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 Dimitrios Terzis

Innovation for construction & the environment

Dr. Dimitrios Terzis

10/09/2024



EPFL



ESTP
PARIS
L'ÉCOLE DES GRANDS PROJETS



 **ARISTOTLE**
UNIVERSITY OF
THESSALONIKI

Senior Scientist & chargé de cours
(2019-aujourd'hui)
Post-doc (2017-2019)
PhD in Mechanics (2017)

Civil Engineering
MSc program
(Echange 2011-2012)

Civil Engineering Diploma
(2014)

Co-author of 15+ publications
Co-inventor of 4 EPFL patents
Co-founder of Medusoil SA
Supervisory board member EPFL Leaders4impact
Representative ENAC diversity office
Board member Géotechnique Suisse  GEOTECHNIK SCHWEIZ
GÉOTECHNIQUE SUISSE
GEOTECNICA SVIZZERA
10+ years in engineering & business consulting



Dimitrios Terzis



dimitrios.terzis@epfl.ch

Soutenu par: **EPFL INNOGRANTS** **INOVAUDE**



**WISSENSCHAFT.
BEWEGEN**
GEBERT RUF STIFTUNG



SWISS NATIONAL SCIENCE FOUNDATION

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Dans les media:

Forbes **SWISS ENGINEERING** **Swissquote**
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natureresearch

Today's introductory lecture

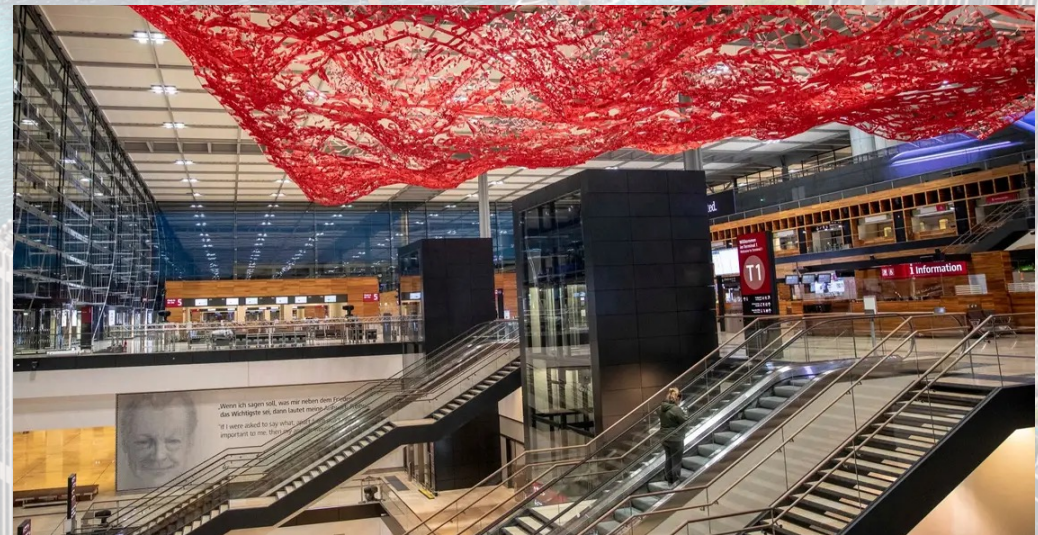
- 1) The goal of the course & how can we define innovation in the most conservative sector?
- 2) Program of the semester
- 3) Structure of the project
- 4) Course's material & guidelines

Break

- 1) The productivity of the construction sector
- 2) Incremental Vs disruptive innovation
- 3) Innovation as an engineering process
- 4) Mapping the innovation construction landscape

Brief guidelines for your projects

A quick quiz: Do you recognize these images?



Can innovation help prevent disasters?

GIS

Traffic
Interruptions,
Microenvironnement,
Historical buildings,
Settlements,
etc

Circulation, meteo (sattelite)

Natural light,
Ventilation,
Flood simulation
Rainfall events
etc

BIM

300 kg of rebar
for m3 of
concrete

Passenger behaviour

Emergency
exits, cleaning
schedule...

Income

Commercial
zones, rental
price/m2

The course's goal

"We developed this course because we believe that a modern civil engineering profession requires graduates who understand innovation as a structured, engineering process and prioritize efficiency across all phases of a project's cycle."

"Need to cultivate the essential technical and economic skills necessary to tackle real-world sustainability issues."

The skill to innovate...

...is in fact a combination of the skills to:

- Research
- Quantify
- Compare
- Learn from return of experiences
- Synthesize individual elements to more complete systems
- Communicate
- Solve disputes

The program of the semester

CIVIL-424 Innovation for construction and the Environment / Fall 2024

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

Room GCA331

		Title
Week 1	10.Sep 45 mins 45 mins	Introduction to the course Disruptive, Incremental Innovation and Research, Projects from last year and takeaways
Week 2	17.Sep 45 mins 45 mins	Cement-free concrete Cement-free concrete
Week 3	24.Sep 45 mins 45 mins	Circular economy, Impact and Life Cycle Assesement Sustainalytics
Week 4	01.Oct 45 mins 45 mins	Traffic Operations, Unmanned Aerial Systems (UAS) and Data Science for smart mobility Traffic Operations, Unmanned Aerial Systems (UAS) and Data Science for smart mobility
Week 5	08.Oct 45 mins 45 mins	Data-driven structural health monitoring and damage detection for smart infrastructure and buildings Data-driven structural health monitoring and damage detection for smart infrastructure and buildings
Week 6	15.Oct 45 mins 45 mins	Project preparation / Paper reading Project preparation / Paper reading
Week 7	29.Oct 45 mins 45 mins	Monitoring and surveillance GIS and BIM for construction and risk management
Week 8	05.Nov 45 mins 45 mins	Sustainalytics Sustainalytics
Week 9	12.Nov 45 mins 45 mins	Industrial innovation from the perspective of a construction giant Industrial innovation from the perspective of a construction giant
Week 11	19.Nov 45 mins 45 mins	Harnessing renewables for buildings Harnessing geo-energy for buildings
Week 12	26.Nov 45 mins 45 mins	Nature-based innovations Nature-based innovations
Week 13	03.Dec 45 mins 45 mins	Parametric design Robotic construction
Week 14	10.Dec 45 mins 45 mins	Project presentations - schedule to be announced Project presentations - schedule to be announced
Week 15	17.Dec 45 mins 45 mins	Synthesis of Innovation project and takeaways Synthesis of Innovation project and takeaways

