EPFL

The class will start at 16h15

Innovation for construction & the environment

Dr. Dimitrios Terzis

04/11/2025

Also part of :

E4S
Enterprise for Society

sia

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

Today’s class

INNOVATION FOR CONSTRUCTION AND THE ENVIRONMENT

CIVIL-424 Innovation for construction and the Environment / Fall 2025

Tuesdays 16:15-18:00 pm — Lectures
Tuesdays 18:00 - 19:00 pm — Project discussions and continuous reporting
Office hours: — Via doodle (or upon email request and confirmation)

Room GRA331

			Title
Week 1	09.Sep	45 mins	Introduction to the course
		45 mins	Disruptive, Incremental Innovation and Research, Projects from last year and takeaways
Week 2	16.Sep	45 mins	Cement-free concrete
		45 mins	Cement-free concrete
Week 3	23.Sep	45 mins	Circular economy, Impact and Life Cycle Assesement
		45 mins	Sustainalytics
Week 4	30.Sep	45 mins	Harnessing renewables for buildings
		45 mins	Harnessing geo-energy for buildings
Week 5	07.Oct	45 mins	How do we digitize reality?
		45 mins	
Week 6	14.Oct	45 mins	Project preparation / Paper reading
		45 mins	Project preparation / Paper reading
Week 7	28.Oct	45 mins	Traffic Operations, Unmanned Aerial Systems (UAS) and Data Science for smart mobility
		45 mins	Traffic Operations, Unmanned Aerial Systems (UAS) and Data Science for smart mobility
Week 8	04.Nov	45 mins	Parametric design
		45 mins	Robotic construction
Week 9	11.Nov	45 mins	Industrial innovation from the perspective of a construction giant
		45 mins	Industrial innovation from the perspective of a construction giant
Week 11	18.Nov	45 mins	Monitoring and surveillance
		45 mins	GIS and BIM for construction and risk management
Week 12	25.Nov	45 mins	Nature-based innovations
		45 mins	Nature-based innovations
Week 13	02.Dec	45 mins	Sustainalytics
		45 mins	Sustainalytics
Week 14	09.Dec	45 mins	Project presentations - schedule to be announced
		45 mins	Project presentations - schedule to be announced
Week 15	16.Dec	45 mins	Synthesis of Innovation project and takeaways
		45 mins	Synthesis of Innovation project and takeaways

Dr. Dimitrios Terzis

EPFL

Today's class

1) 3D printing and sustainability / Lessons from Mobbot

2) S-curves and pivoting while innovating

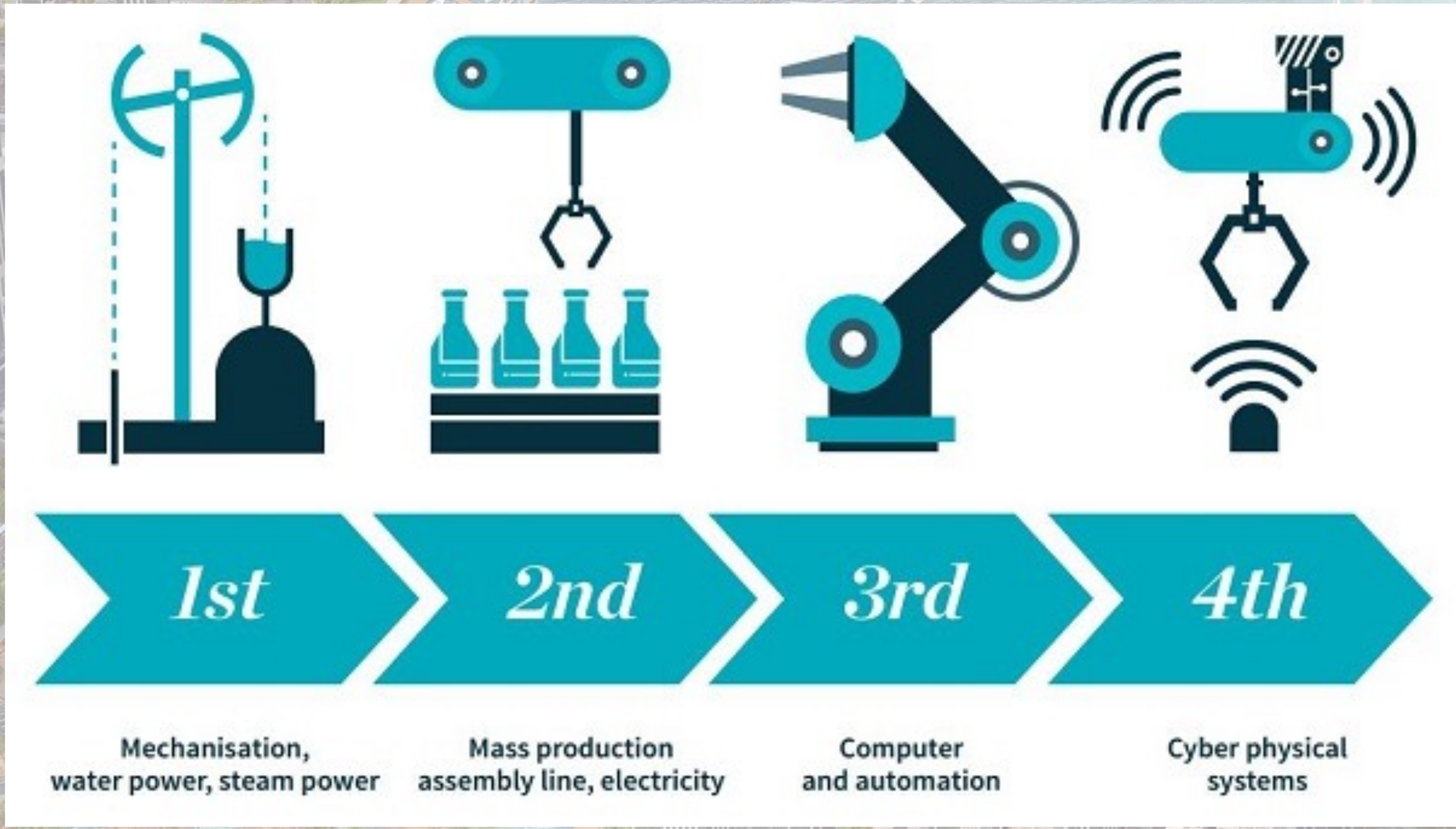
3) Parametric design

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



The four Industrial Revolutions (Source: Marcellus Drilling)

Understanding the scale of natural ressources 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 and area for sand mining on a dried lake bed in Jiangxi province, China. Photograph: Aly Song/Reuters

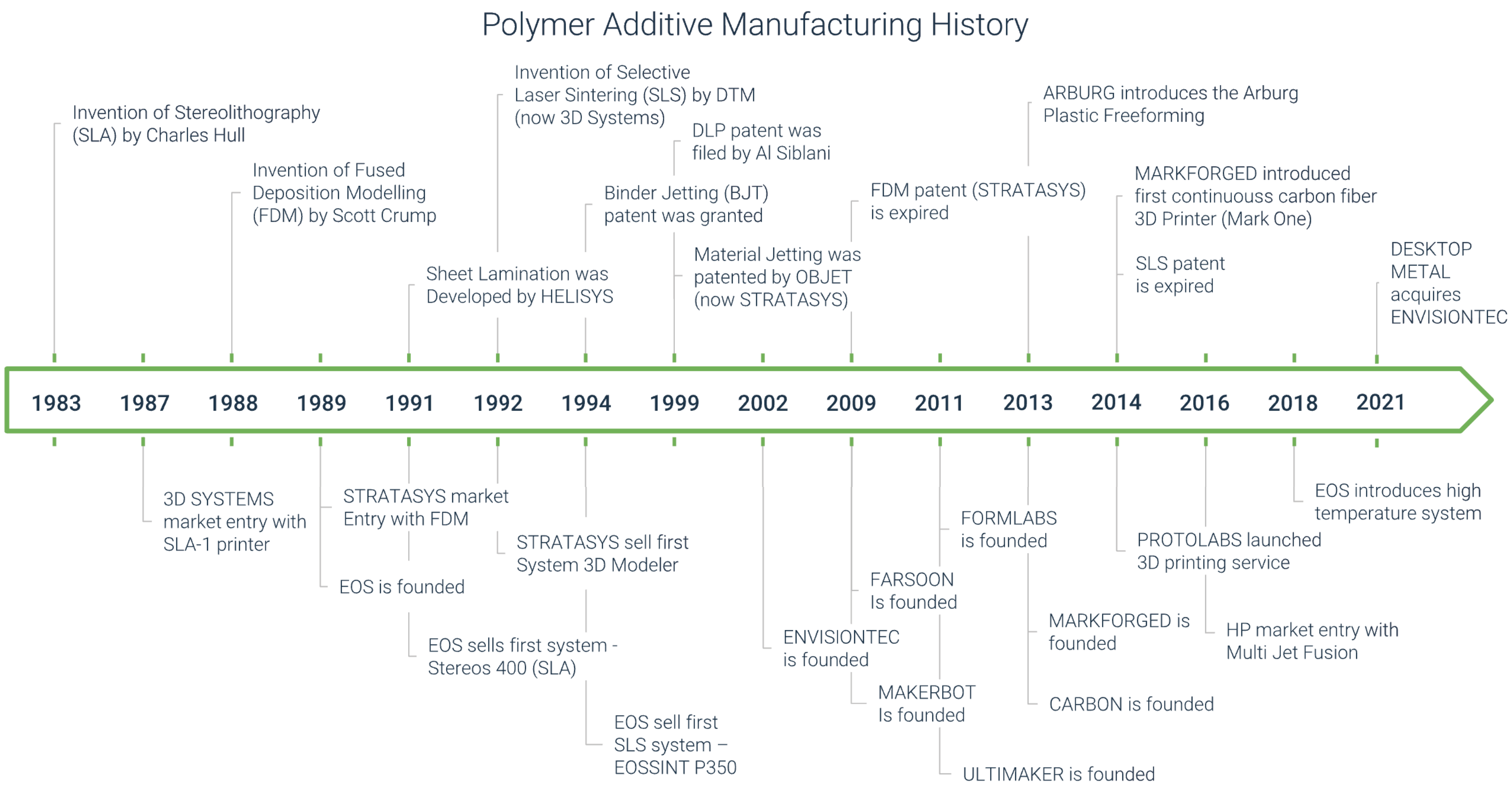
Humans extract 50bn tonnes of sand and gravel every year, according to UN research, enough to build a wall 27 metres high by 27 metres wide around the planet.

