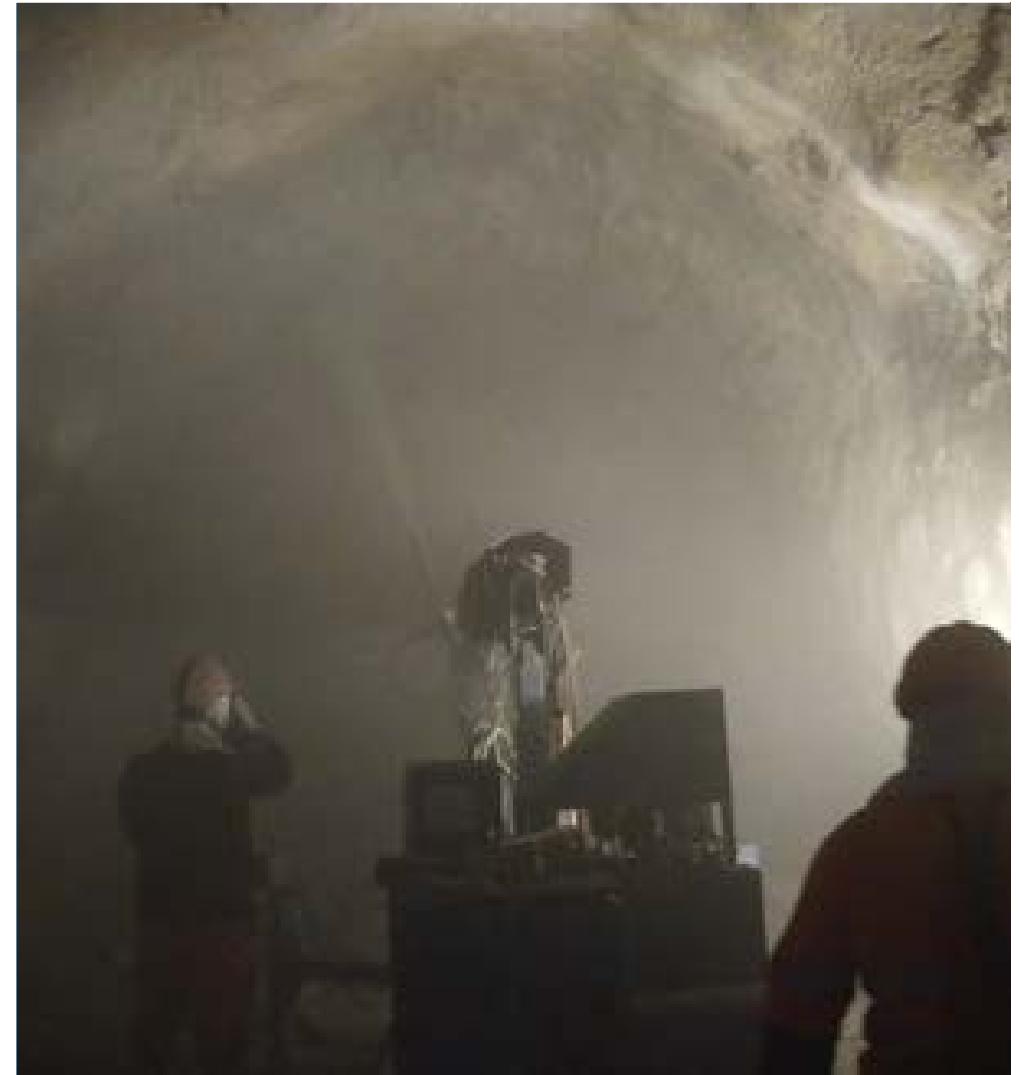
# The challenges of underground projects

No visibility on operations

Spraying managed by  
feeling

High overuse of concrete

Health and safety issues

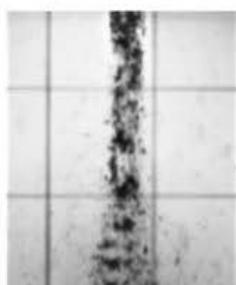
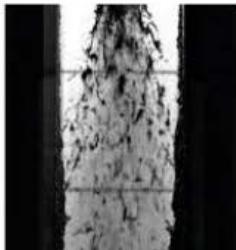