14 weeks, 4 principles

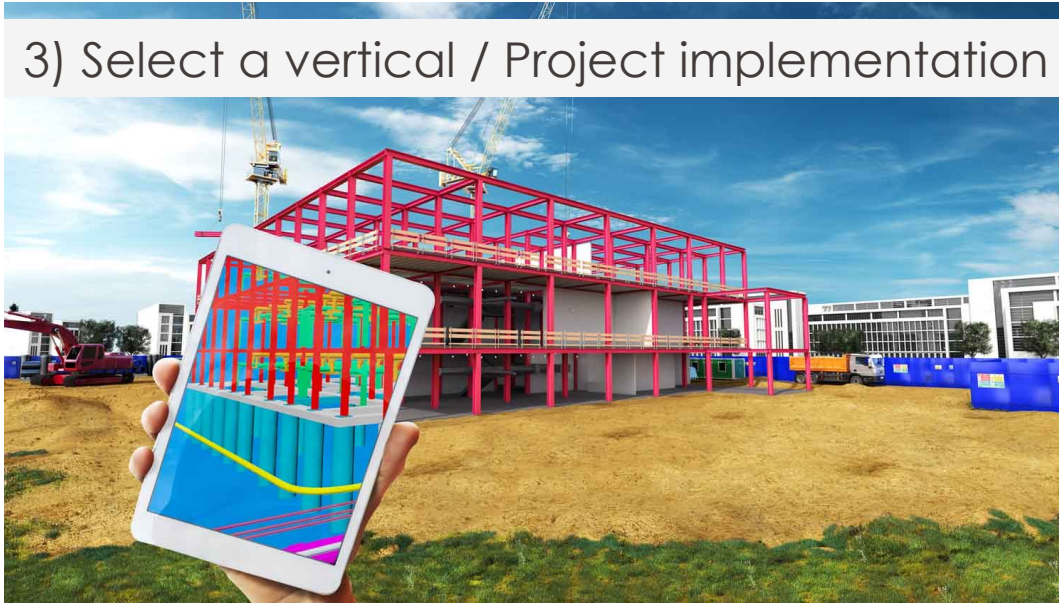
1) Analyzing the innovation landscape



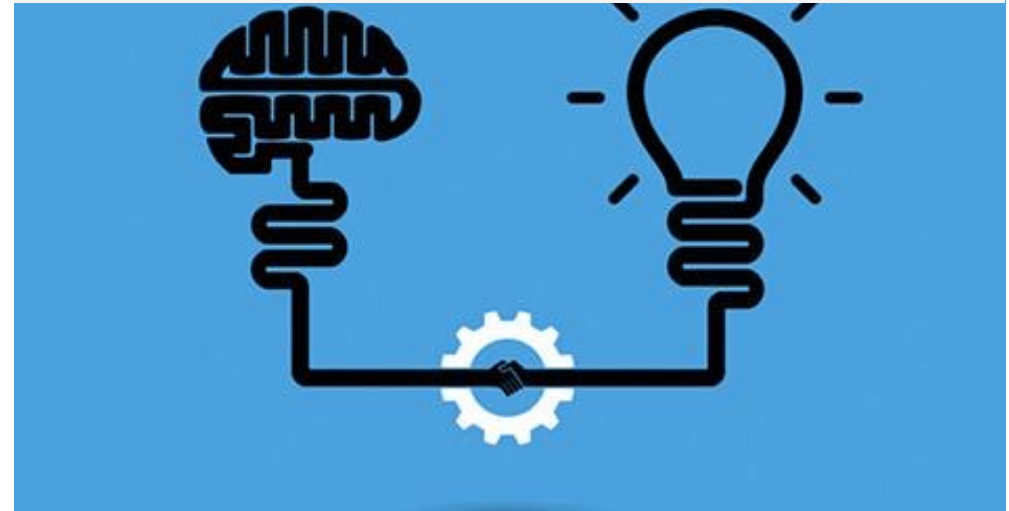
2) Collaboration and Impact



3) Select a vertical / Project implementation



4) Learn to innovate



Structure of your project

		Contents	Weighting factor
Literature review	1.	Problem statement <i>What problem are you solving? How big is the need to solve this problem in our field? What are some key relevant quantities in volumes/costs/damages/environmental impact?</i>	5%
	2.	Current solutions overview <i>What are existing solutions to tackle the above problem? Which are their main technical features? What is their level of maturity and under what conditions these solutions can be implemented?</i>	20%
	3.	Use cases <i>What are the use cases of the above solutions and their outcomes? What are key advantages and drawbacks/limitations?</i>	15%

Structure of your project

		Contents	Weighting factor
Literature review	1.	Problem statement <i>What problem are you solving? How big is the need to solve this problem in our field? What are some key relevant quantities in volumes/costs/damages/environmental impact?</i>	5%
	2.	Current solutions overview <i>What are existing solutions to tackle the above problem? Which are their main technical features? What is their level of maturity and under what conditions these solutions can be implemented?</i>	20%
	3.	Use cases <i>What are the use cases of the above solutions and their outcomes? What are key advantages and drawbacks/limitations?</i>	15%

- Search
- Quantify
- Compare
- Learn from return of experiences

Innovation and impact creation	4.	Room for innovation <i>Have you identified opportunities to innovate and if yes what lies in the core of studied innovation (hardware/software/infrastructure?)</i>	25%
	5.	Value creation <i>Who benefits from your studied innovation? What is the value you create and for which partners? Who do you depend on and who depends on you (regulations, technology manufacturers, service providers etc)? You can use elements of your business model canvas to facilitate this section</i>	20%
	6.	Potential Risks <i>Have you identified any potential risks or barriers from regulations or competition from existing solutions? Are there any technological limitations that could hinder your studied innovation?</i>	5%
	7.	Impact created <i>What is the created environmental/societal/economic impact of your studied innovation?</i>	5%
Overall quality of presentation and of used references from literature.			5%

Structure of your project

Join at menti.com | use code 8174 6528

 Mentimeter

Have you heard of state-of-the-art / literature review before?

0
Yes

0
No

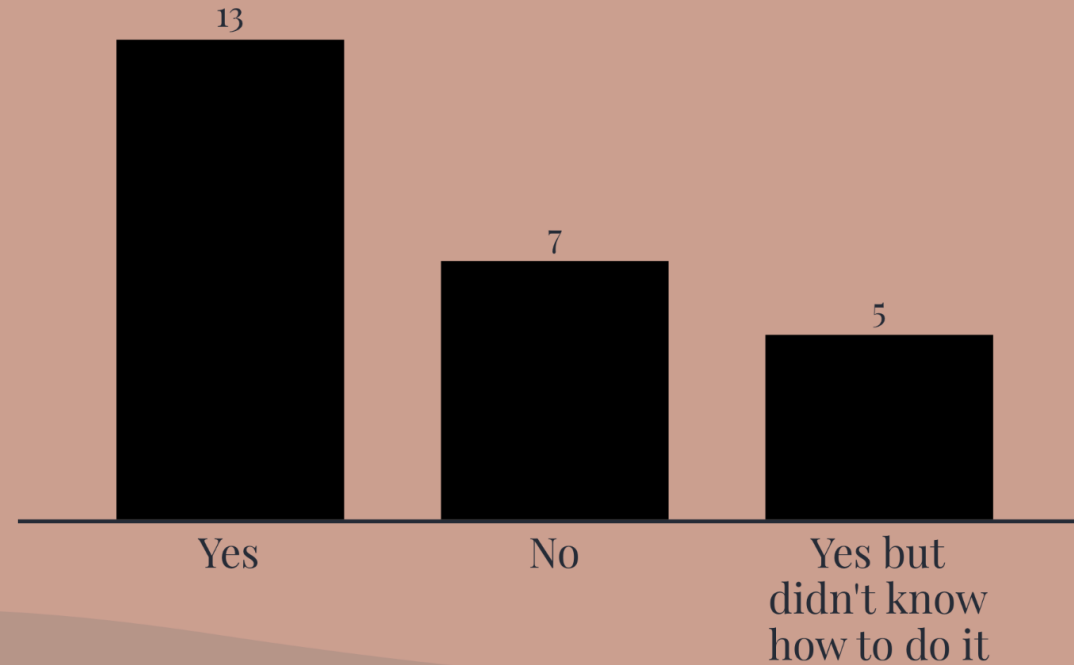
0
Yes but didn't know how to do it

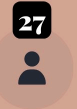


Go to www.menti.com and use the code **21 98 90 5**

Mentimeter

Have you heard of state-of-the-art / literature review before?





Let's get things started...



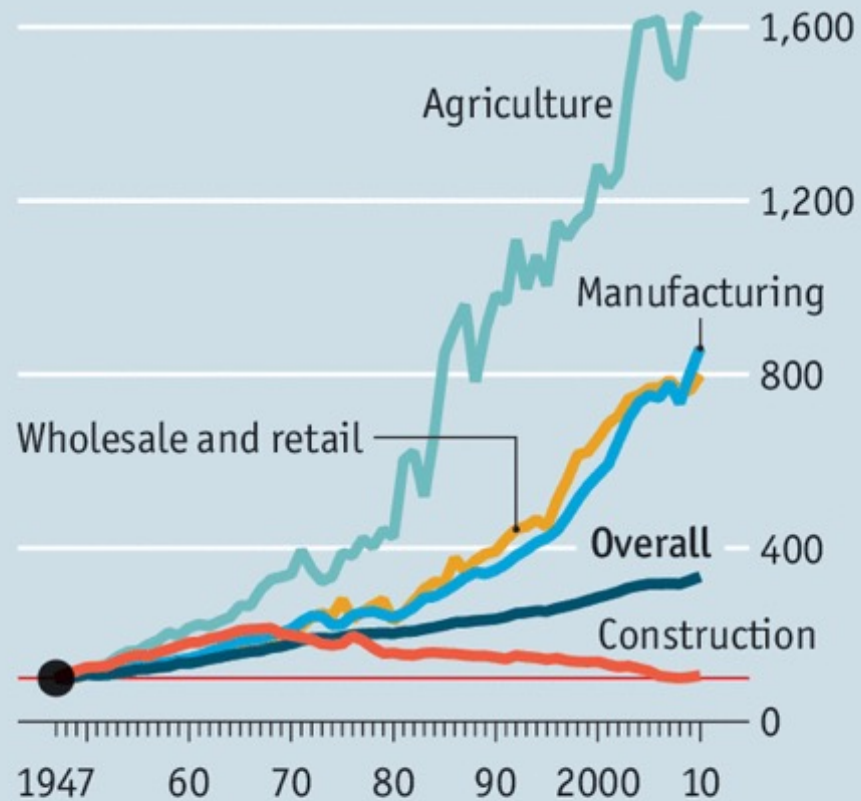
**Understanding
productivity in
relation to
innovation**