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

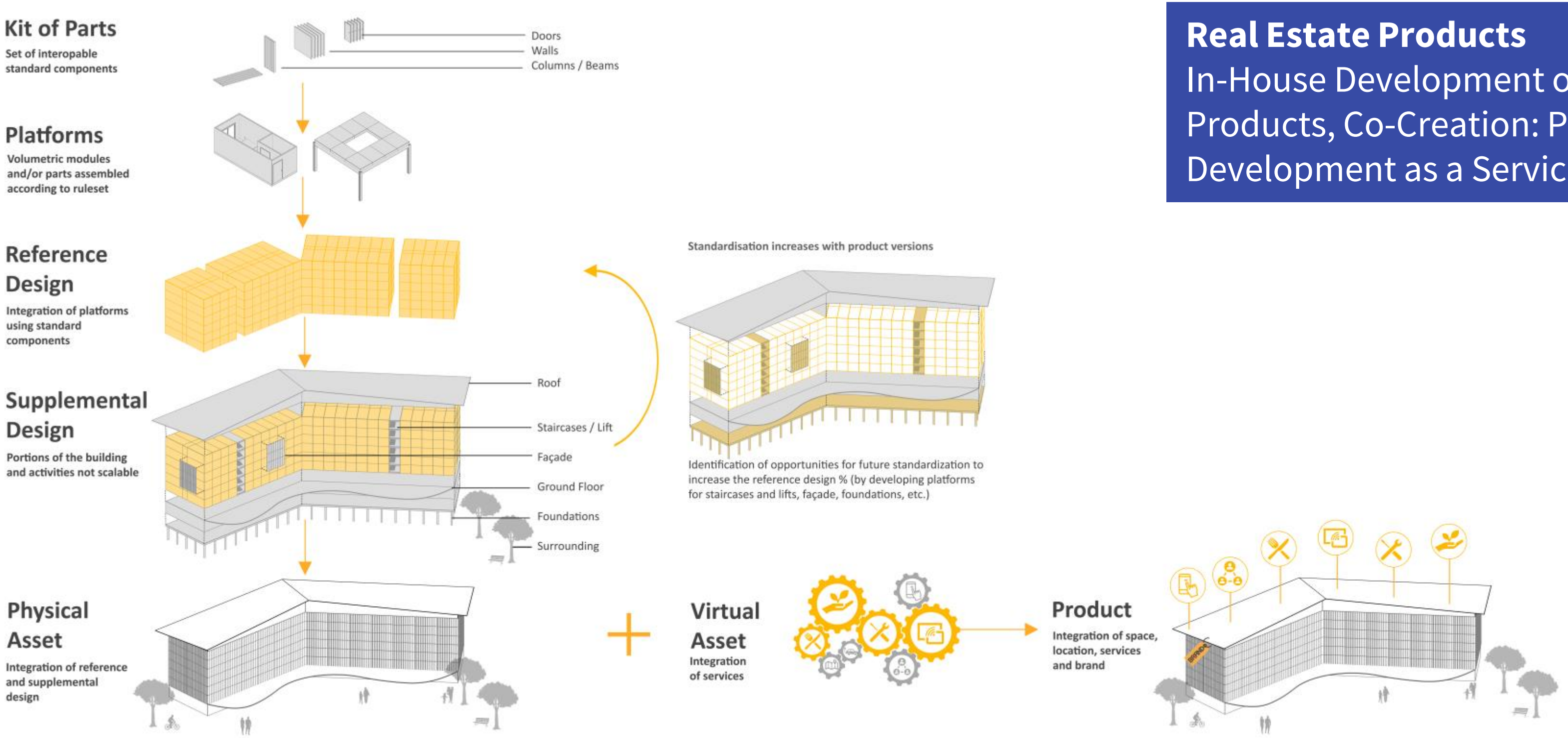


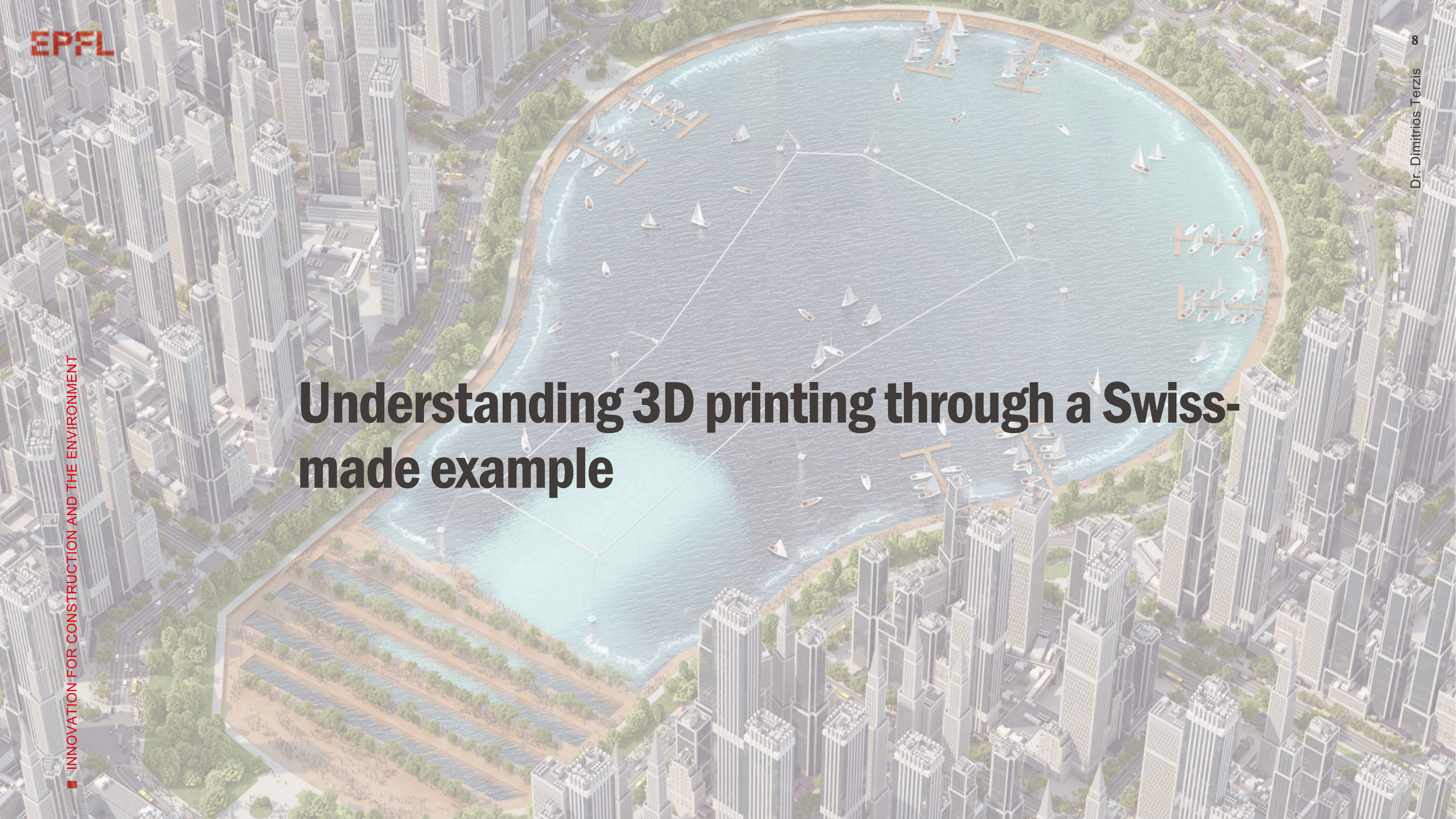
Overall, the link between 3D printing in construction and additive manufacturing is that 3D printing is a specific application of additive manufacturing technology within the construction industry. It leverages the principles of additive manufacturing to create customized, efficient, and often innovative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

IMPLENIA

FROM TRADITIONAL MODELS TO INDUSTRIALIZED CONSTRUCTION

Real Estate Products
In-House Development of Real Estate Products, Co-Creation: Product Development as a Service





Understanding 3D printing through a Swiss-made example

MOBBOT

AUTOMATION AND ROBOTICS OF SPRAYED CONCRETE

Using less concrete for Sustainable infrastructures

Concrete is the second most consumed material on Earth and is responsible for massive CO_2 emissions

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

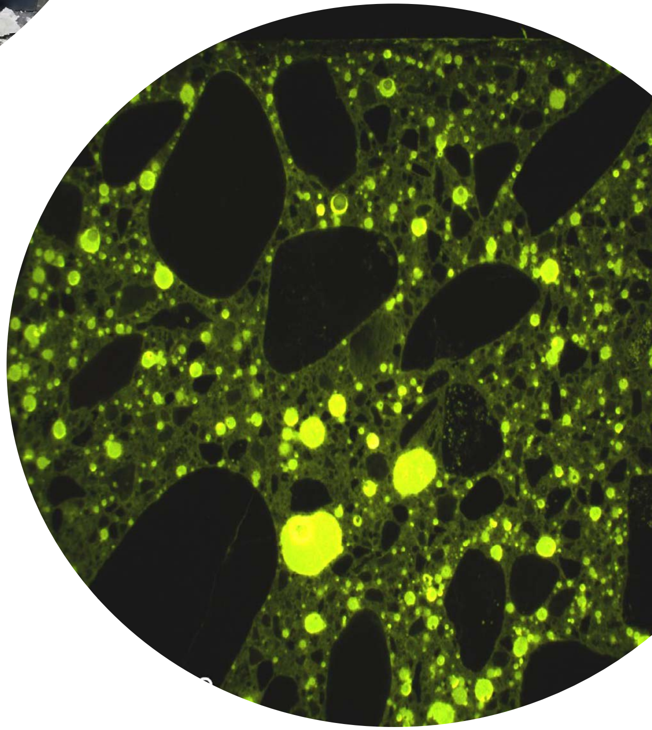
Cement is responsible for 7% of the global CO_2 footprint.

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 the 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

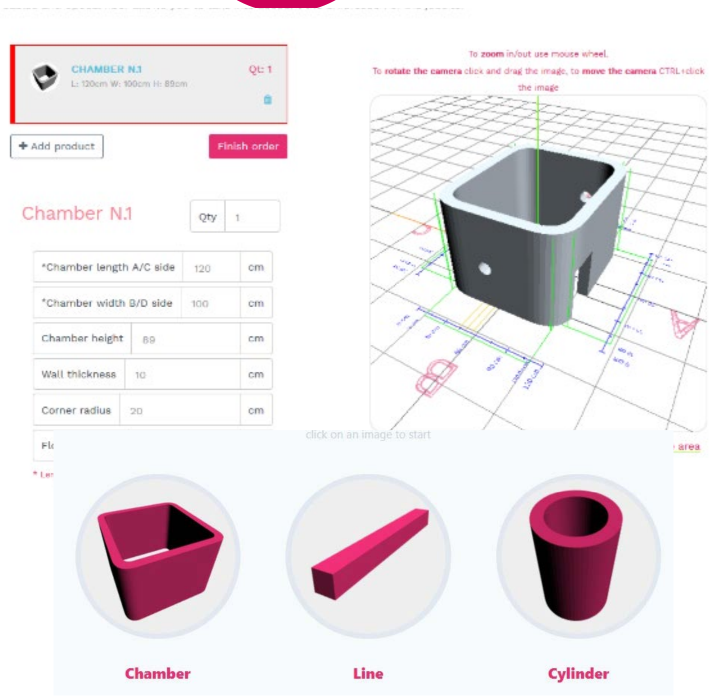
Comparison of 3D concrete printing

"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

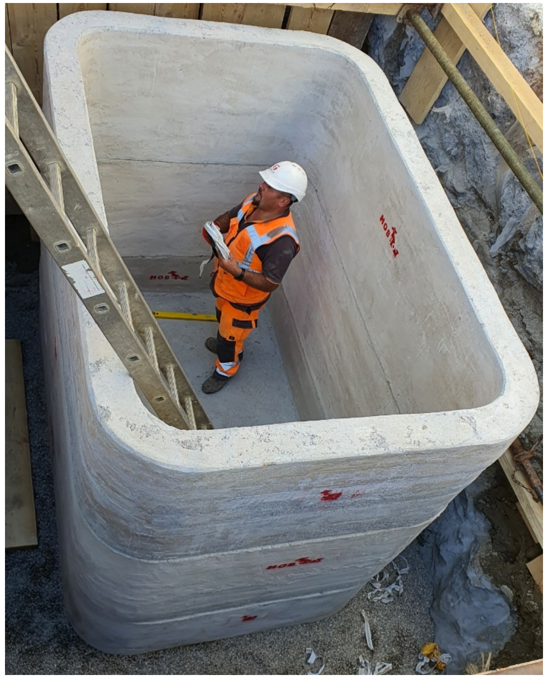
- Sprayed concrete Ø 8mm
- Conventional concrete and recycled material up to 45%
- Price of raw material
- Monolithic elements
- Compatible with standards
- Integration of traditional rebars
- Watertight