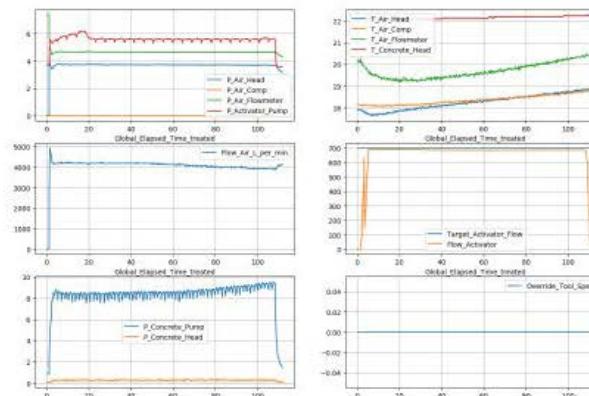
Tons of concrete  
wasted

# What could we offer to these contractors ?

**Waste reduction thanks to nozzle geometry and aerodynamic optimization**



**Process and equipment efficiency with real time data control**



**Automation of existing equipment  
Use of our automated spraying equipment**

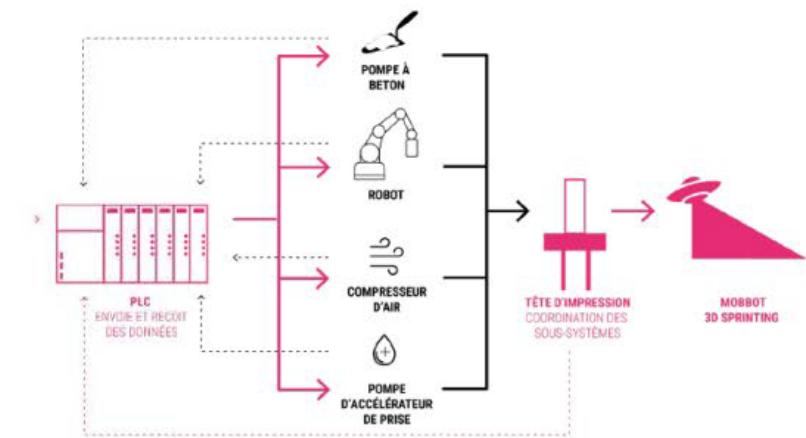


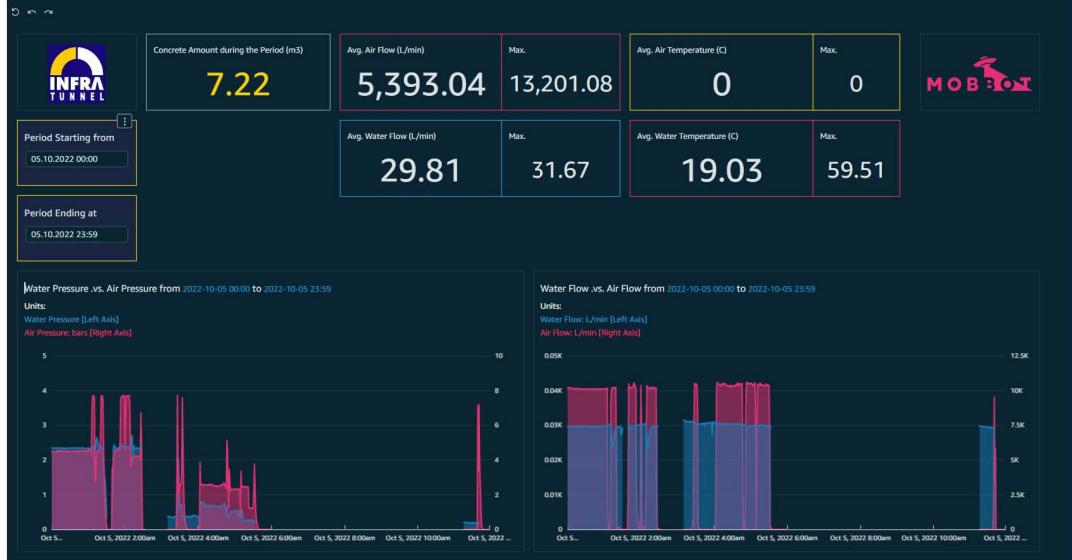
Image 1: schéma plc et sous-systèmes



**The pivot toward  
underground projects**



# Turning data into material and time savings

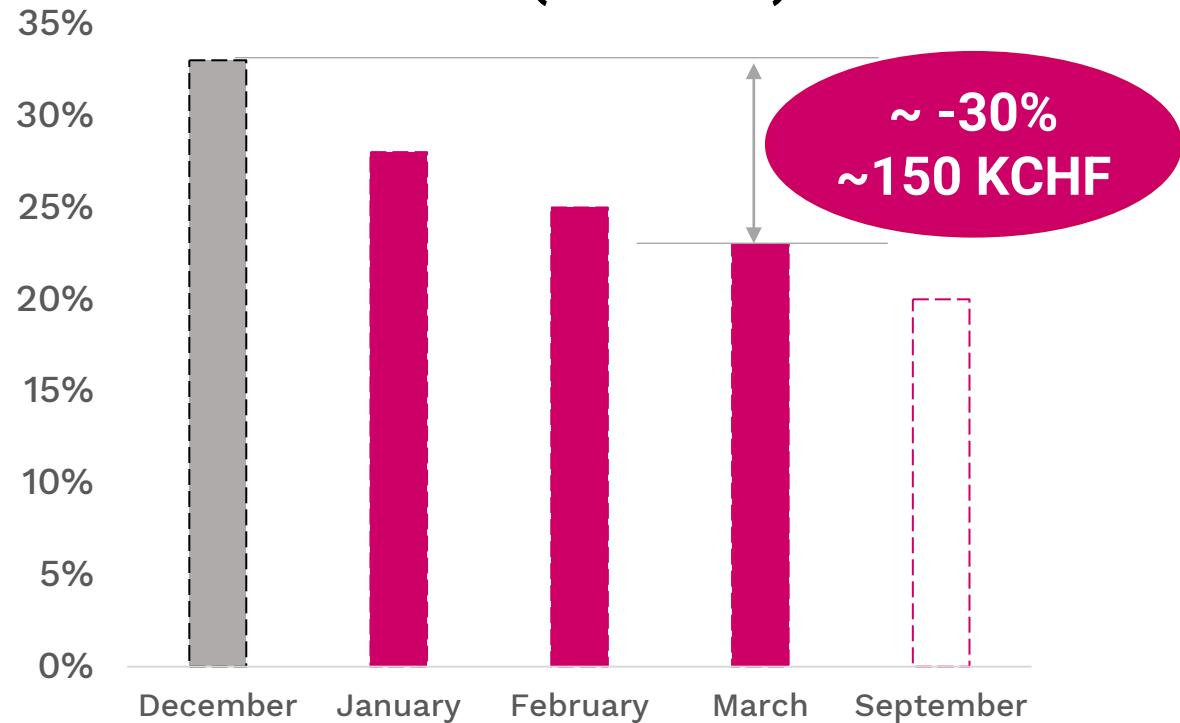


**“**The monitoring system is an aid to standardize spraying practices to **optimize spraying phases and identify equipment usage issues**.