Construction is suffering in terms of productivity

Unlearning by doing

United States, gross value-added*

Per hour worked, 1947=100



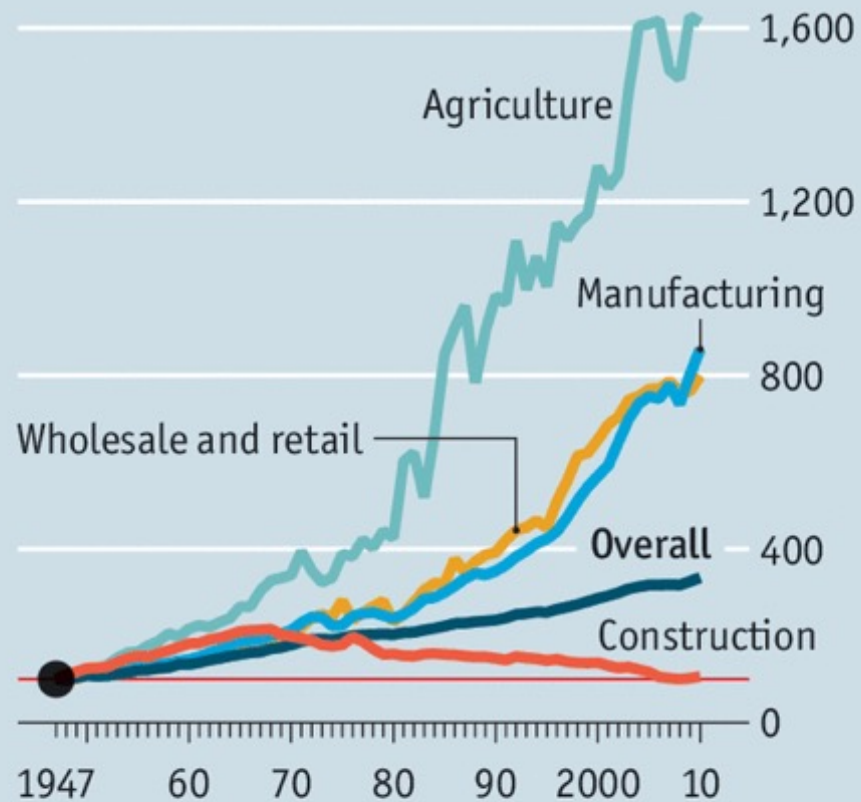
Source: McKinsey Global Institute

*At constant prices

Innovation, R&D are much needed in our field

Unlearning by doing

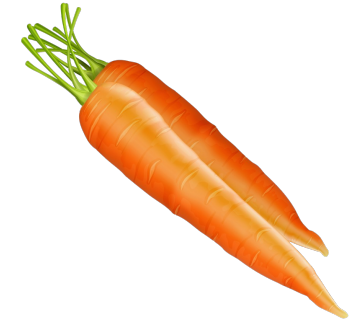
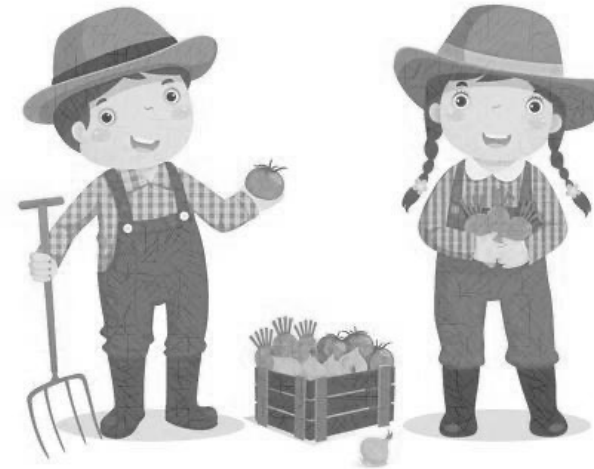
United States, gross value-added*
Per hour worked, 1947=100



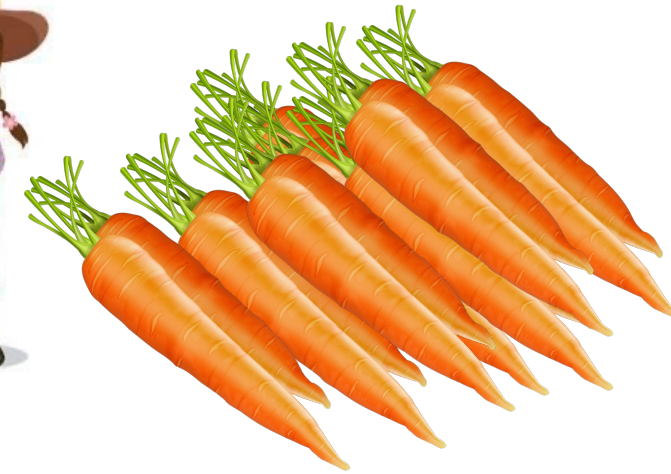
Source: McKinsey Global Institute *At constant prices