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



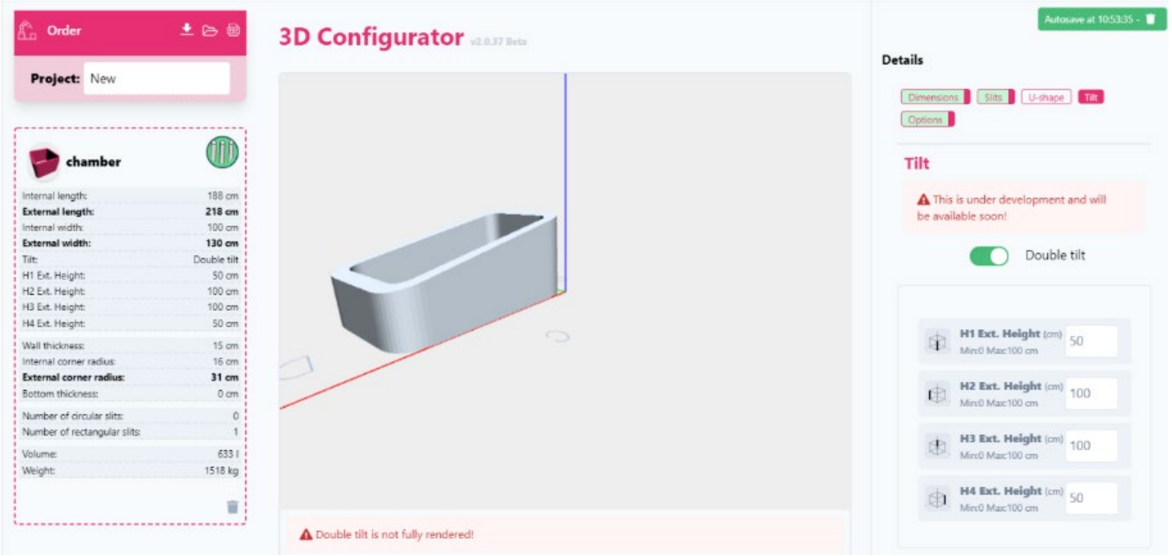
Design

Sprint

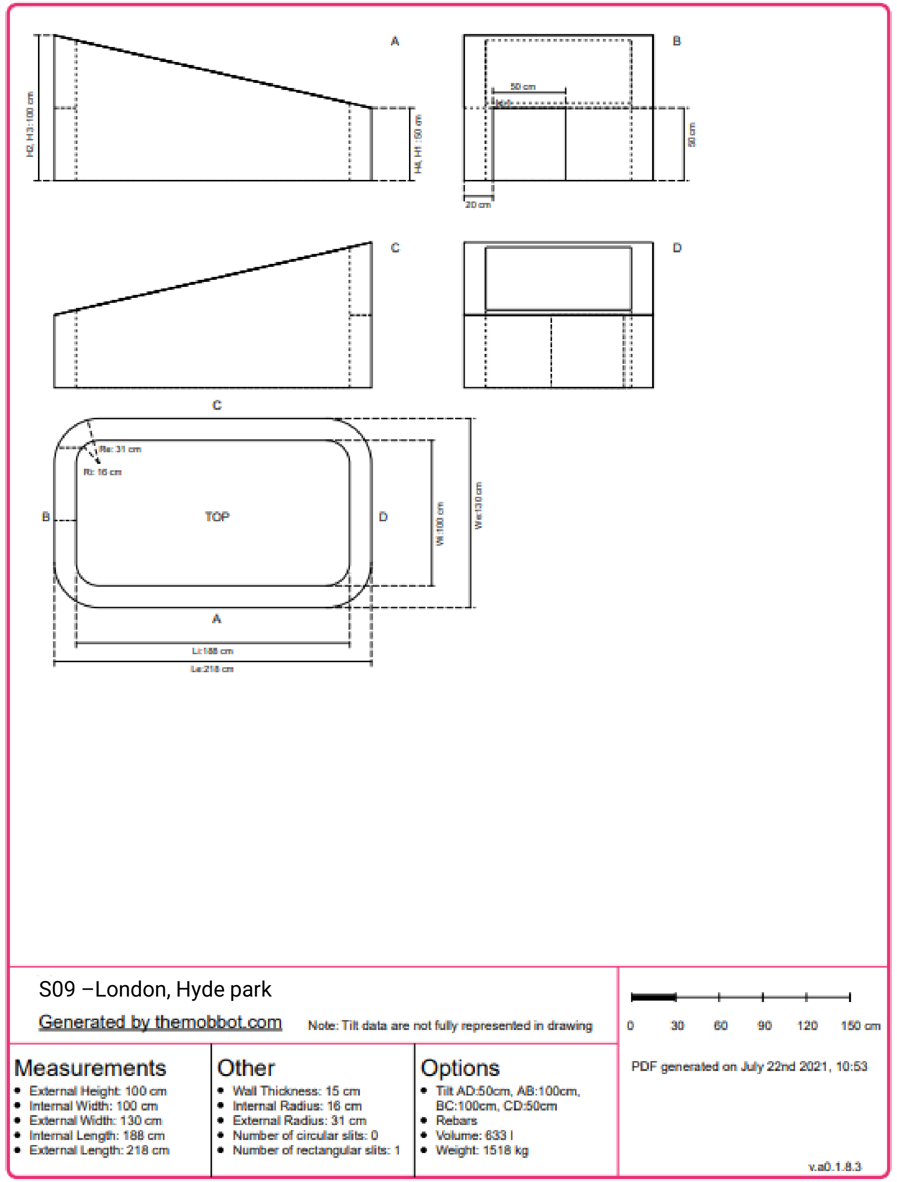


Delivery

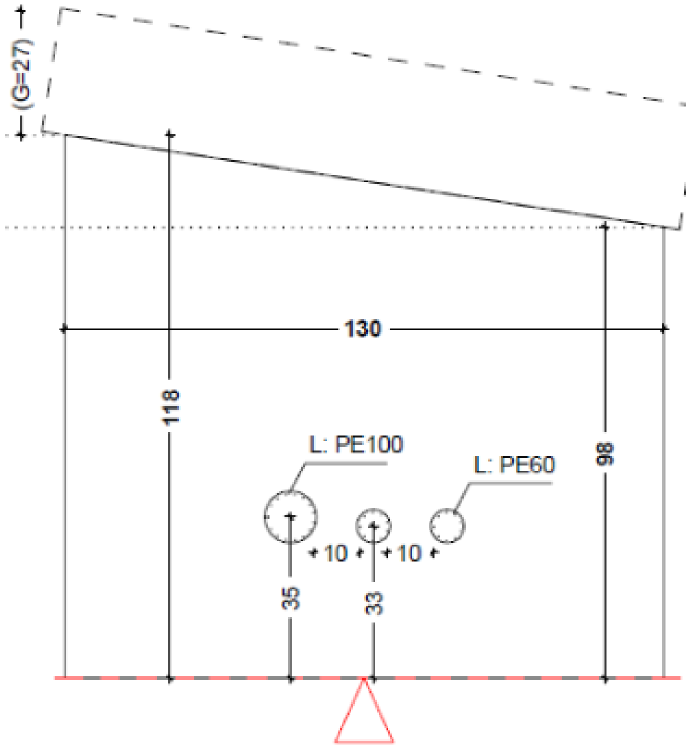
Digital design with an online configurator

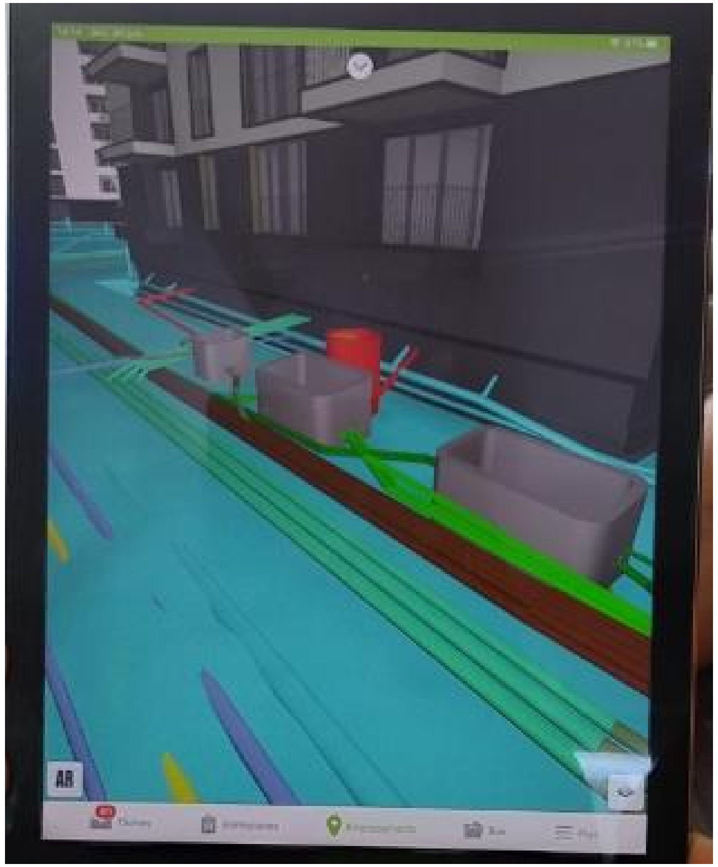


[PRODUCT CONFIGURATOR | themobbot.com]



But we can use and generate BIM model





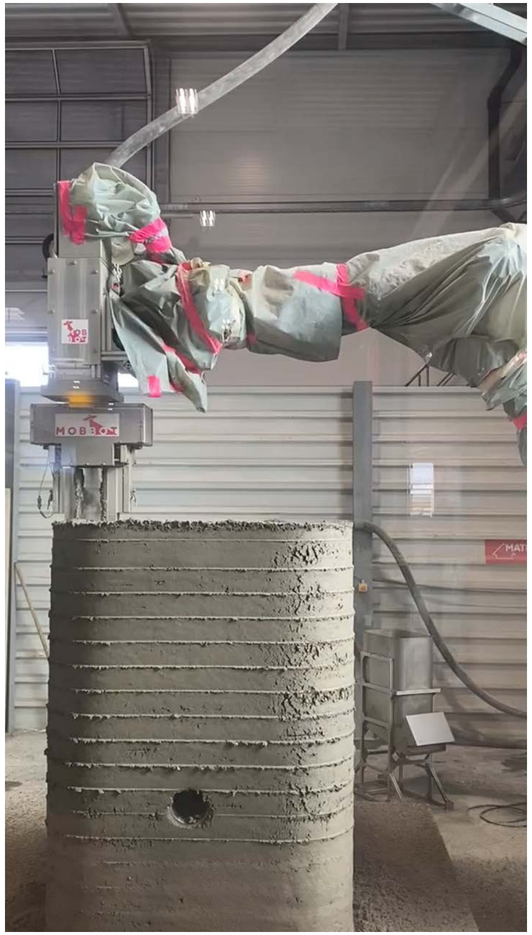
Project owner: LOSINGER MARAZZI

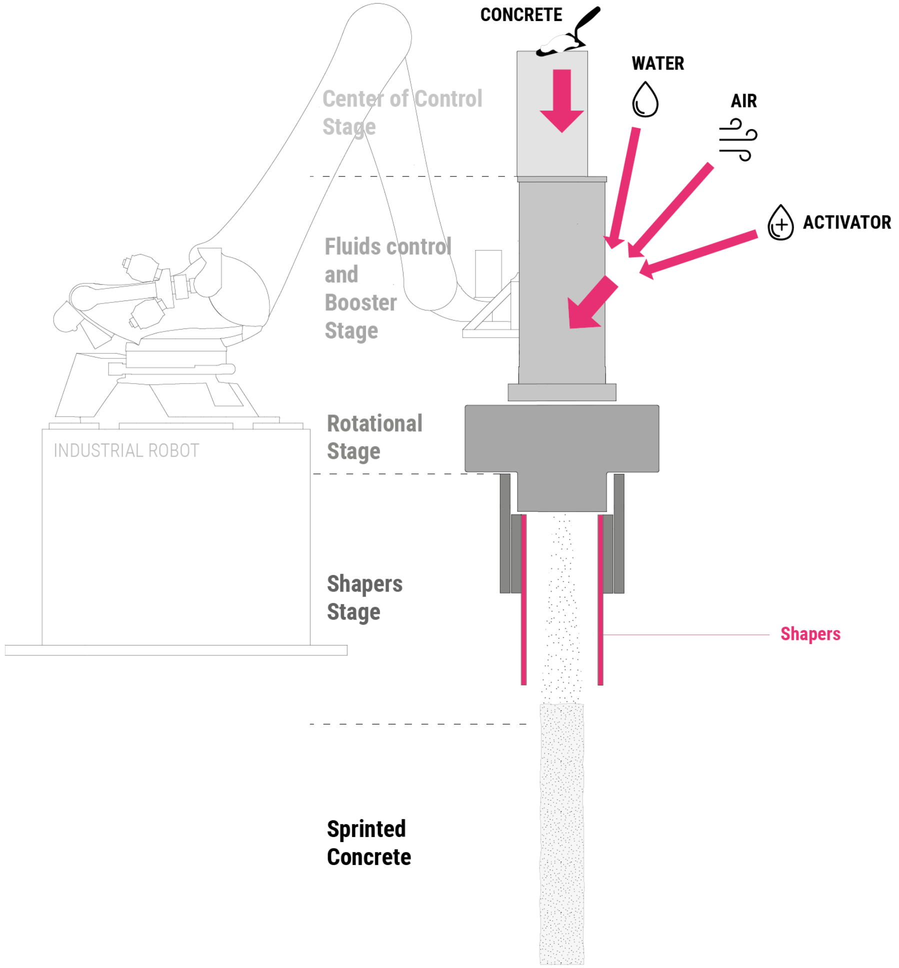
Contractor: swisscom COLAS SUISSE

Benefits :

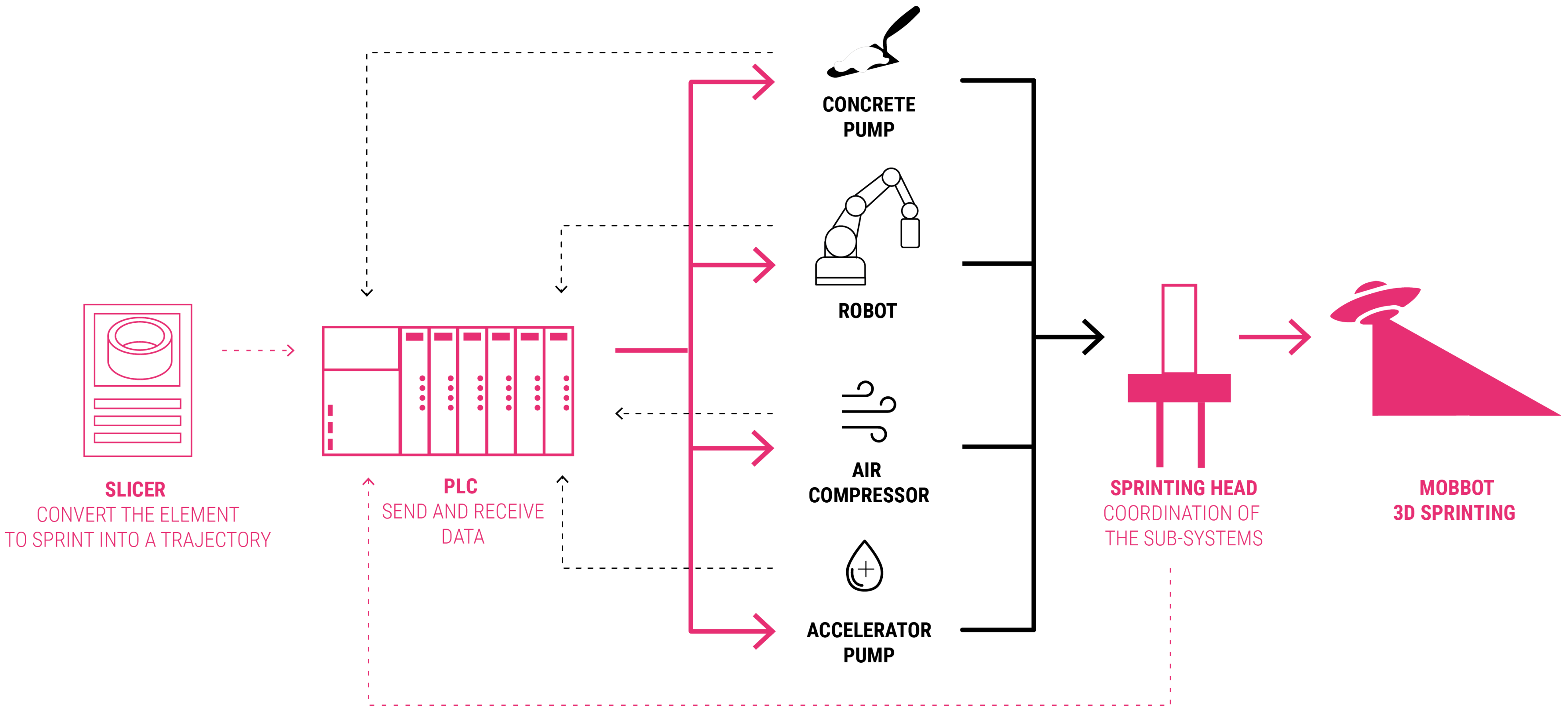
- Solution « Plug & Play »
- Integration in BIM and georeferenced
- Ergonomic and safe for workers

So how does the system work ?