The **real-time visualization**, allows the foreman and myself to follow the spraying phase and intervene if necessary to correct usage.

M. Petit, Head logistics and machine, InfraTunnel

## Rebound (= waste)



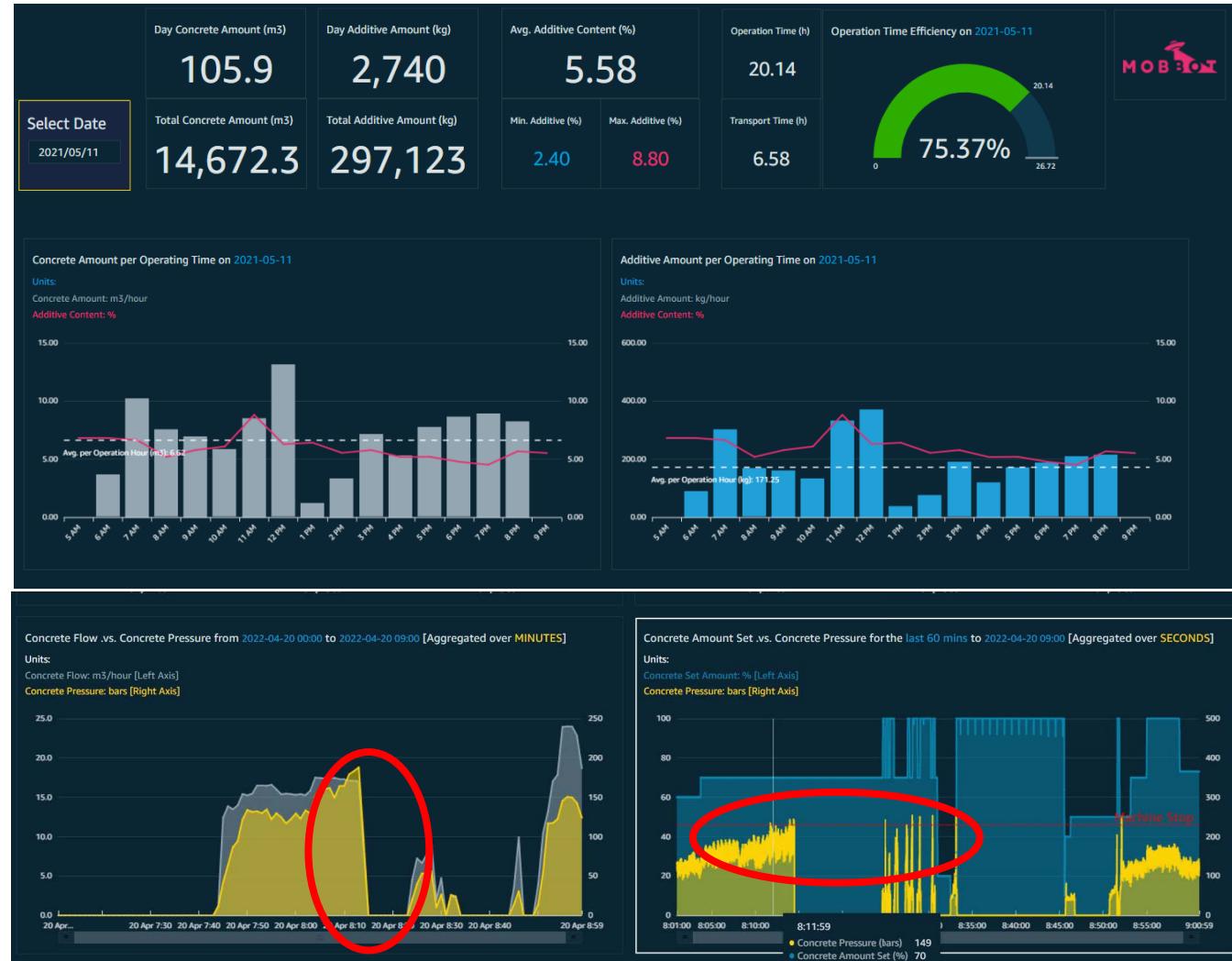
# Remote access to your spraying data

## Product

- Data acquisition frequency 10 Hz
- Daily reports
- Alerts send automatically
- CANBus port
- Help in the identification of problem
- Customizable interface
- Machine errors for technical service support
- Historical data for quality assurance

## Benefits

- ✓ Visibility on spraying data
- ✓ Save time in the resolution of problems
- ✓ Predict clogging (under development)



Note: We analyse your data, develop algorithm to identify and classify problems and customize the output to your need – Also available for TBM spraying data.