Economist.com

1947 - 100



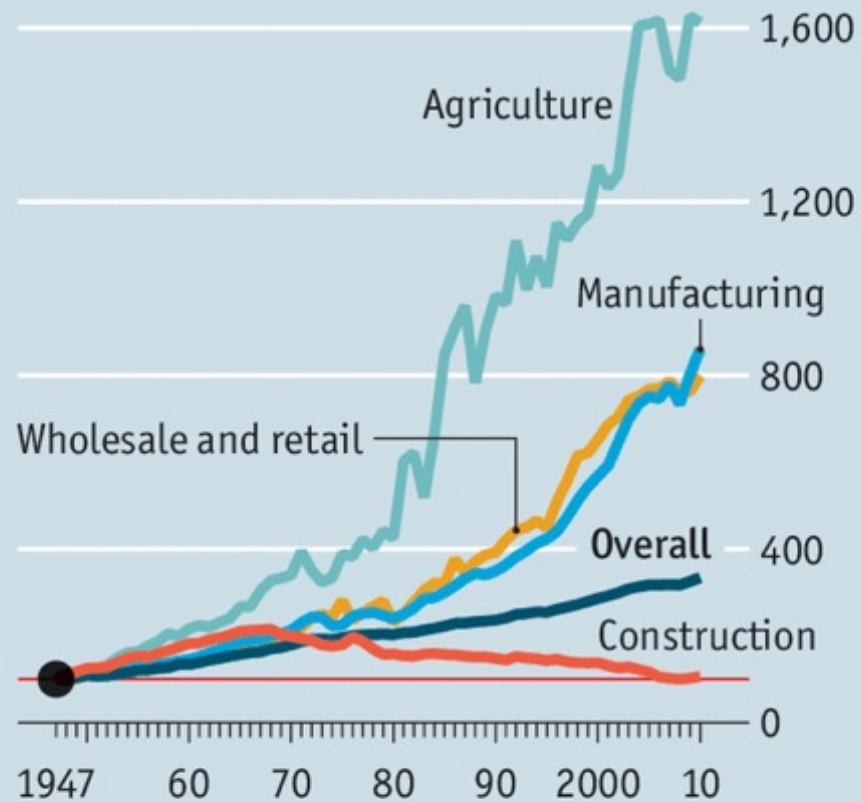
2010 - 1600+



Innovation, R&D are much needed in our field

Unlearning by doing

United States, gross value-added*
Per hour worked, 1947=100



Source: McKinsey Global Institute *At constant prices

Economist.com

1947 - 100



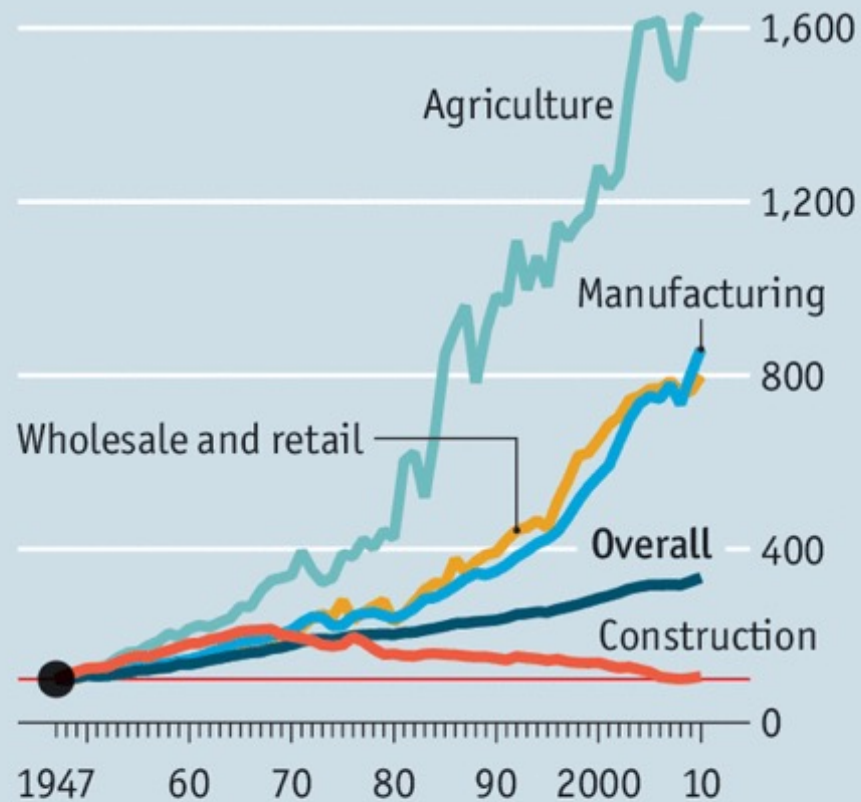
2010 - 100



Innovation, R&D are much needed in our field

Unlearning by doing

United States, gross value-added*
Per hour worked, 1947=100



Source: McKinsey Global Institute

*At constant prices

Economist.com

Why is this happening?

- poor digitalization penetration
- expensive equipment
- expensive resources
- lack of skilled labour
(innovating to overcome hurdles at the construction site)

Turning points

Materials



CAD



Manufacturing



What kind of innovation is this?



This excavator operator at Bauma in Munich, Germany is digging at a jobsite in South Korea!!

“3D machine guidance solution,
5G link”

Doosan Infracore said it worked with South Korean mobile carrier LG Uplus Corp. to set up the 5G link and that further work is under way to expand the technology to reduce lag and ensure a secure data link.

What kind of innovation is this?



Is the end-product/task the same?

Is it safer?

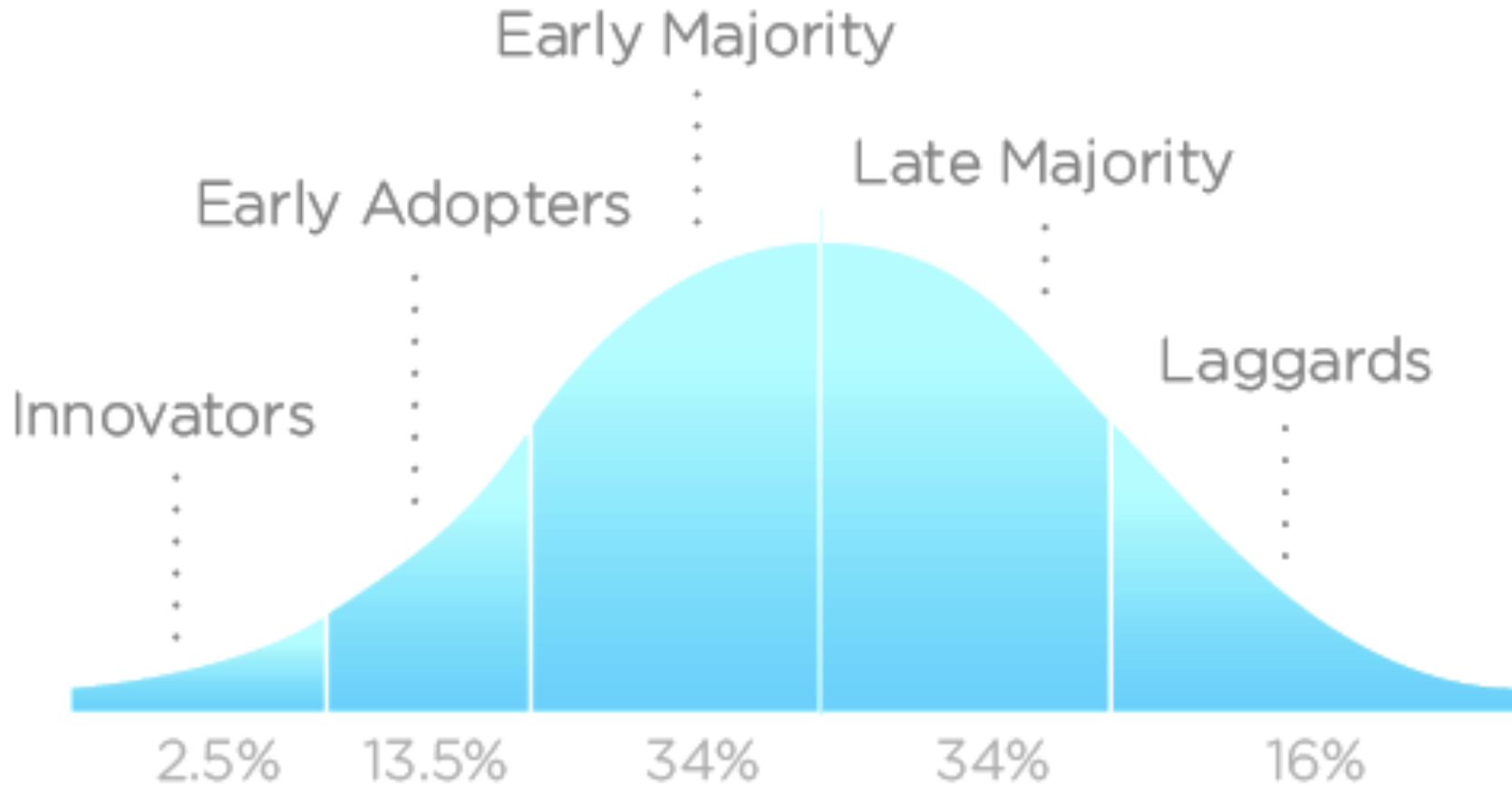
Is it more precise?

Is it easier?

Does it replace men with machines?