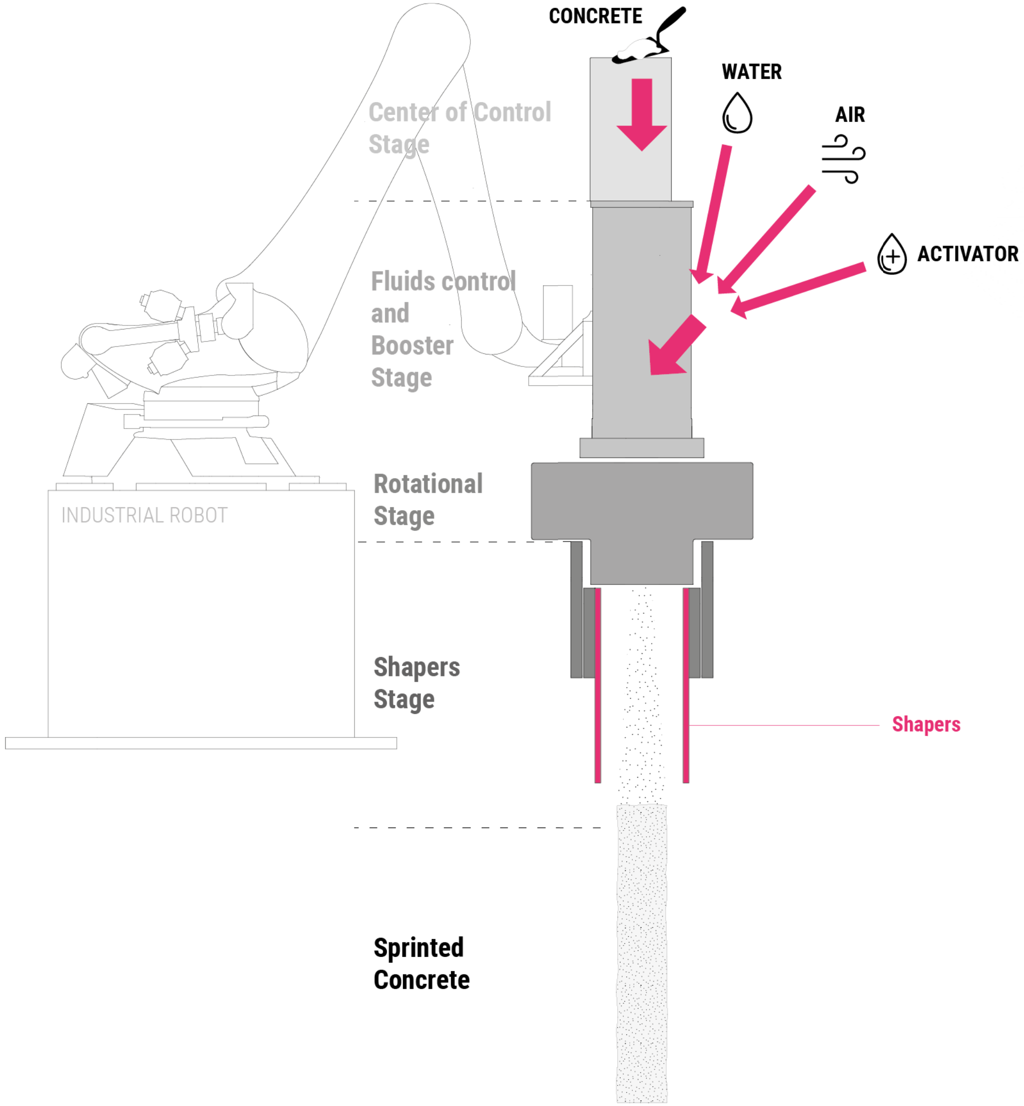


How does it work ?



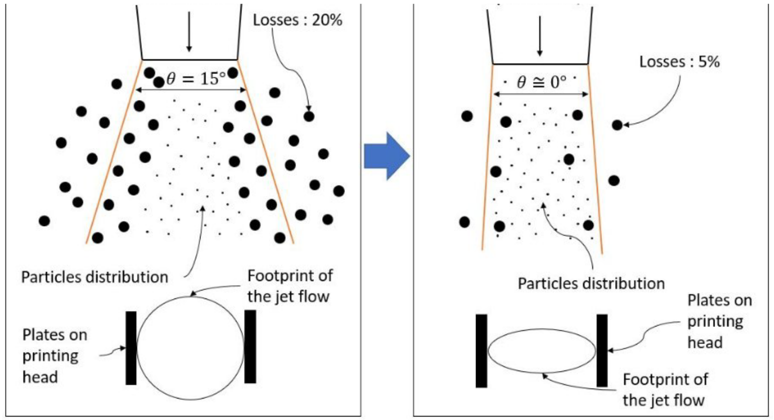
We combine additive and substractive methods

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



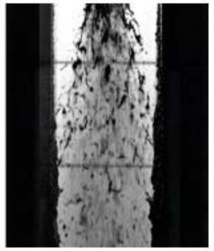


Image 1: standard nozzle

Image 2: Mobbot nozzle stage 1

Image 3: Mobbot nozzle stage 2

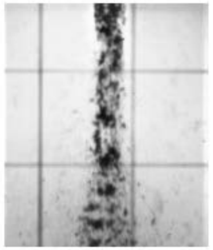
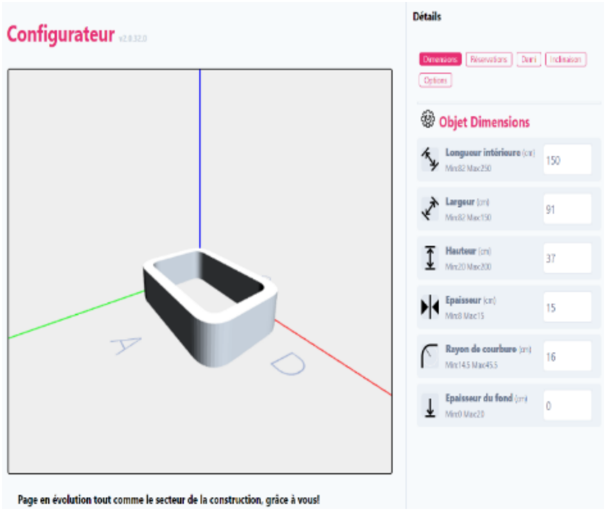


Image 4: Mobbot nozzle stage 3

The benefits for the customers

Online design	Offsite production	New value chain	Installation

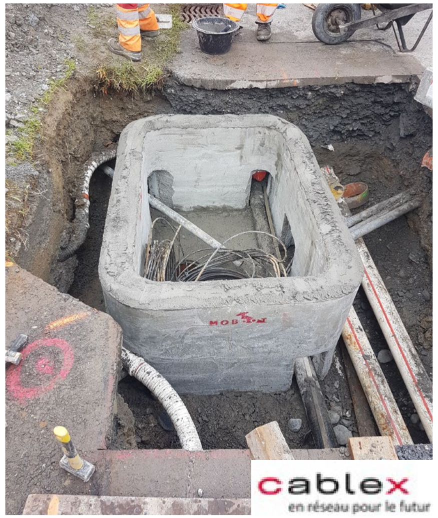


Flexible

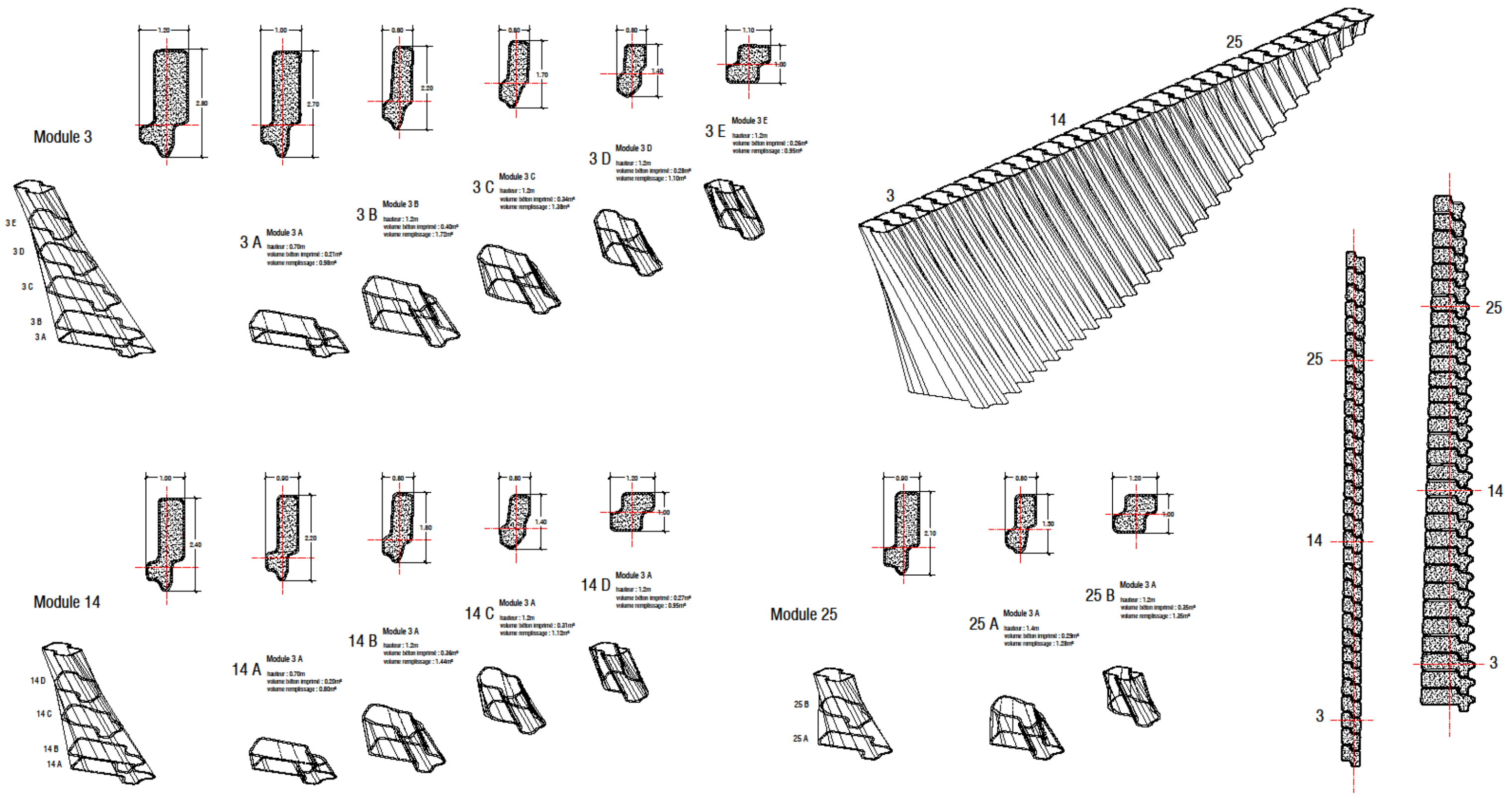
2 hours instead of 2 days

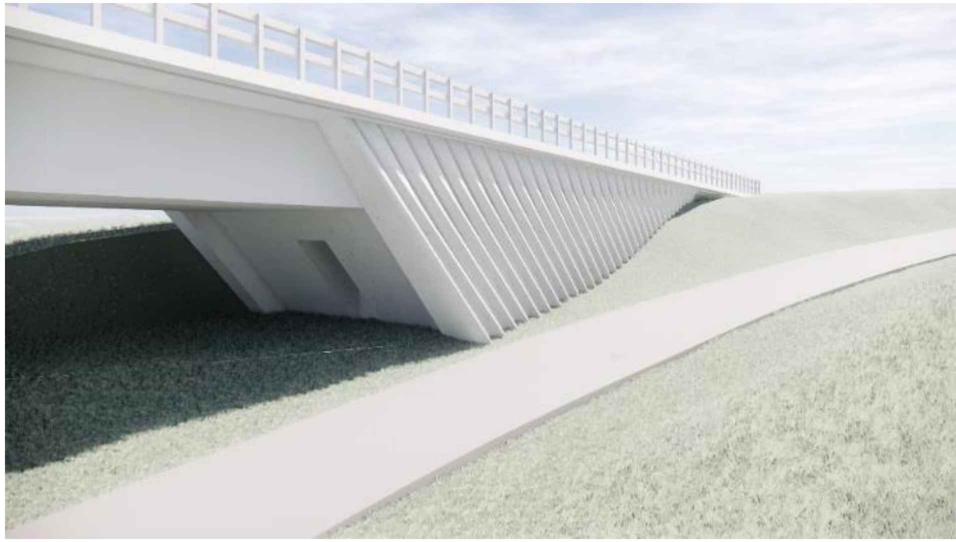
> 30-50% less CO_2

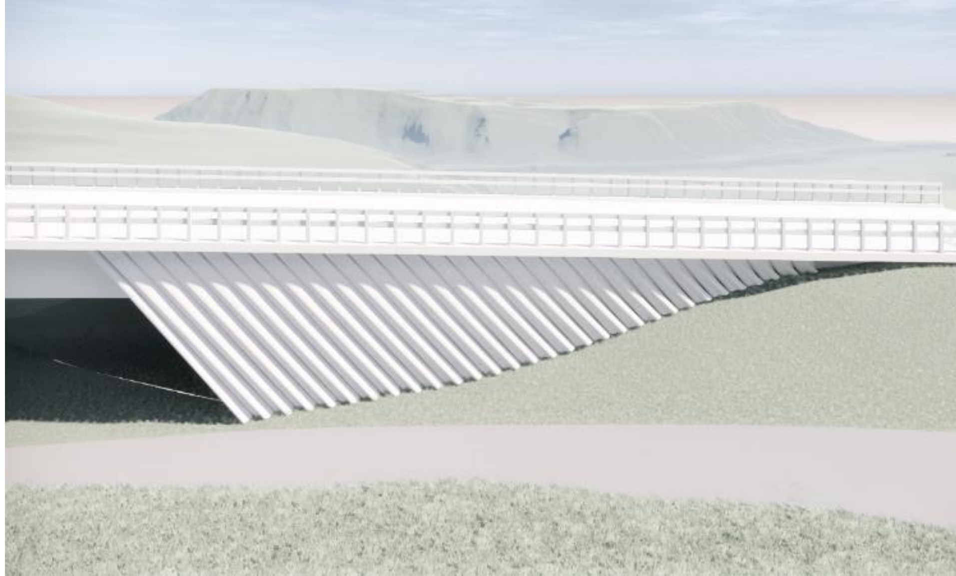
Today the method is used for telecom, railway, energy and water utilities