# Real time monitoring and immediate feedback

## Interfaces



Fieldbus Interface  
to construction  
equipment

## Software



IoT for machines and  
operations

Benefits:  
Analysis and corrective  
measurement

## Unique Sensor Technology



Distance to Excavated  
Profile sensor

Benefits:  
Reduce concrete  
waste



Immersive  
Thickness control  
Device

Benefits:  
Reduce concrete  
consumption

# DEP™ – Distance to excavated profile sensor

## Description

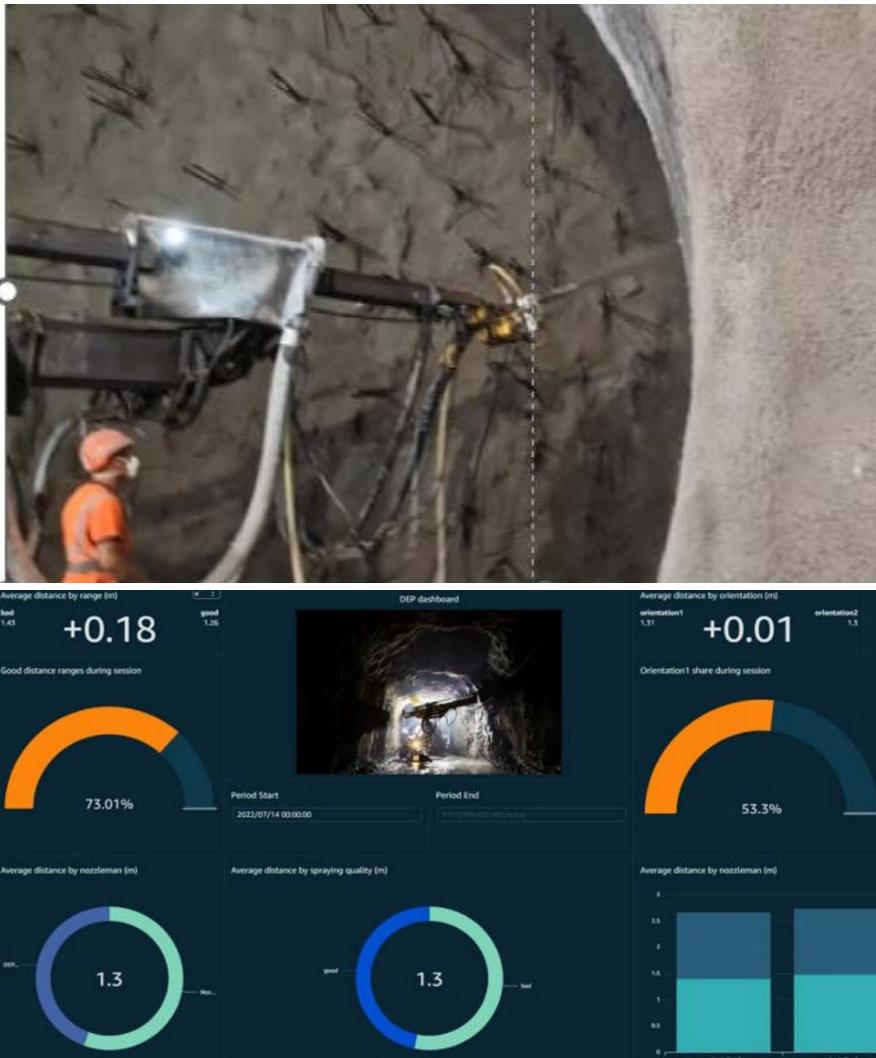
- Real-time nozzle distance to wall
- Provide a real time feedback to the operator
- Data available in a dashboard
- Ideal for training purposes

## Benefits

- ✓ Reduction of rebounds
- ✓ Increase learning curve
- ✓ Save time



# Distance to excavated profile sensor



**Auto wash with air/ water**

**Light signal on/off when distance is outside of the set range**

**Dashboard for teaching purposes**

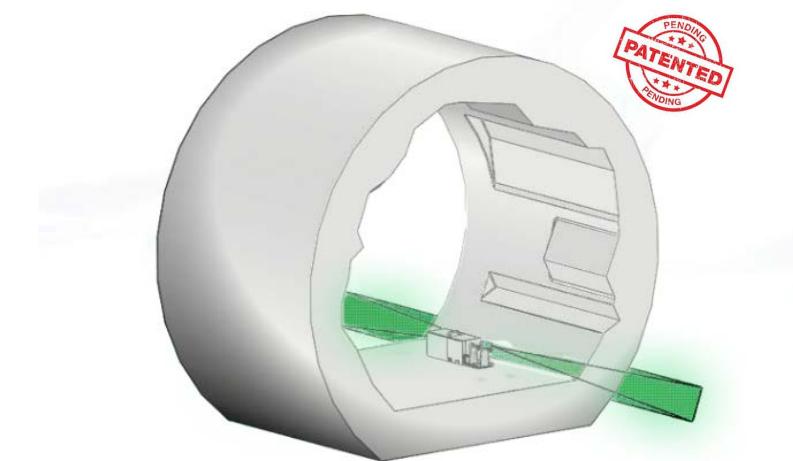
# Thickness measurement in real time

## Product details

- Scan with LiDAR in a continuous way
- Display the shotcrete thickness measurement in real time on the tunnel profile
- Device measure also removable material
- Refresh cycle of 60-90sec