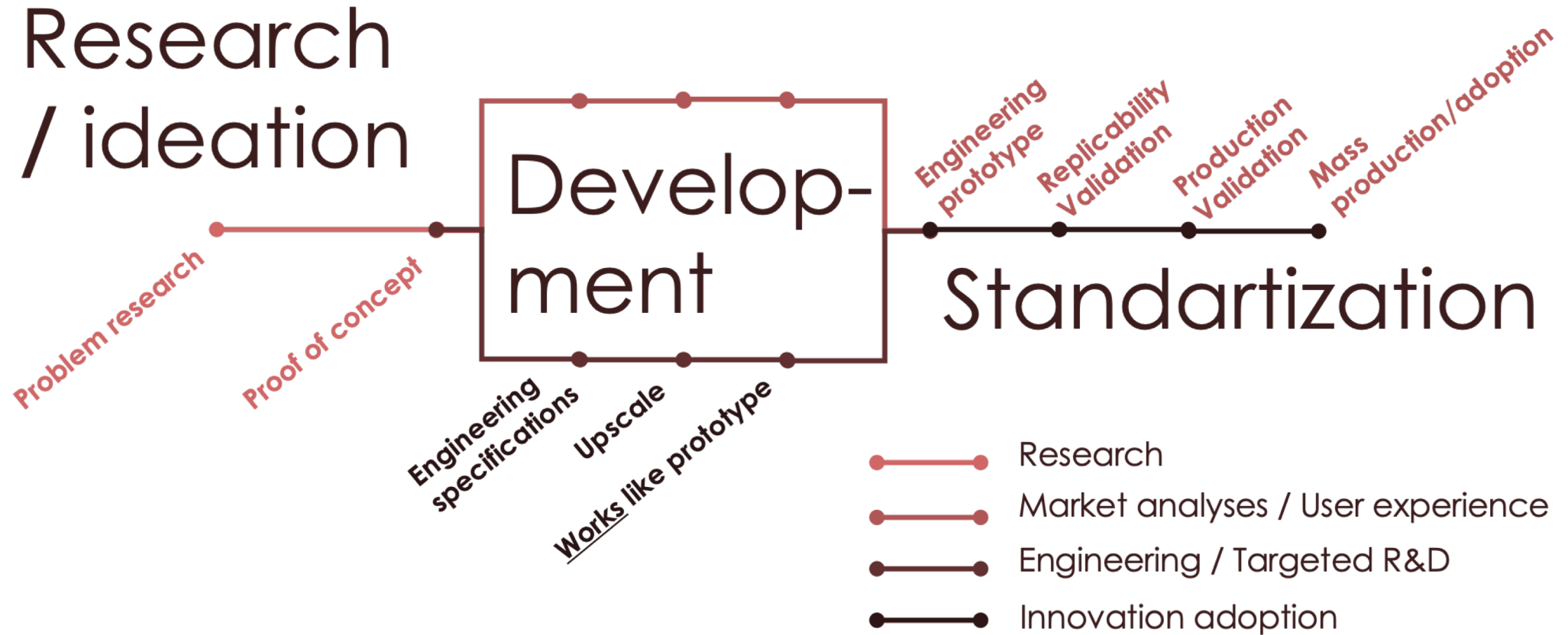
Financial impact?

Forget who's developing and focus on who's using



Rogers' bell curve

Let's try to break down the innovation process



How will things evolve in the next 2–3 years?

FIELD: on-site execution

TEAM: digital collaboration

OFFICE: back-office and adjacencies

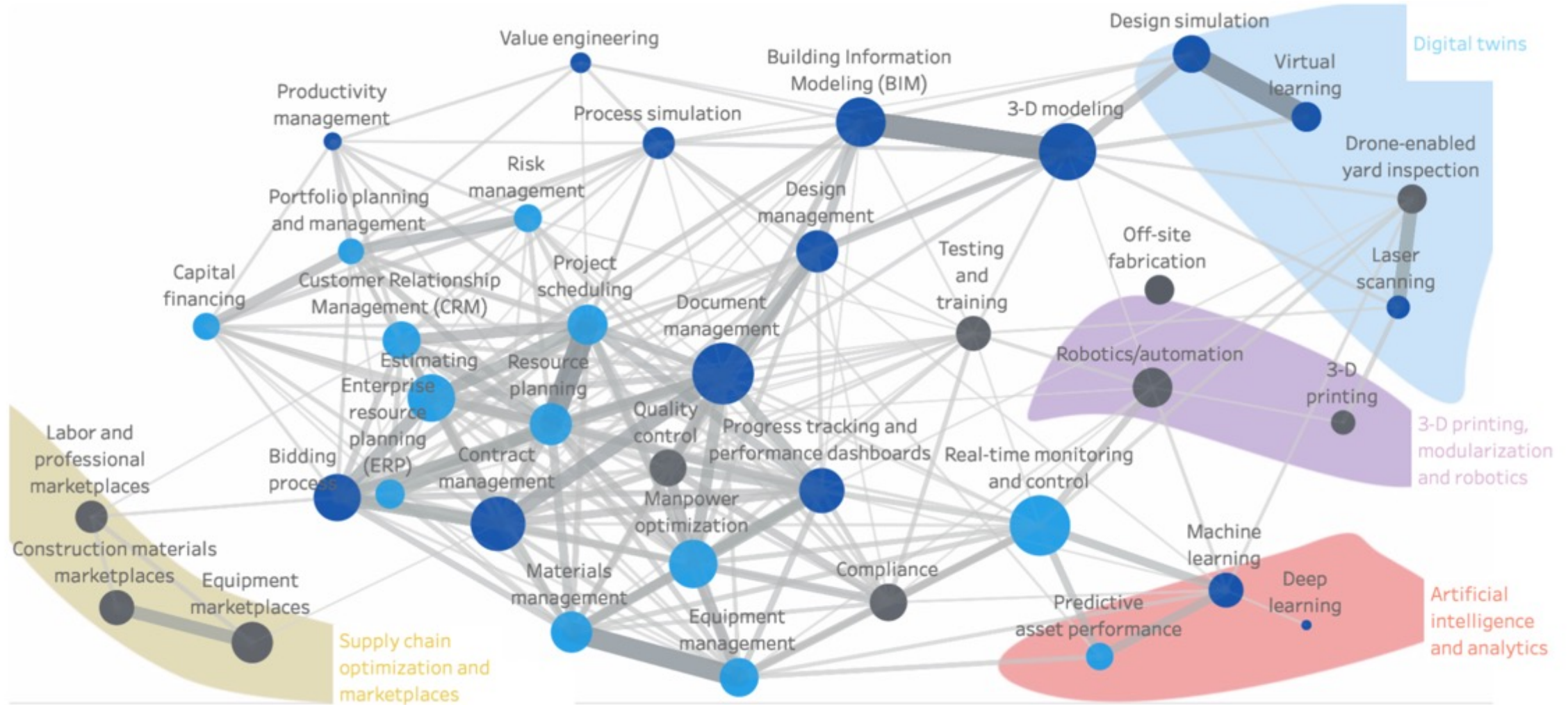
PRE-CONSTRUCTION: concept and feasibility, design

DURING OPERATIONS: engineering, preconstruction, construction and operations

POST-CONSTRUCTION: the entire asset life cycle

Let's analyze trends established in a 2018 report by McKinsey & Co based on 2'400 technology solutions companies

Mapping the construction technology Ecosystem





The banner features a background image of a construction site with a large crane and a city skyline. The text is overlaid on this image.

PIX4D

Products | Solutions | Pricing | Services | Resources

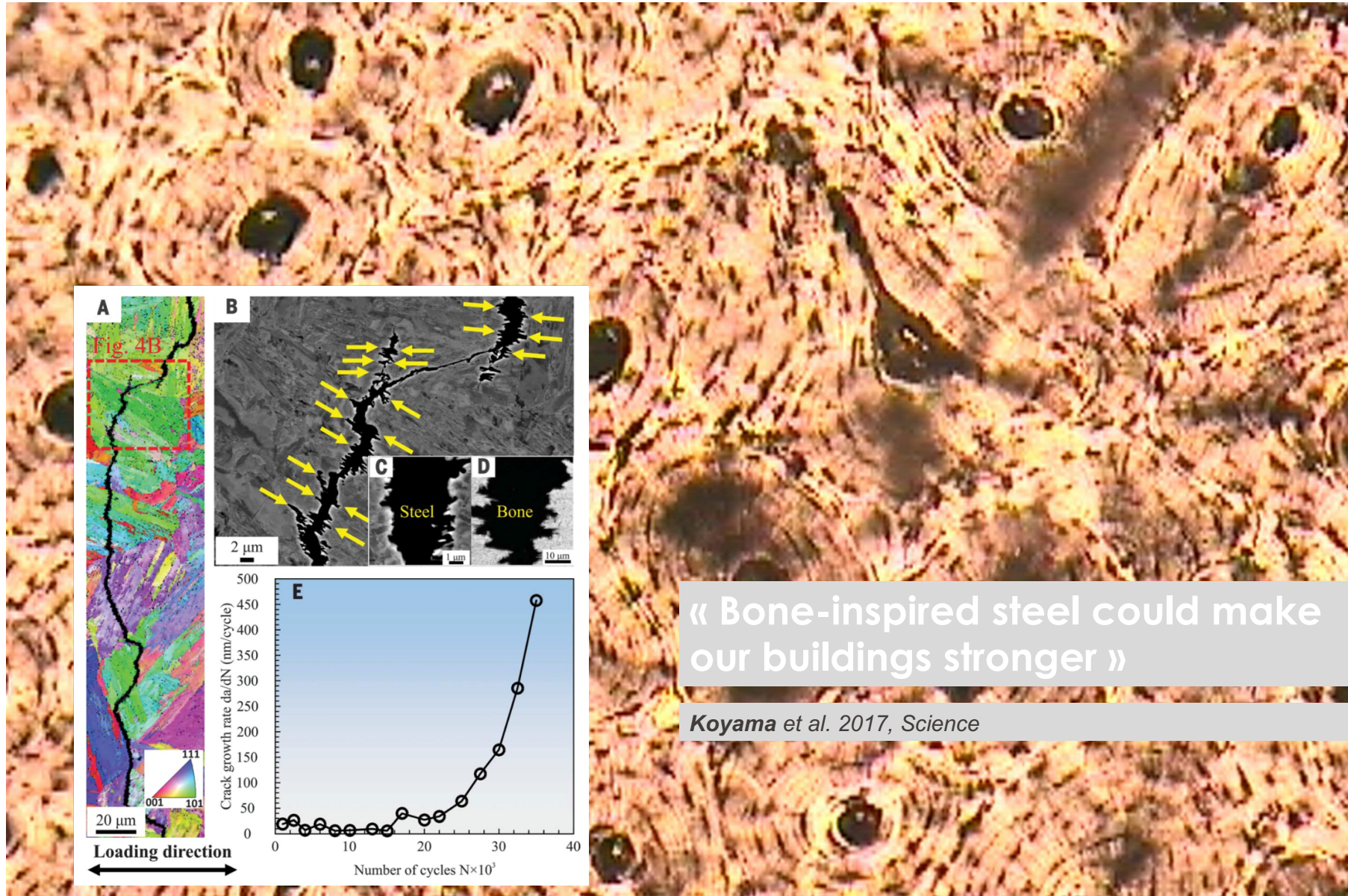
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Drone mapping solutions for construction