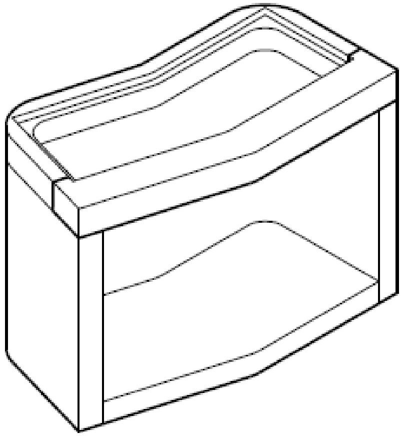
Chesalles Bridge – Fribourg -CH





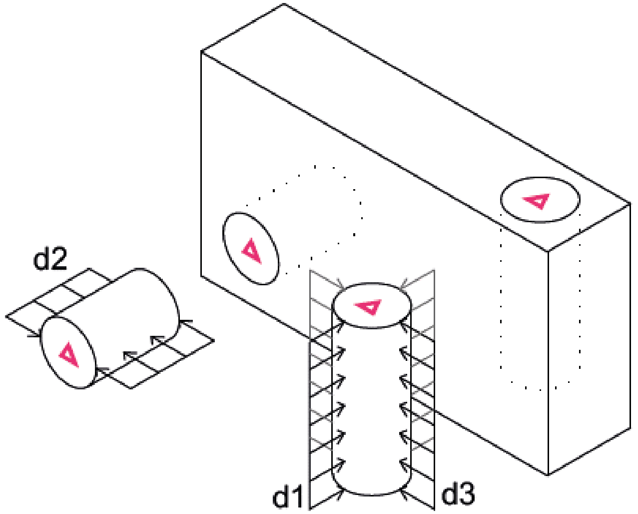


Other possibilities



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

Recycled Materials / Demolition waste

Enhanced properties with sprayed materials

Renovation / building by-products

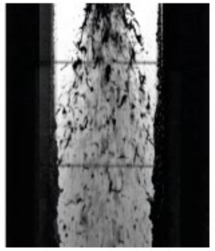


Image 1: standard nozzle

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
450.0
22.3
442
5.27

Our vision

At Mobbot, 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





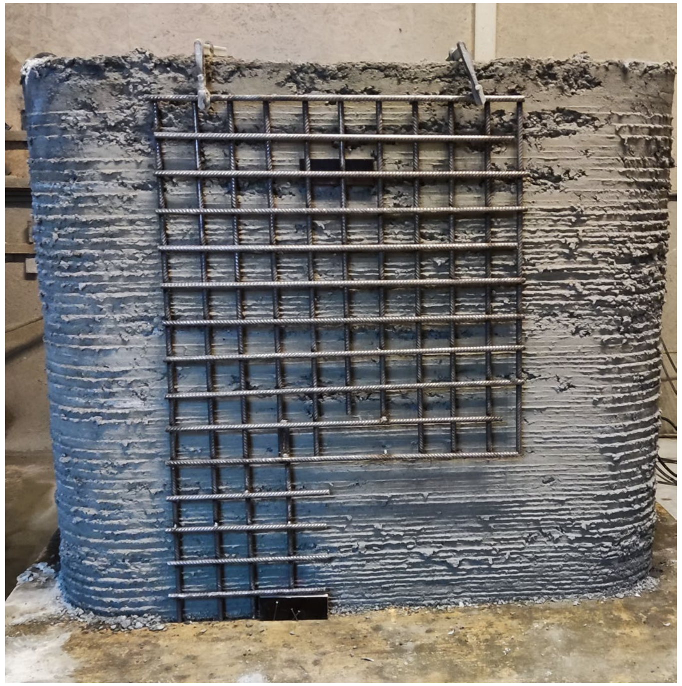


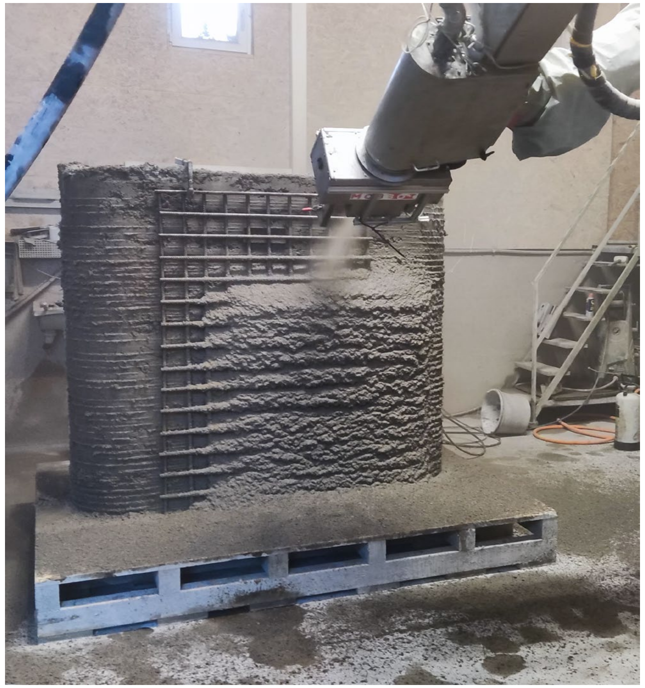
The method offers unique possibilities to integrate structural reinforcement

Rebars Ø 14-16mm, sp. = 10cm

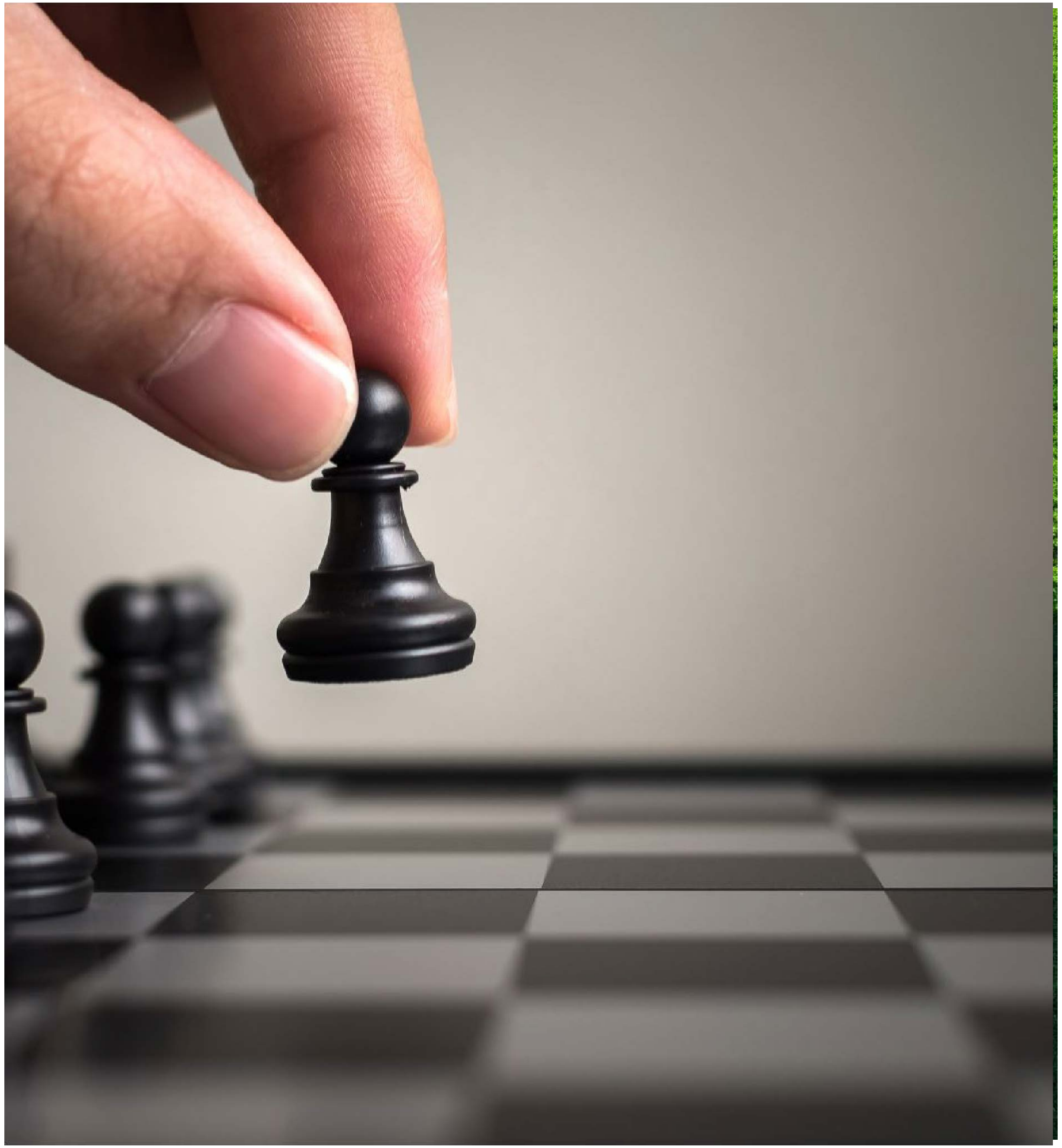
No rebar phantoms

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

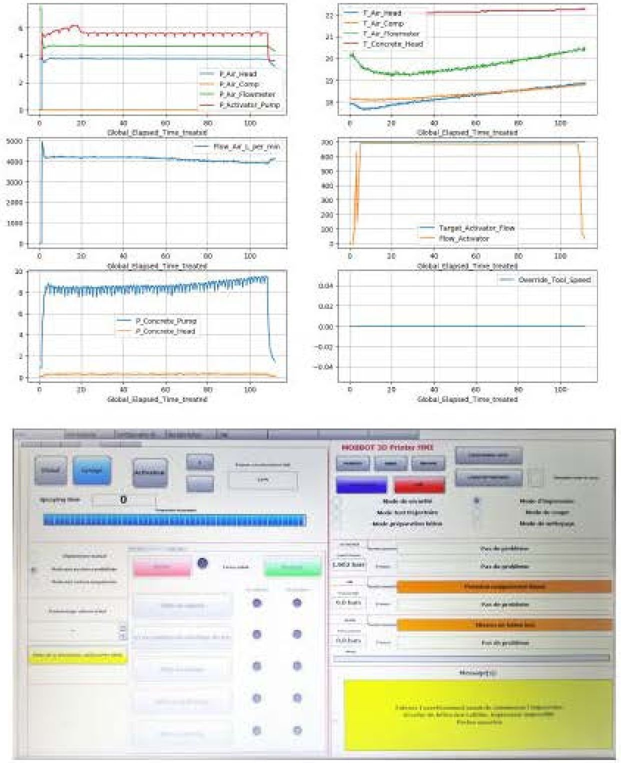
Health and safety issues

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

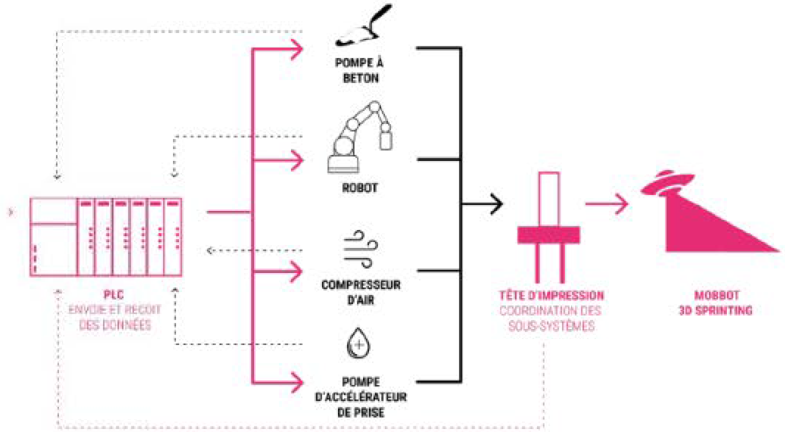
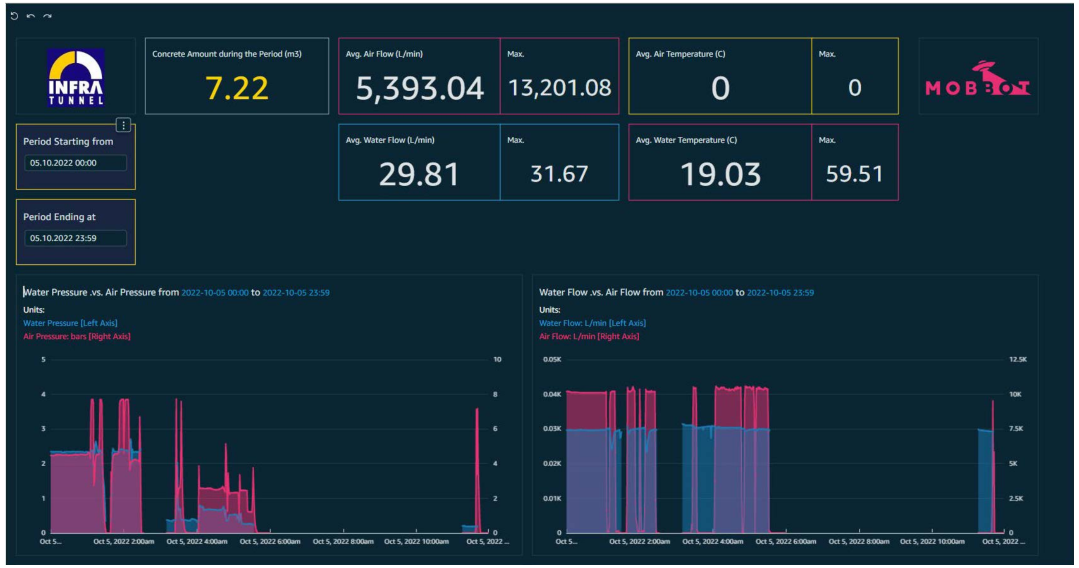