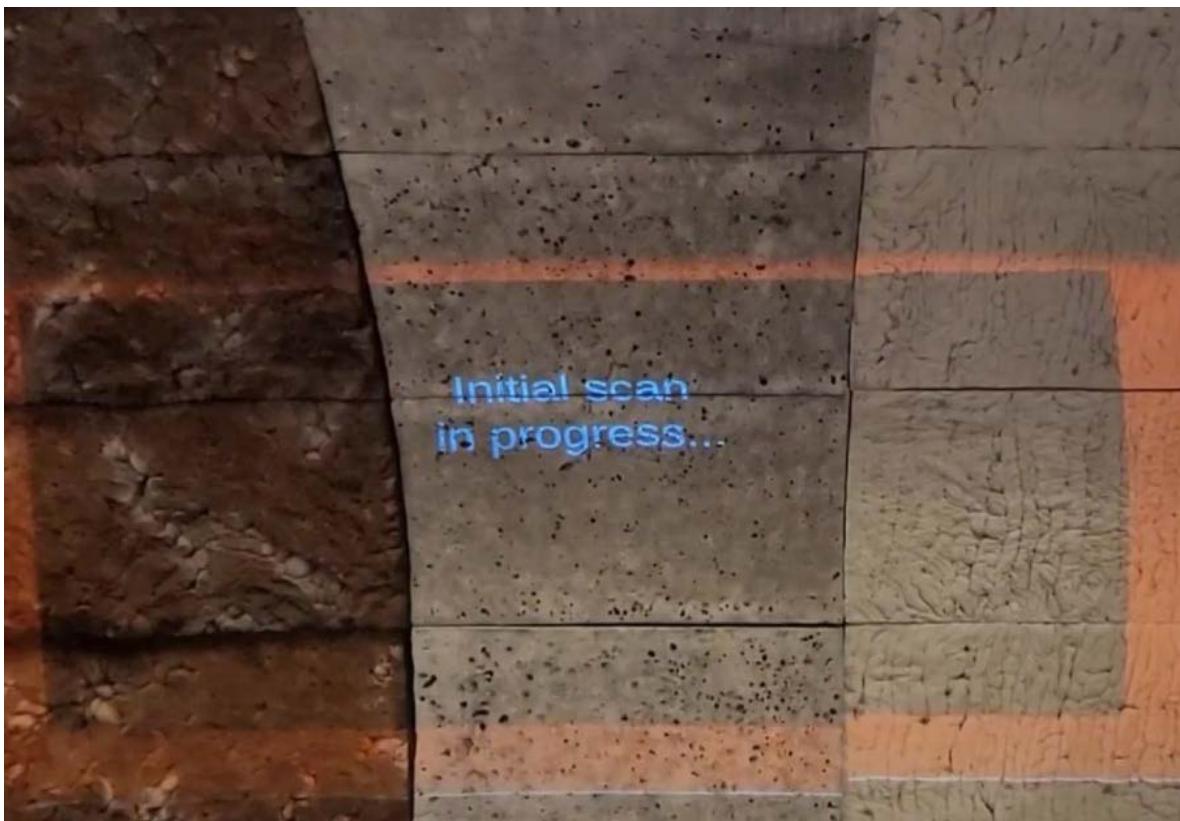
## Benefits

- ✓ Reduce use of concrete
- ✓ Improve productivity
- ✓ Reduce logistics of rebound/waste