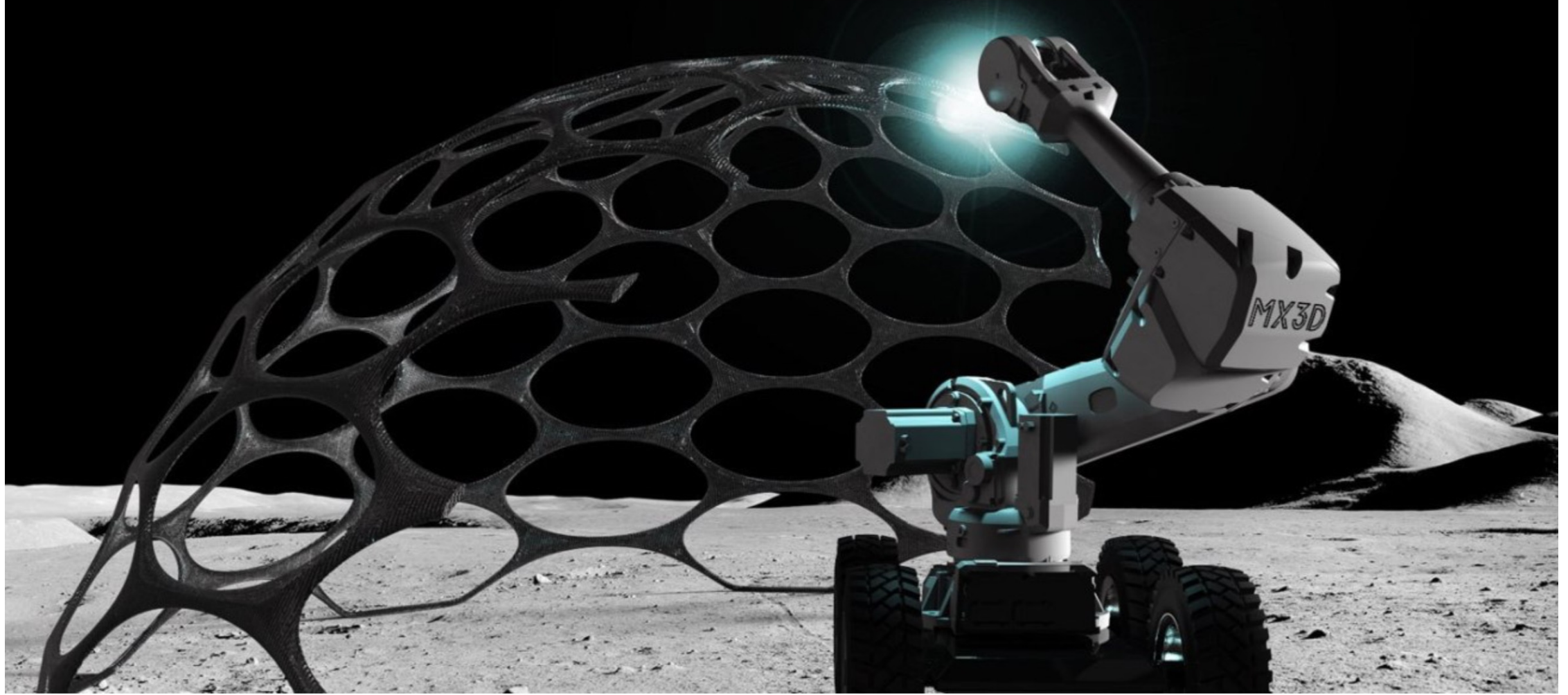
Lower costs and increased productivity with smarter project management

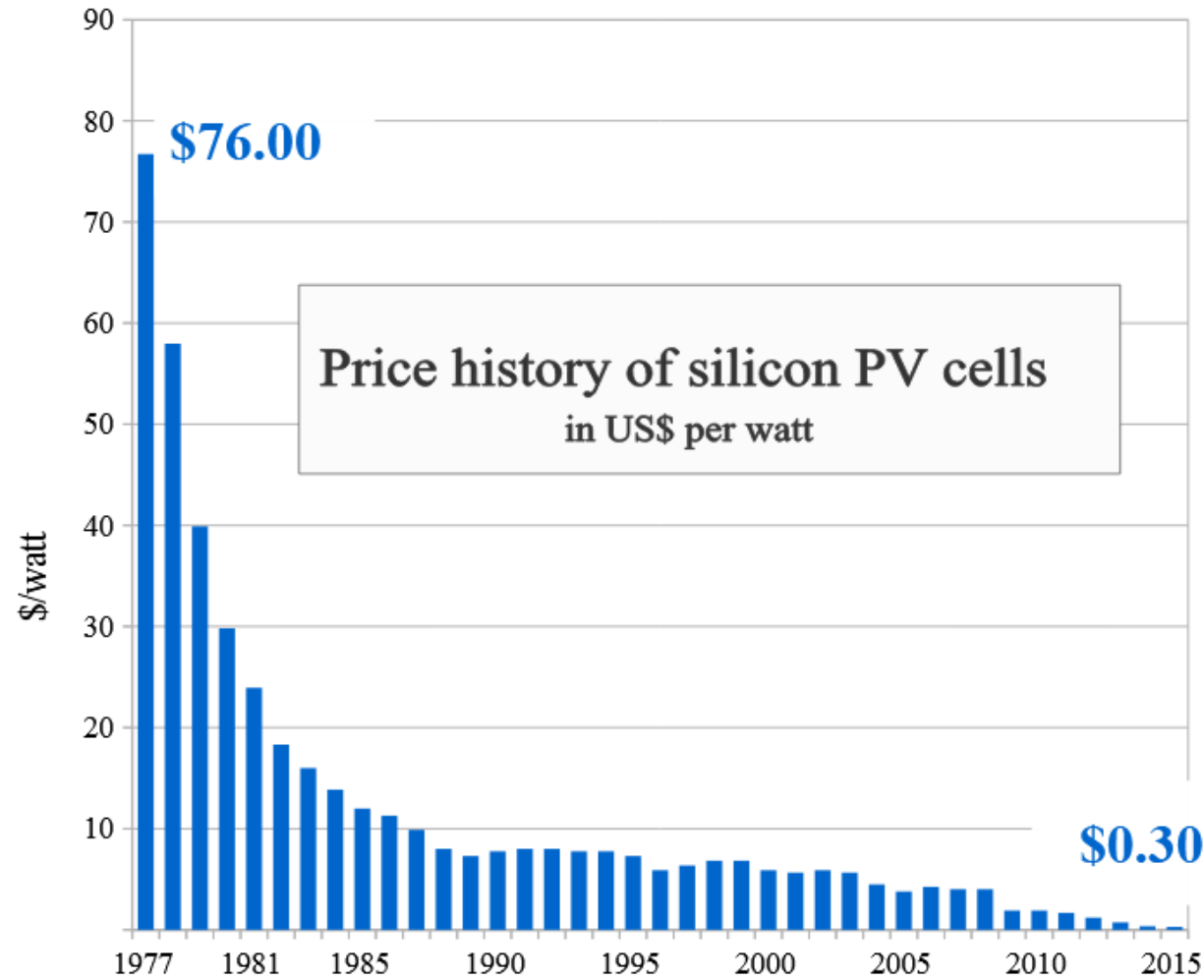
SKANSKA  **Stantec**  **COSTAIN**  **BOUYGUES CONSTRUCTION** **Balfour Beatty**  **ISACHSEN**