Image 1: schéma plc et sous-systèmes

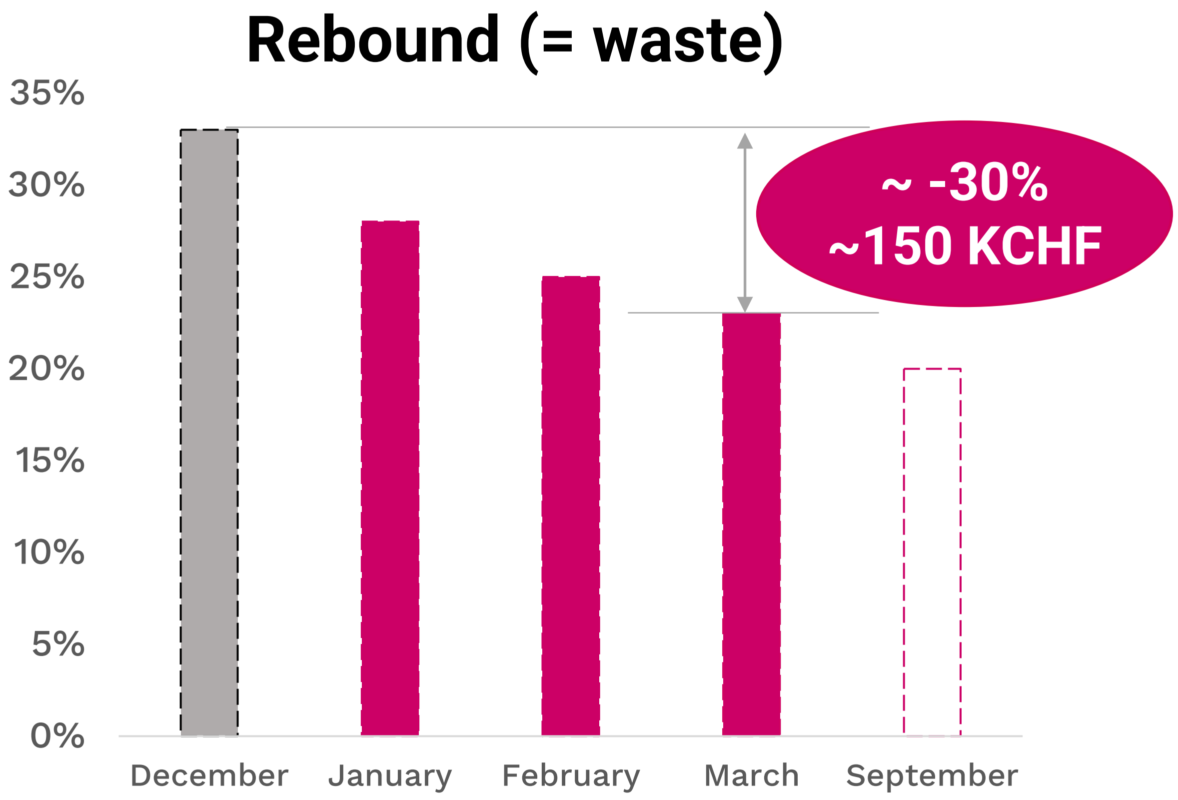
The pivot toward underground projects

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****.*

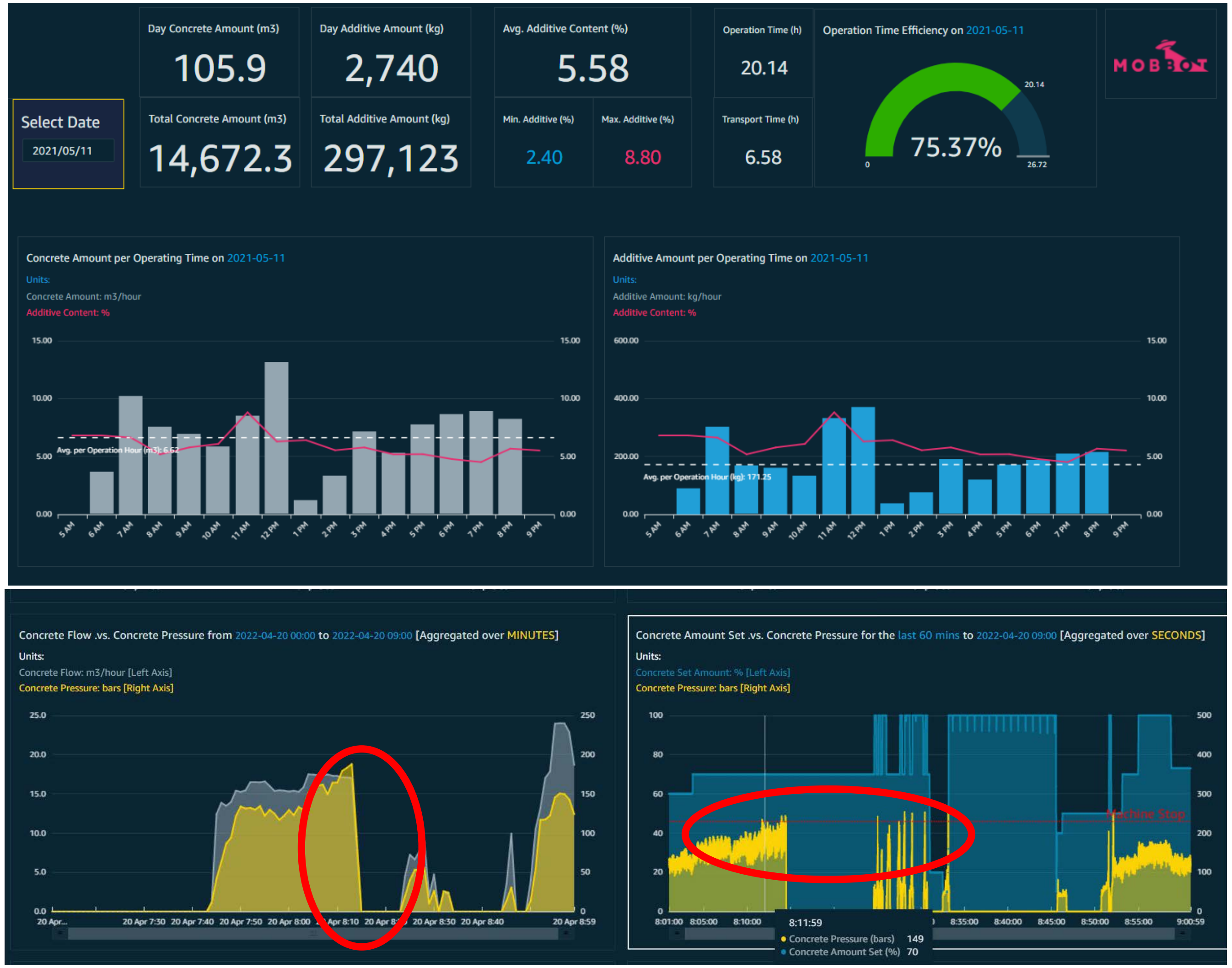
M. Petit, Head logistics and machine, InfraTunnel



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

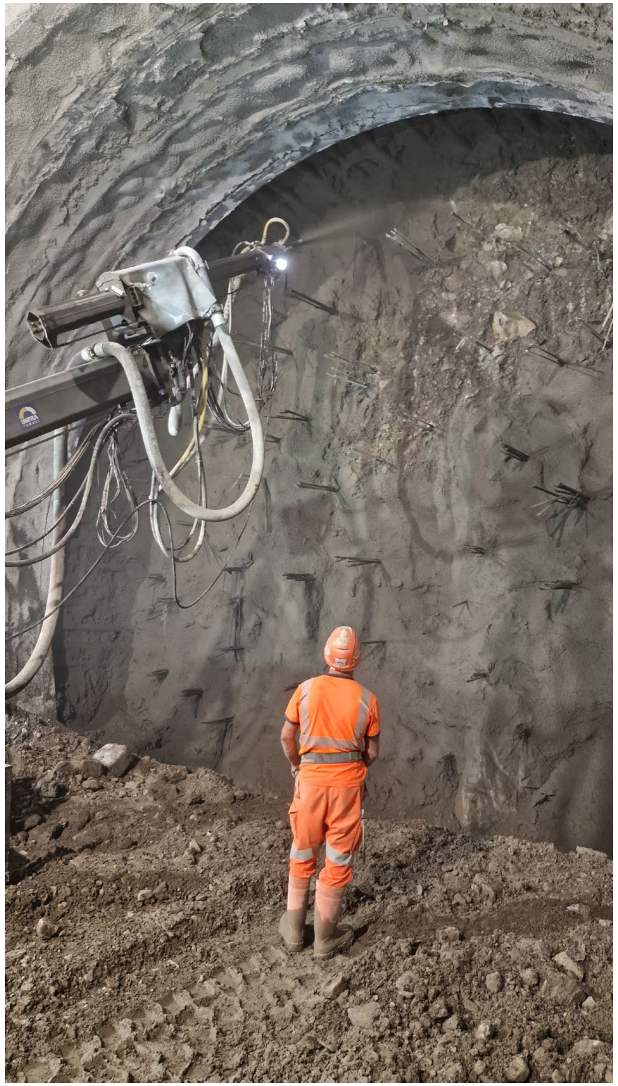
Description

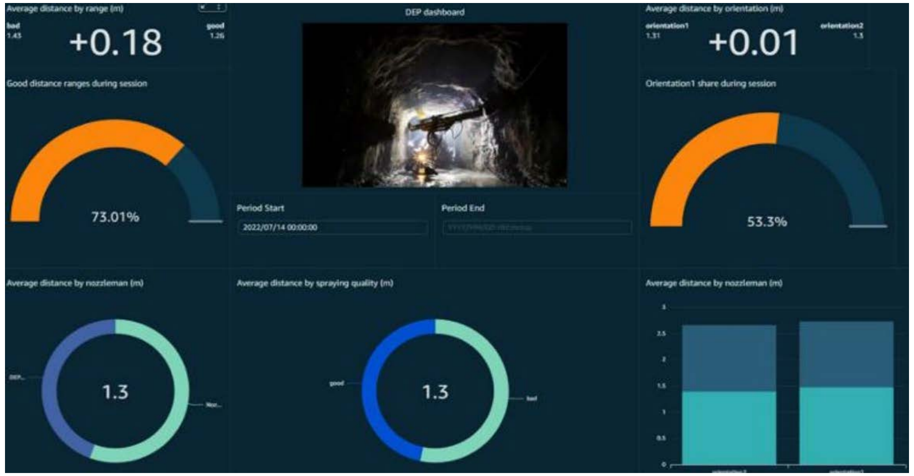
- Real-time nozzle distance to wall
- Provide a real time feedback to the operator
- Data available in a dashboard
- Ideal for training purposes

Benefits

✓ Reduction of rebounds
✓ Increase learning curve
✓ Save time

Distance to excavated profile sensor





Auto wash with air/ water

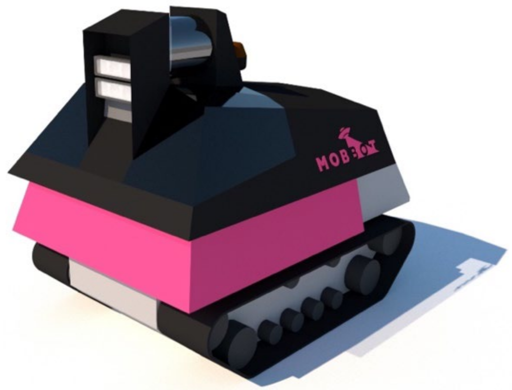
Light signal on/off when distance is outside of the set range