# Real time thickness measurement

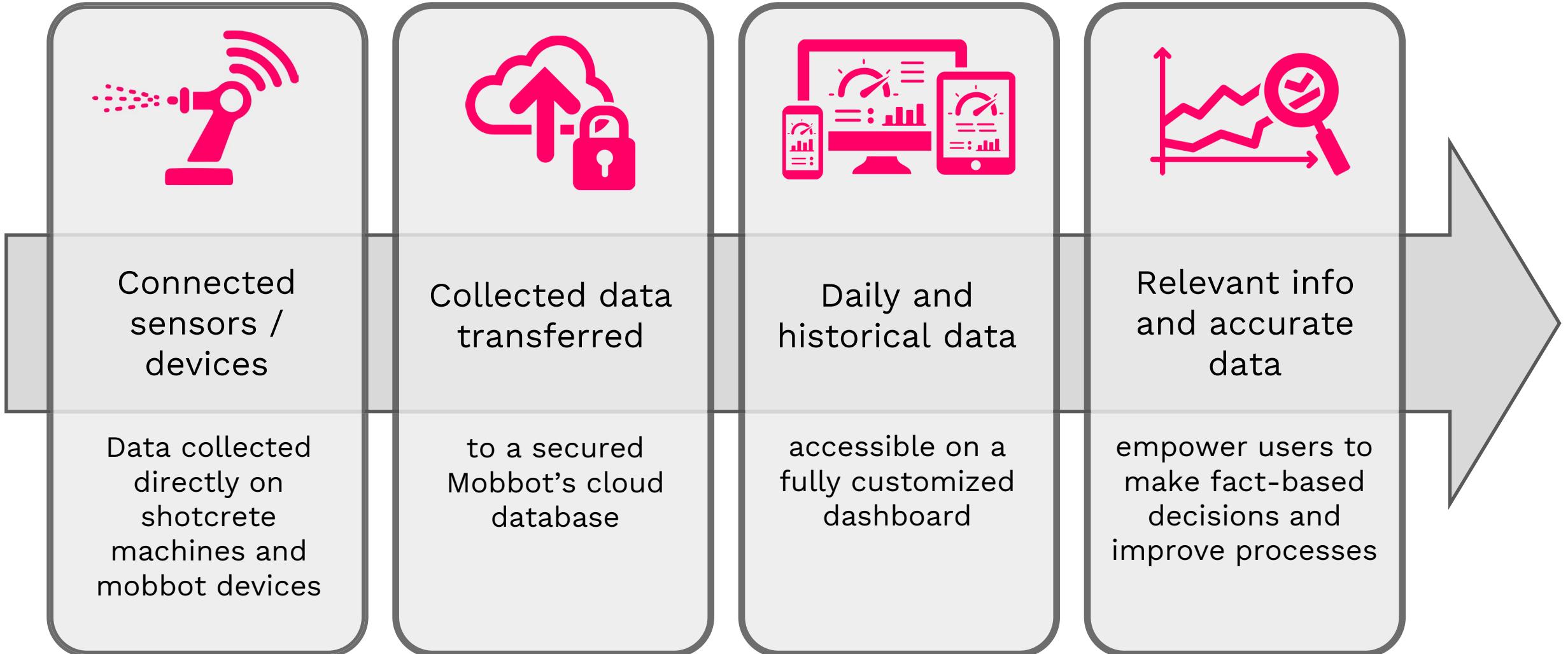
**Initial scan**



**Continuous & real time display of thickness in the tunnel**



# A centralized dashboard to improve shotcrete processes



# What our client says about Mobbott

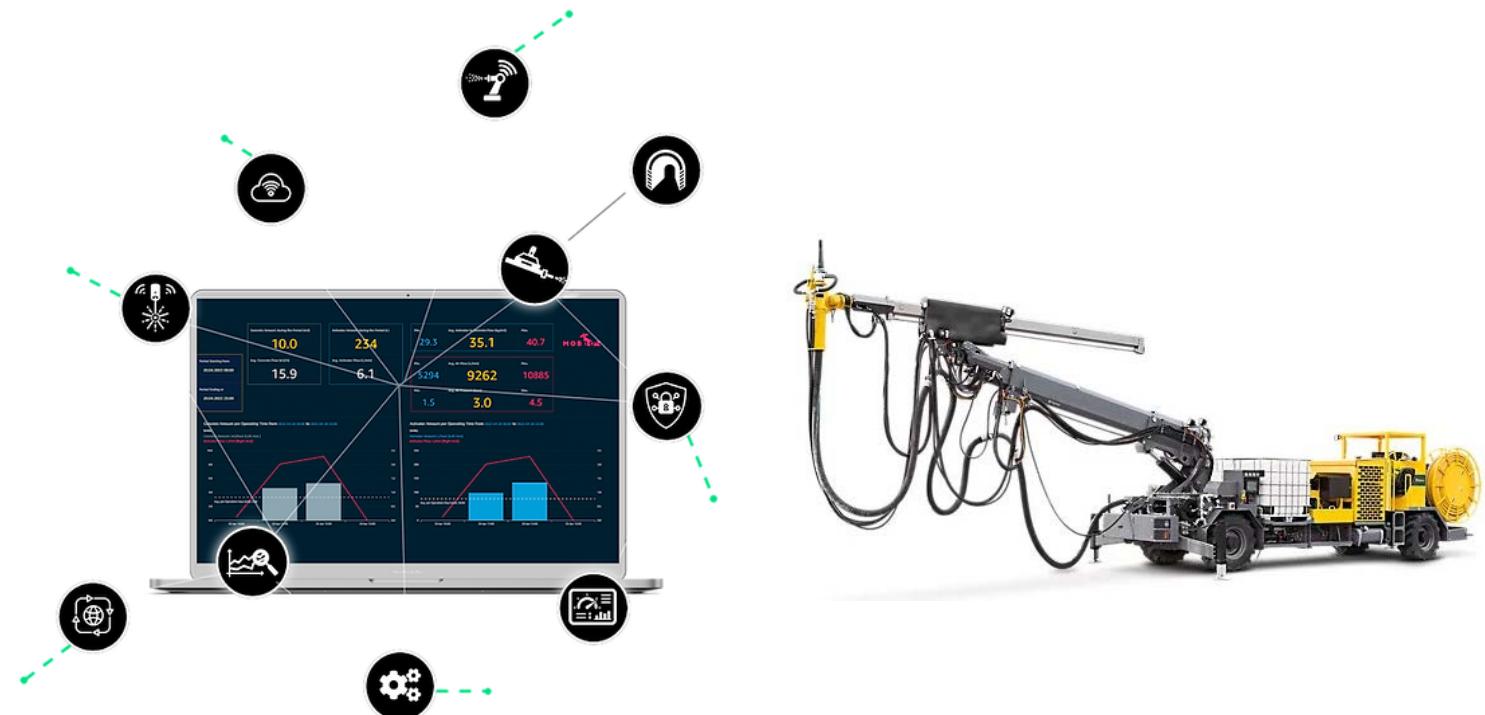