CL3VER





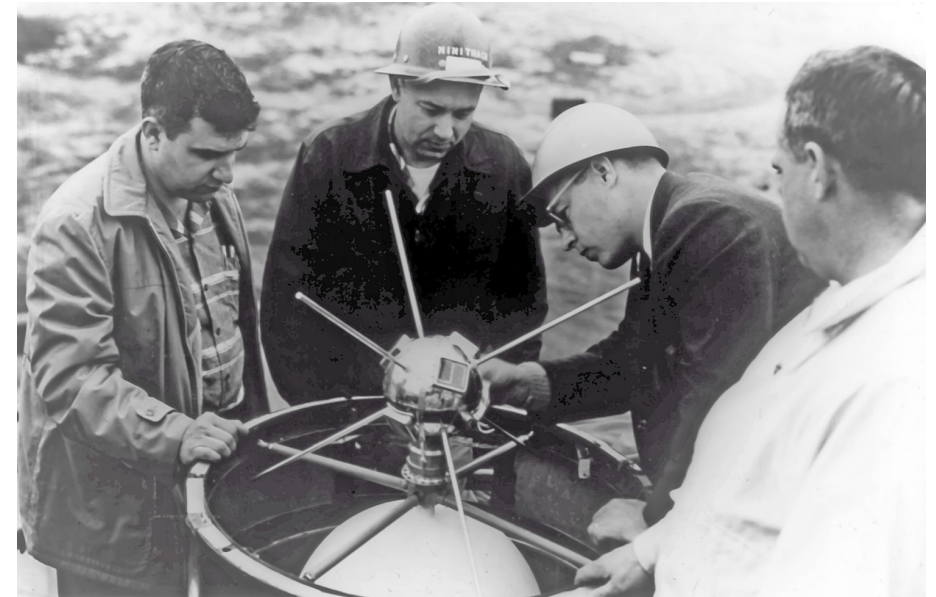
Source: Bloomberg New Energy Finance & pv.energytrend.com

Vanguard 1

The **first** spacecraft to use **solar panels** was the Vanguard 1 **satellite**, launched by the US in 1958. This was largely because of the influence of Dr. Hans Ziegler, who can be regarded as the father of spacecraft **solar** power.

[Solar panels on spacecraft - Wikipedia](#)

https://en.wikipedia.org/wiki/Solar_panels_on_spacecraft



Innovation or Science fiction?

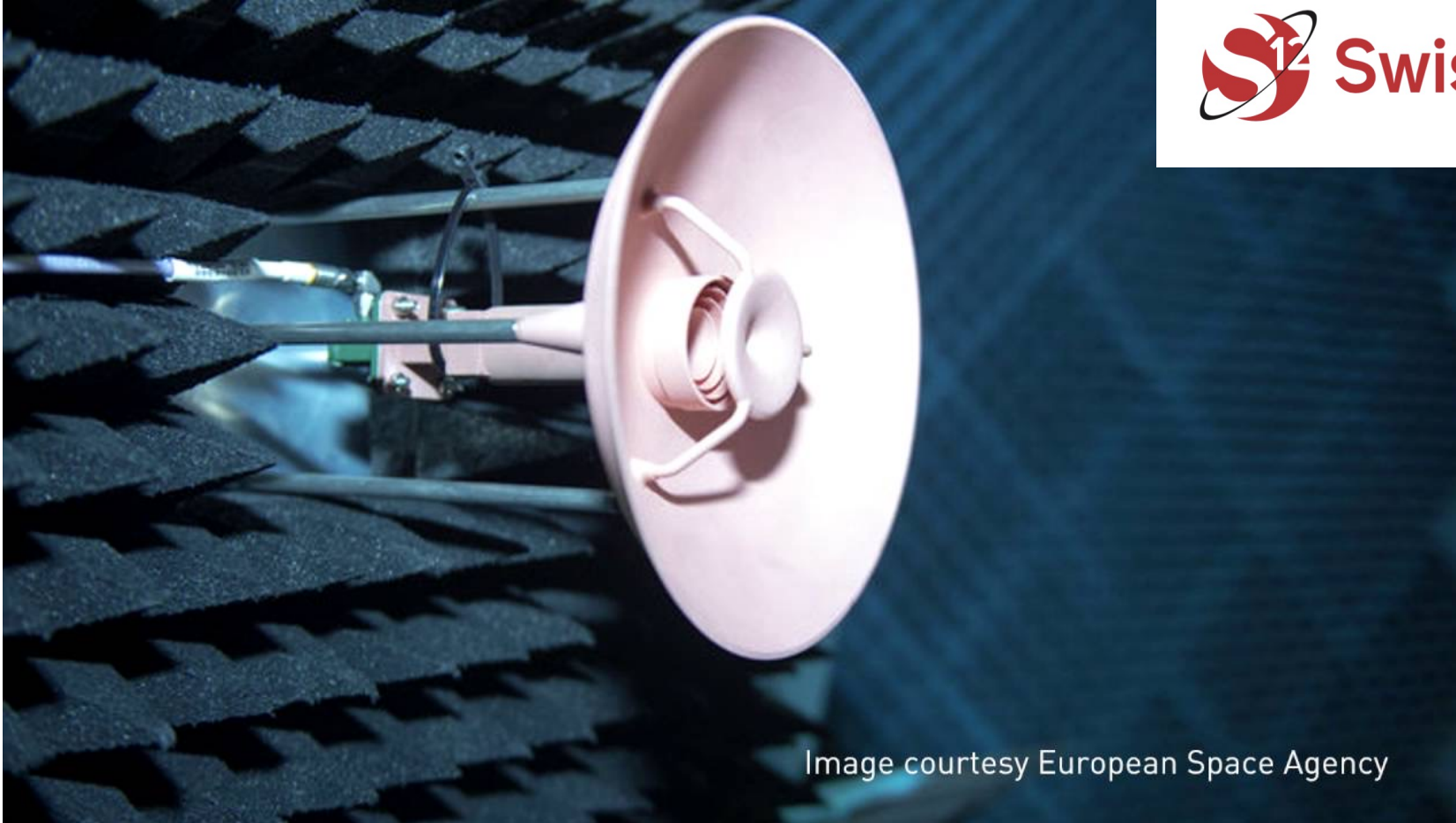


Image courtesy European Space Agency



Innovation or Science fiction?