Dashboard for teaching purposes

Thickness measurement in real time

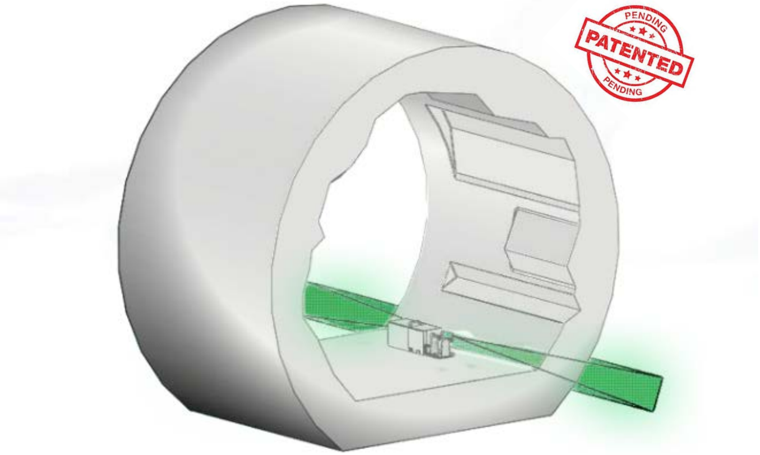
Product details

- 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



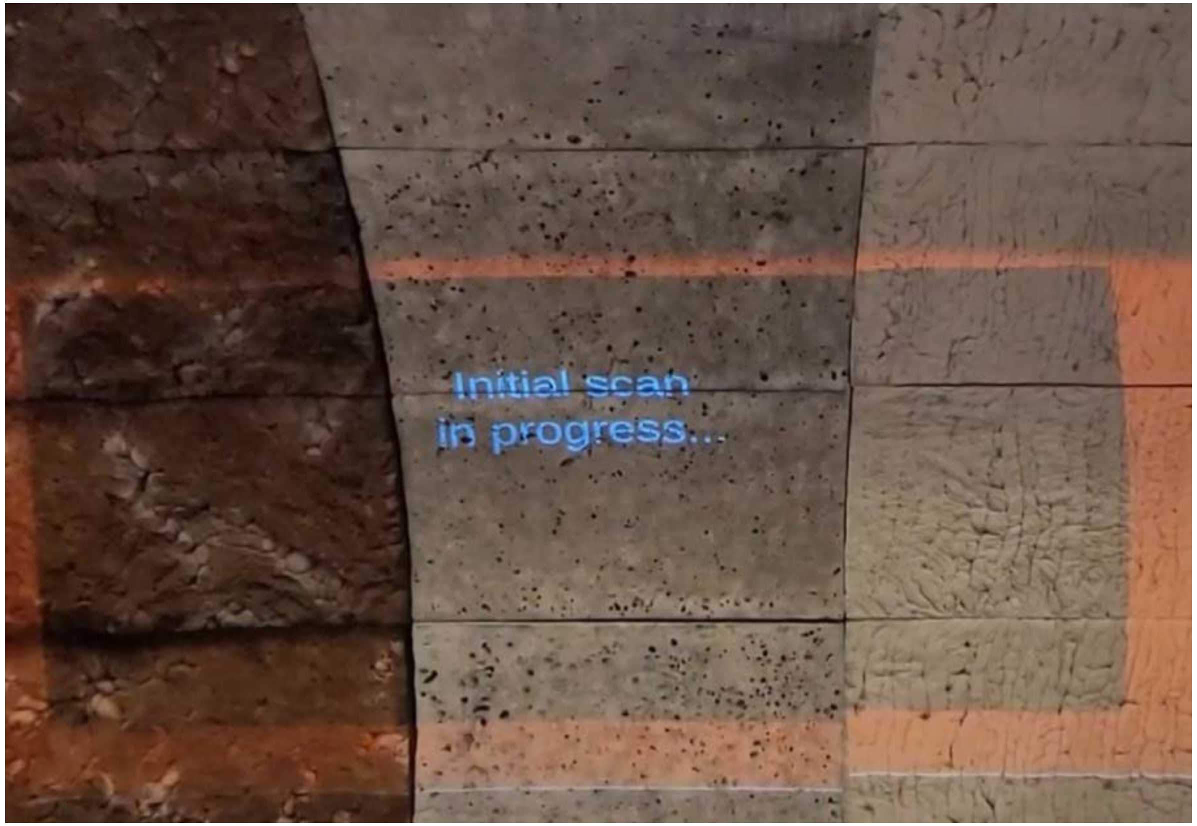
Benefits

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

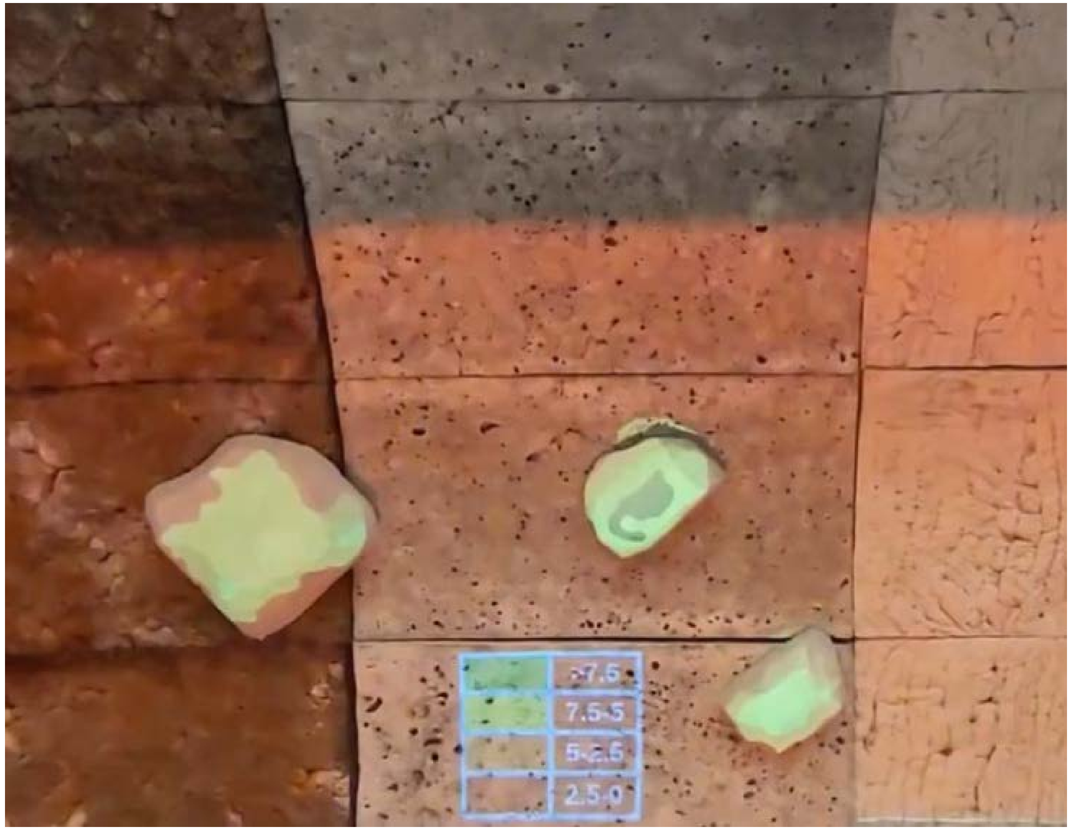


Real time thickness measurement

Initial scan



Continuous & real time display of thickness in the tunnel



A centralized dashboard to improve shotcrete processes

Connected sensors / devices

Data collected directly on shotcrete machines and mobbot devices

Collected data transferred

to a secured Mobbot's cloud database

Daily and historical data

accessible on a fully customized dashboard

Relevant info and accurate data

empower users to make fact-based decisions and improve processes

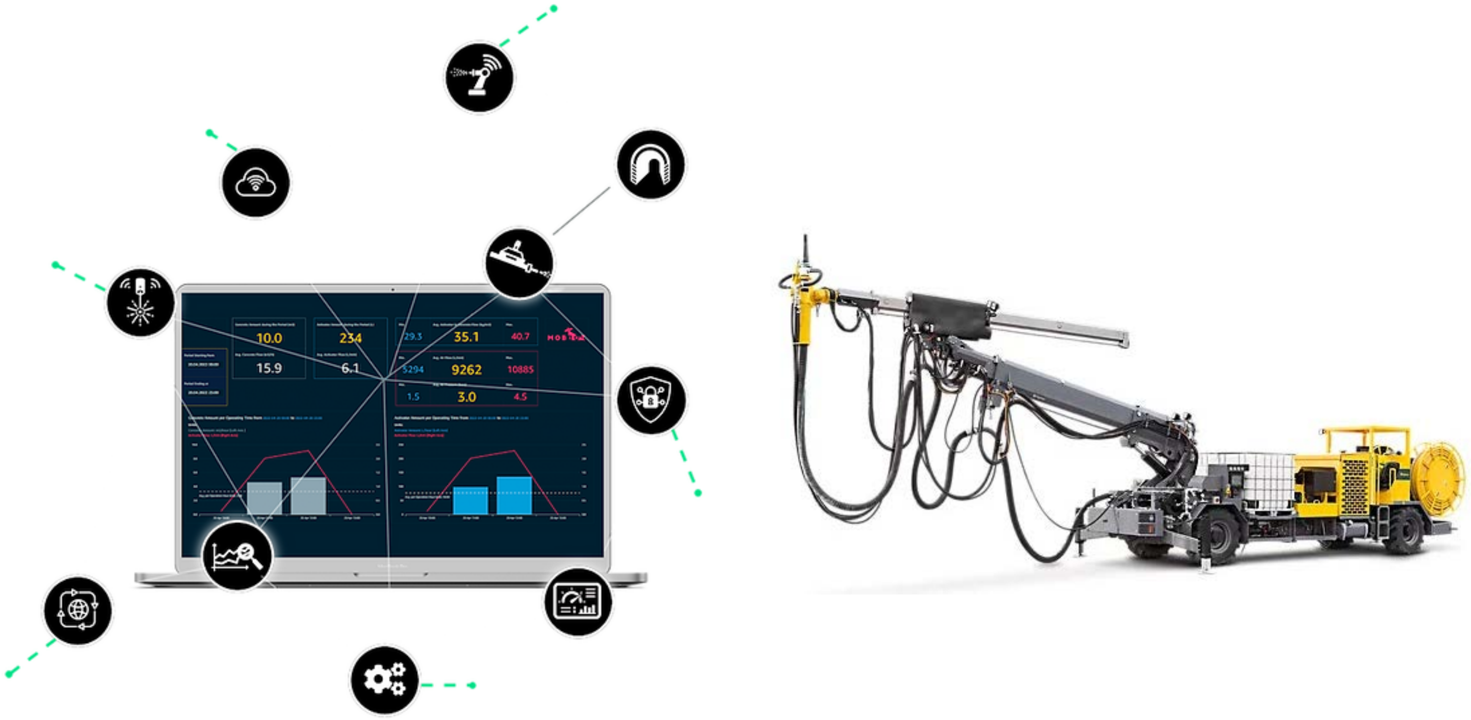
What our client says about Mobbot

G. Lequertier
Managing director, Infra Tunnel SA

"Thanks to Mobbot, 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.