G. Lequertier  
Managing director, Infra Tunnel SA

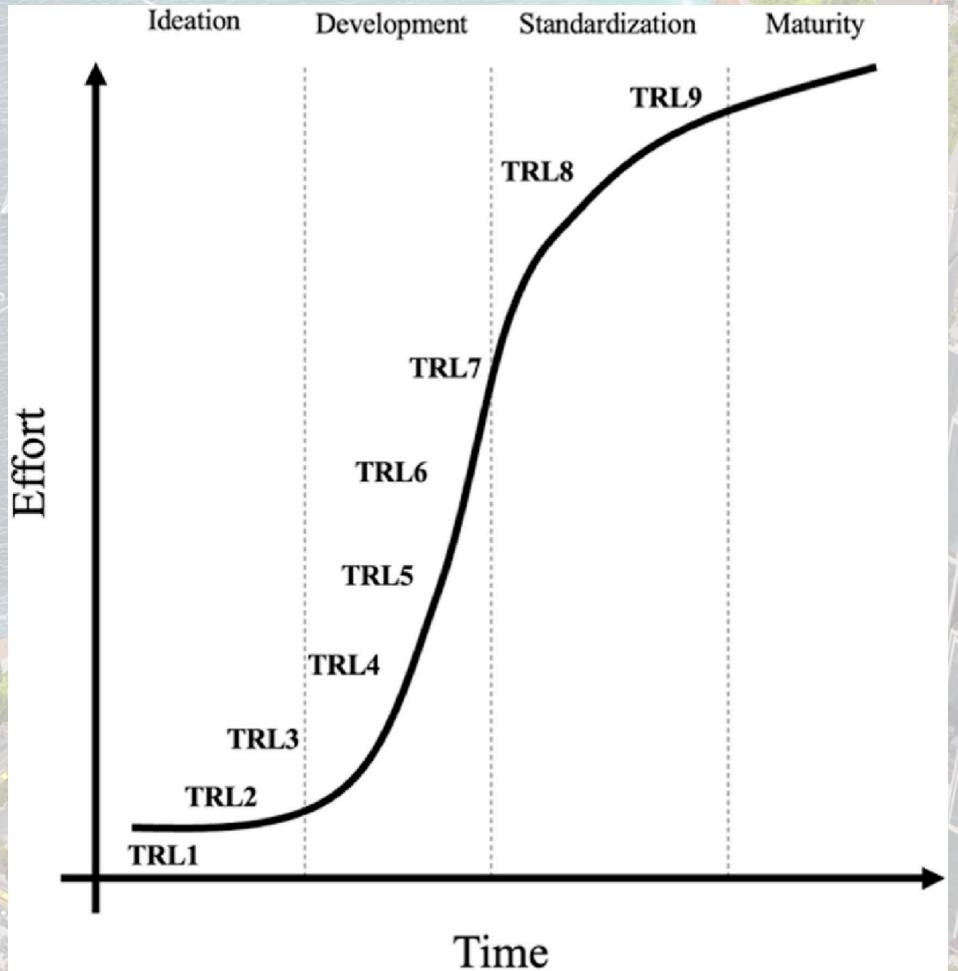
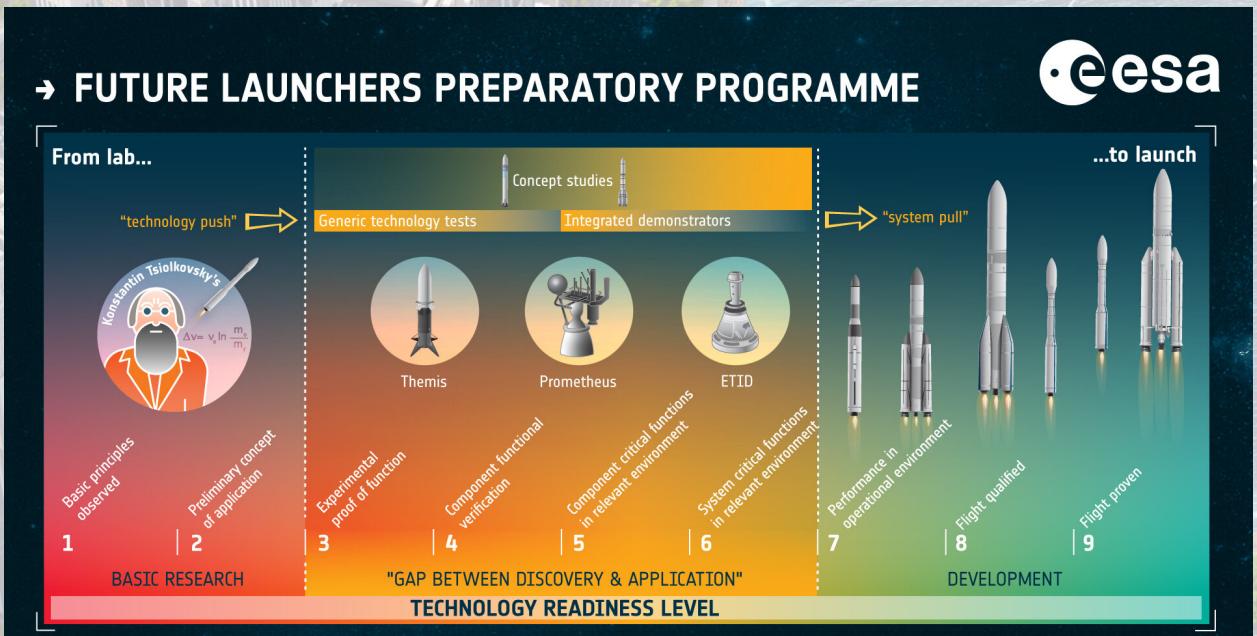
*"Thanks to Mobbott, we were able to win in visibility of our shotcrete operations and were able to take corrective actions."*