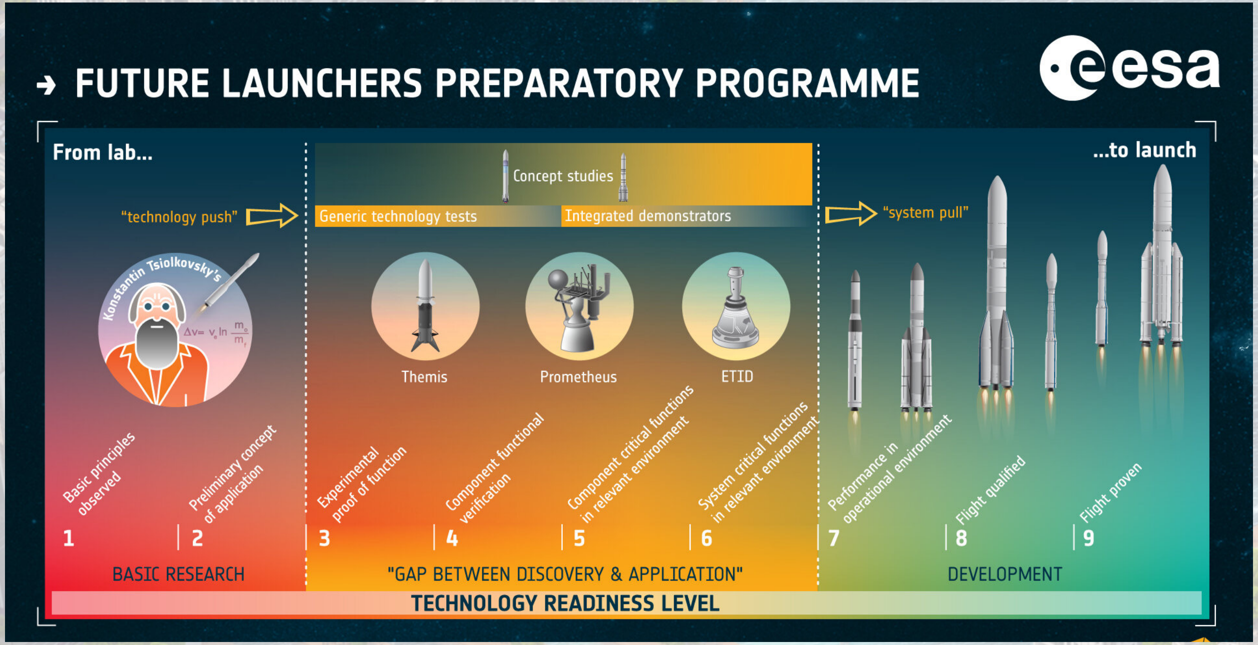


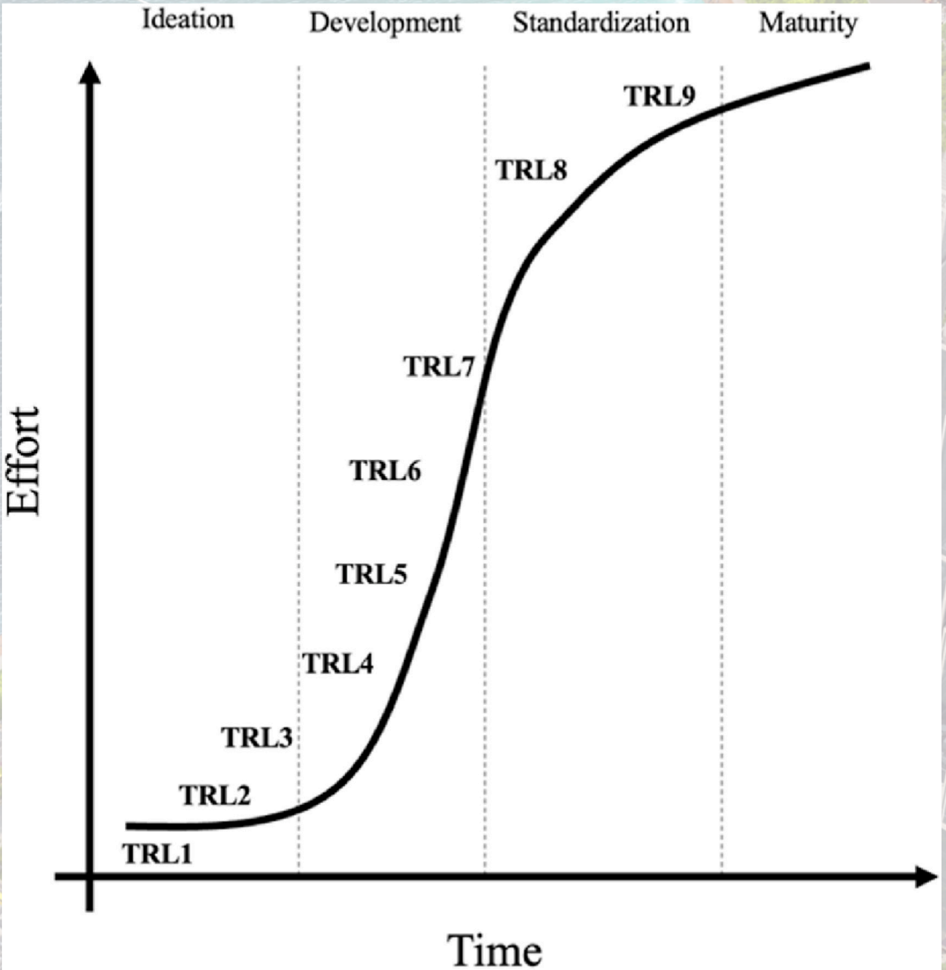
Parametric design

*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**.*

Dr. Dimitrios Terzis

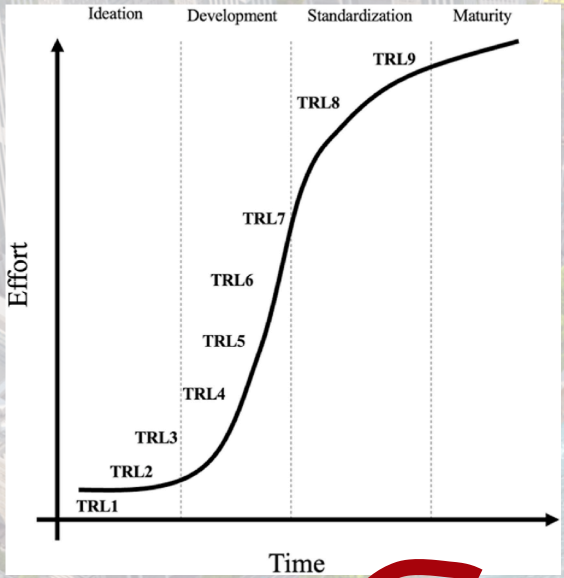
TRL and S-curves

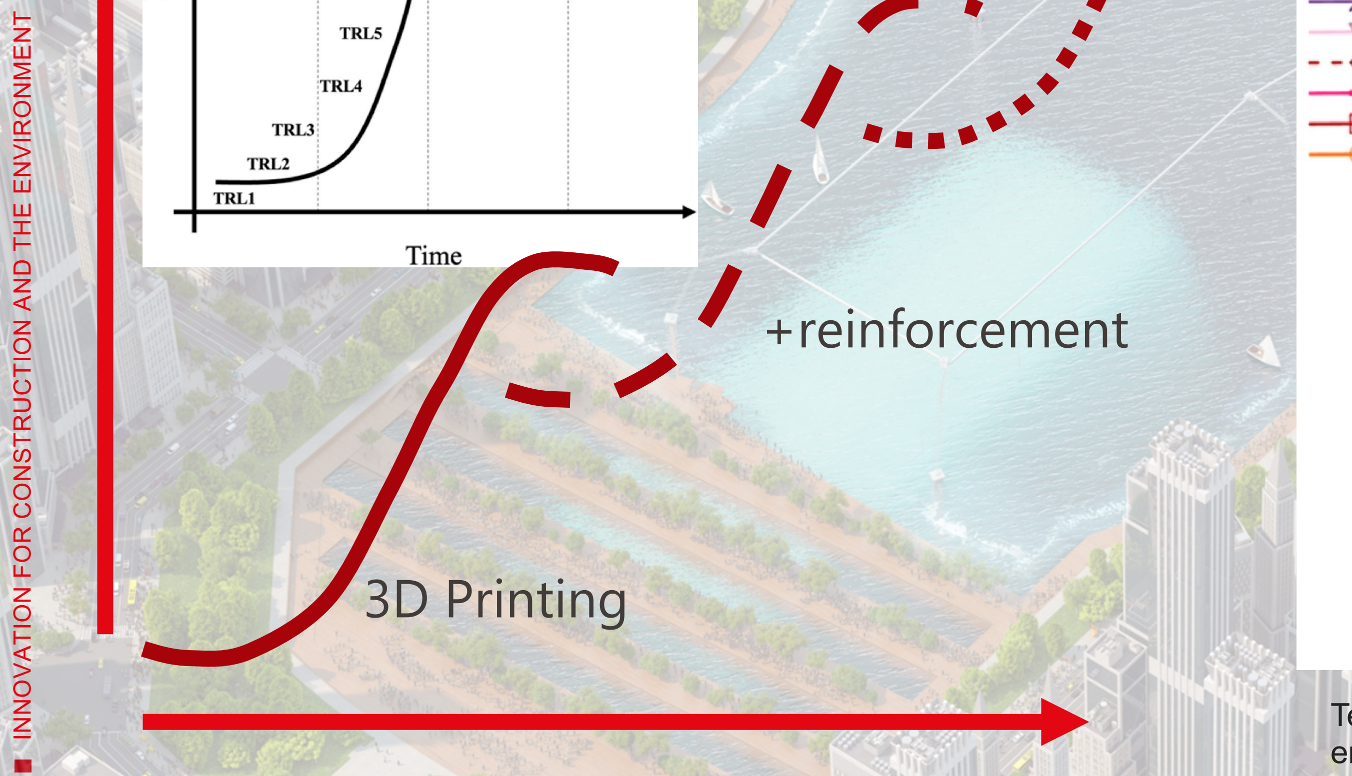


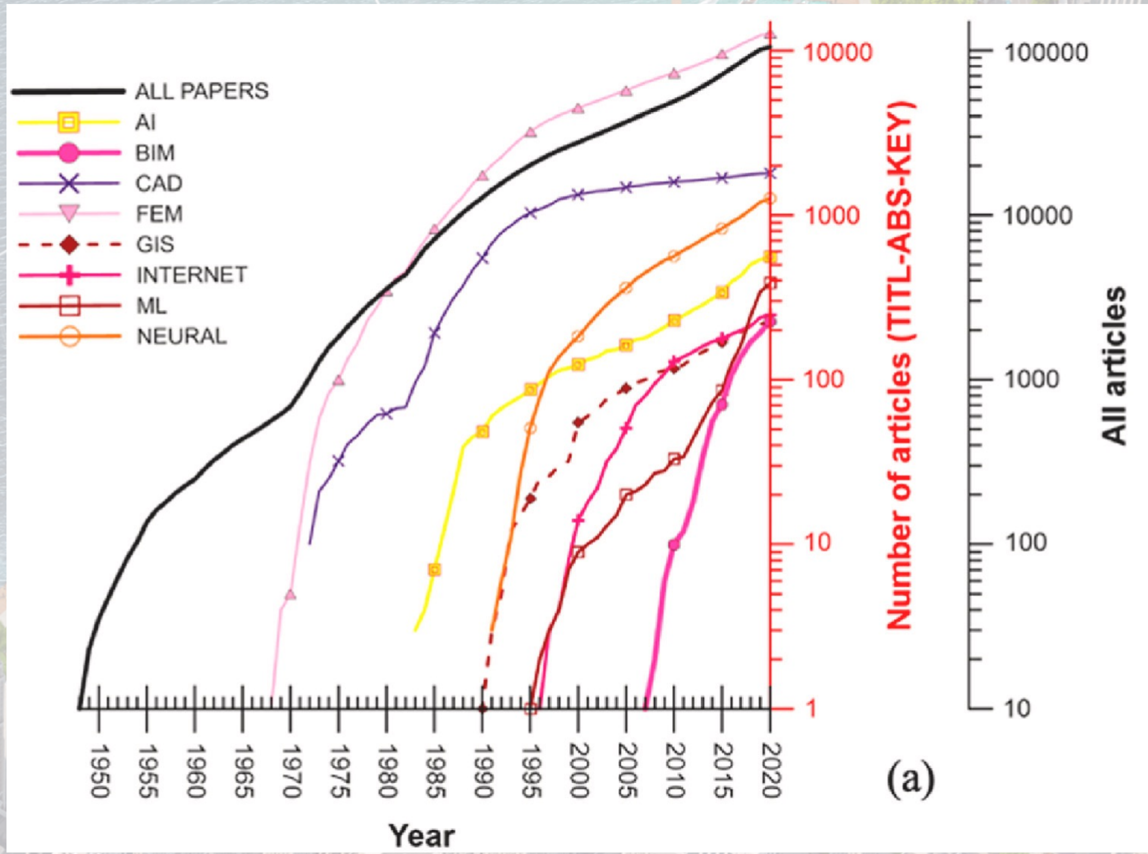


Dr. Dimitrios Terzis

TRL and S-curves







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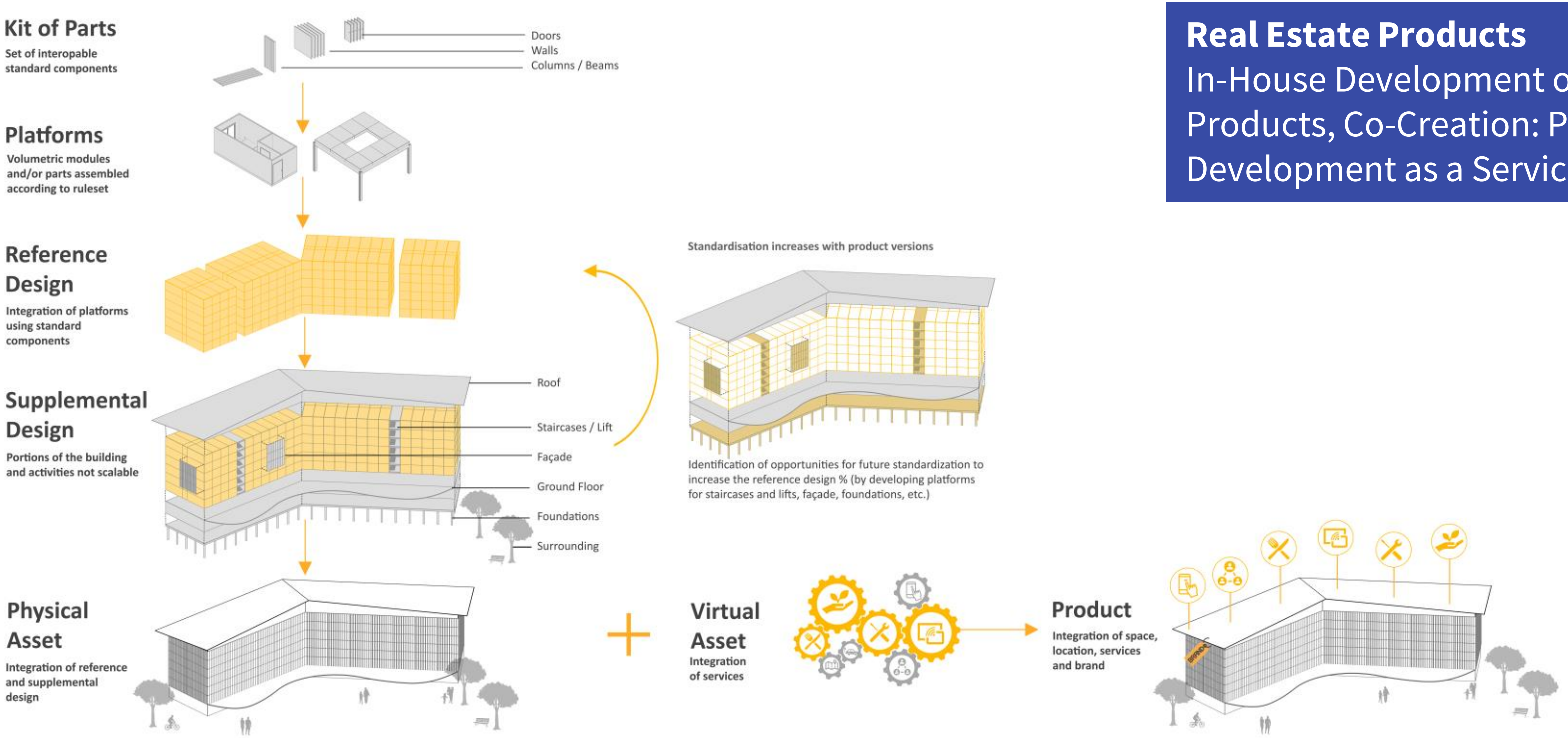
FROM TRADITIONAL MODELS TO INDUSTRIALIZED CONSTRUCTION

Real Estate Products
In-House Development of Real Estate Products, Co-Creation: Product Development as a Service



Parametric design and execution

LINK