# Bridging asset data with operator behavior and real time feedback opens many opportunities

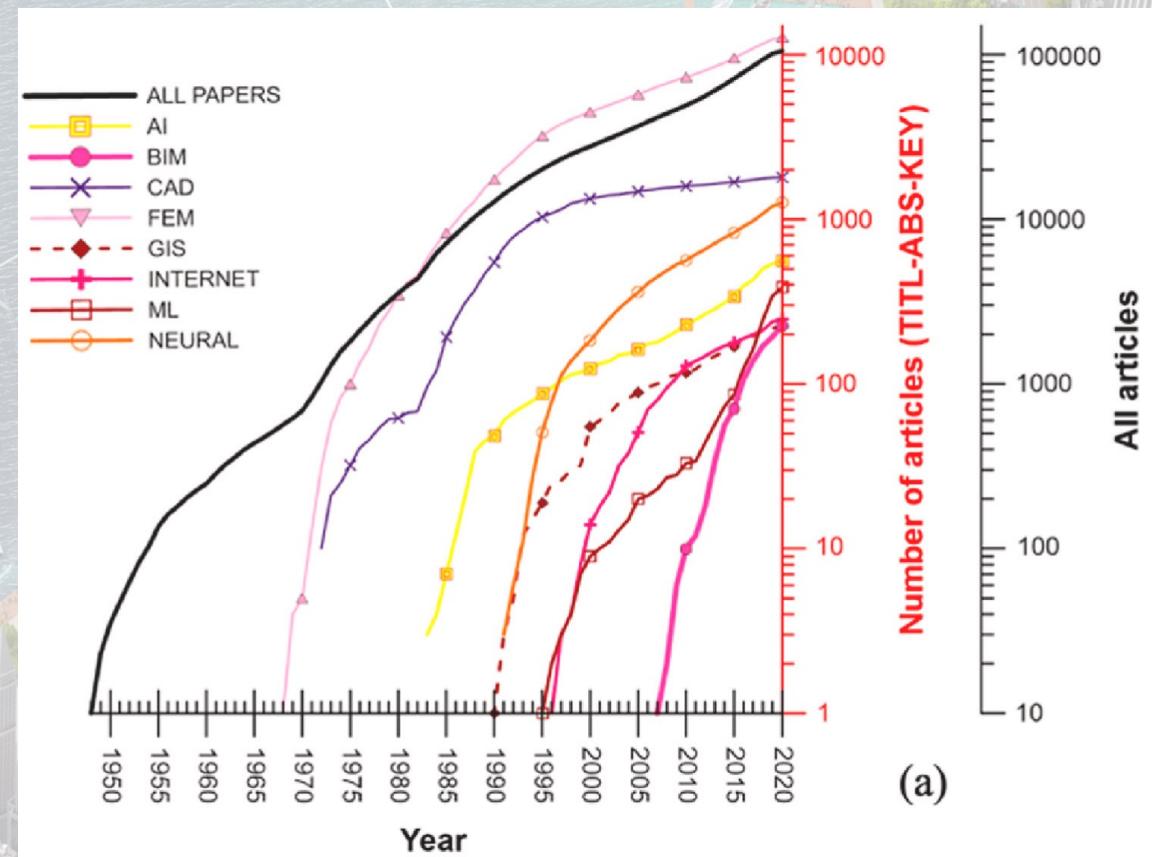
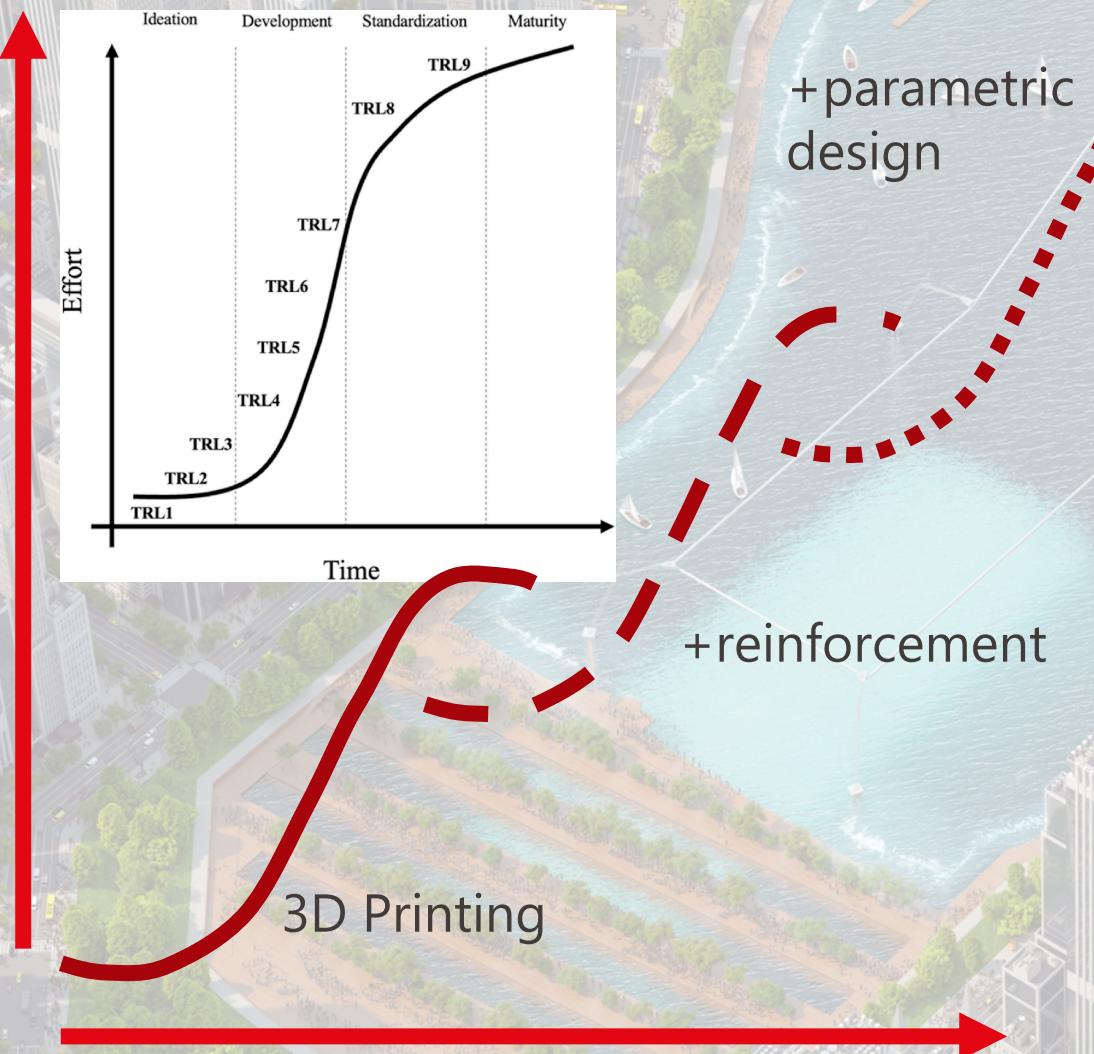
There are hundreds of thousands of construction machines that cause massive, unplanned downtime and delay construction projects. It is necessary to provide real-time monitoring tools to employees to make the right decisions at the right time, reduce overconsumption of raw materials and decrease waste.



# TRL and S-curves



# TRL and S-curves



Terzis, D., 2022. Monitoring innovation metrics in construction and civil engineering: Trends, drivers and laggards. *Developments in the Built Environment*, 9, p.100064.

# Parametric design

Parametric design is commonly believed to be a design **language** but refers at the base merely to a method of designing, that is, via **computing specific parameters**. Buildings can then be seen as the physical result of the interplay of various such parameters. This circumstance makes parametric design essentially well-equipped for its **surroundings**, cost-effective, and highly unique, raising the question of **possibilities for prefabrication**.



The class will  
start at 16h15

Also part of :



**Dr. Dimitrios Terzis**

05/11/2024

**Thank you!**