Spin-off SWISSto12 raises 18.1 million



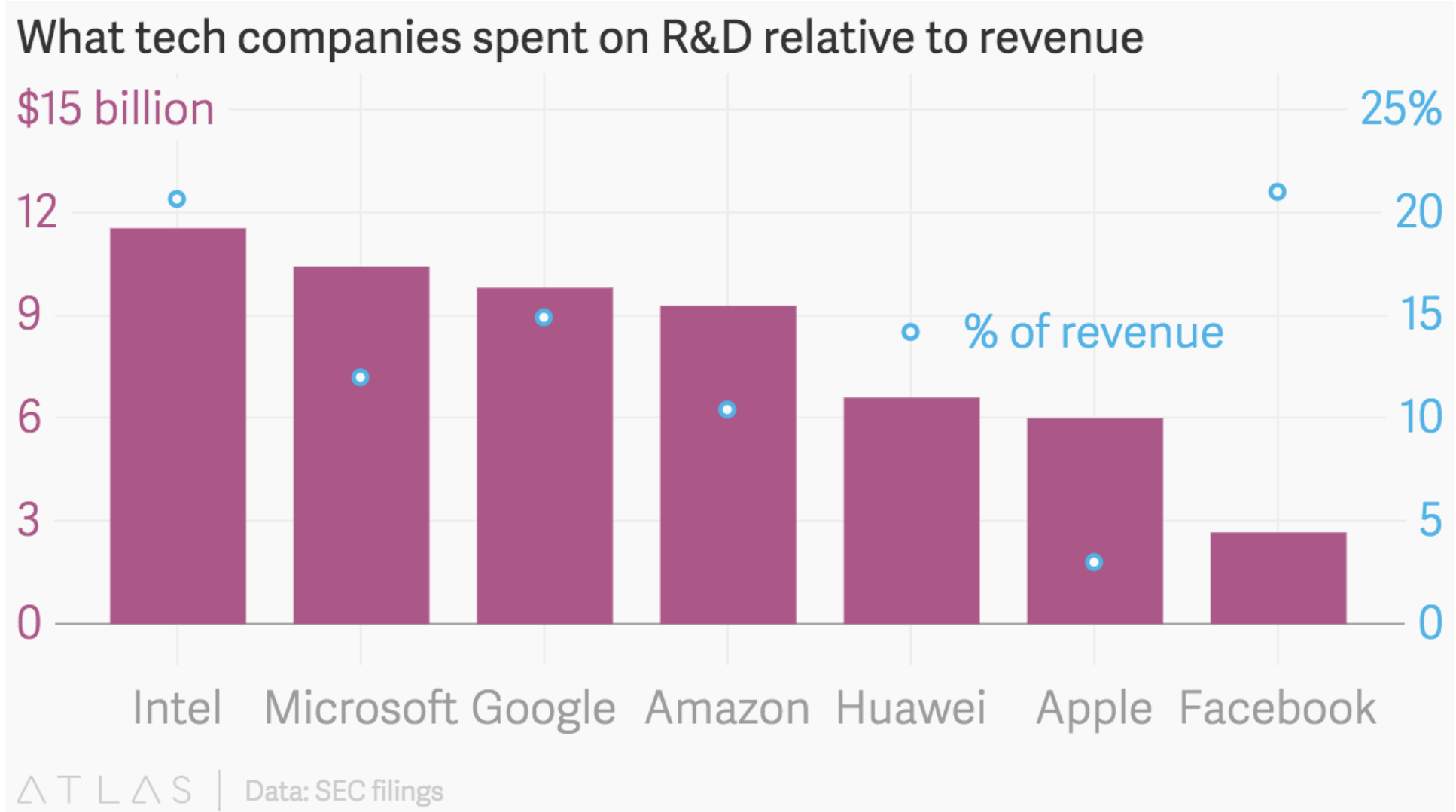
EPFL spin-off SWISSto12, which manufactures antennas for satellite communications, has raised CHF 18.1 million from investors. The firm will use the fresh injection of capital, announced today, to ramp up marketing of its 3D-printed waveguides and expand its offices in the US and Israel.

29.08.19

LINKS

■ [Swissto12](#)

How do we quantify innovation?



How do we quantify innovation?



120 patents filed per month.

75000 active patents and over **2200** more since the beginning of 2017 (as of 06/2018).

Revenue: **233.2 billion EUR** (2018)
A R&D budget of around **6 Billion \$** (2016)



21 patents filed in 2016

3172 active patents

Revenue **43.5 billion EUR** (2018)
A R&D budget of around **50 million EUR** a year

A 5.4 times higher revenue and a 120-fold
higher R&D investment

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TITLE-ABS-KEY (3d AND construction)

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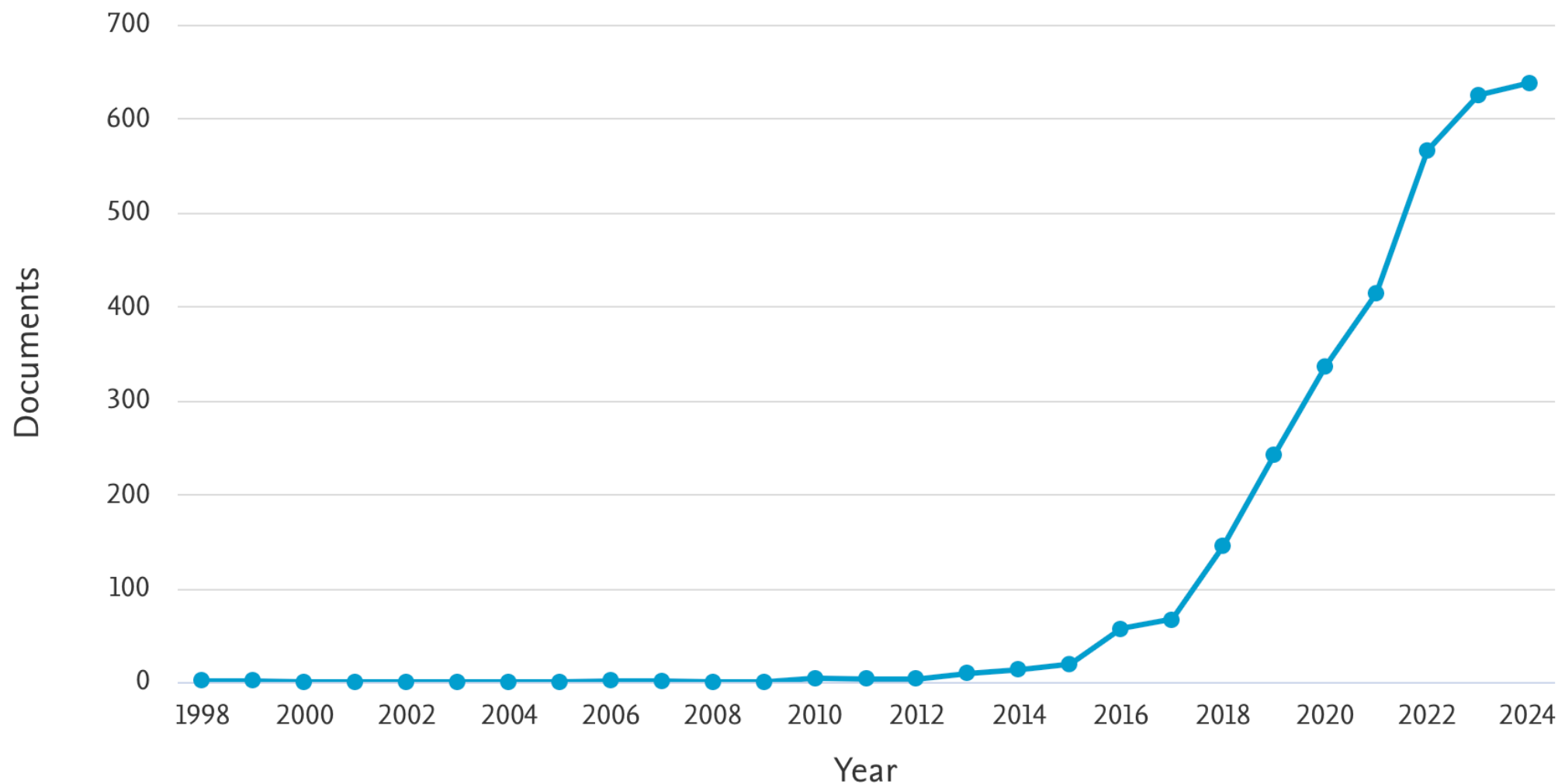
PDF

	Document title	Authors	Year	Source	Cited by
☐ 1	High rate and cycling stable Li metal anodes enabled with aluminum-zinc oxides modified copper foam	Lu, S., Wang, Z., Yan, H., (...), Qin, W., Wu, X.	2020	Journal of Energy Chemistry 41, pp. 87-92	0
View abstract View at Publisher Related documents					
☐ 2	Case study analysis for development strategies of construction 3D printing	Men, X., Zhang, X.	2020	Advances in Intelligent Systems and Computing 975, pp. 439-450	0

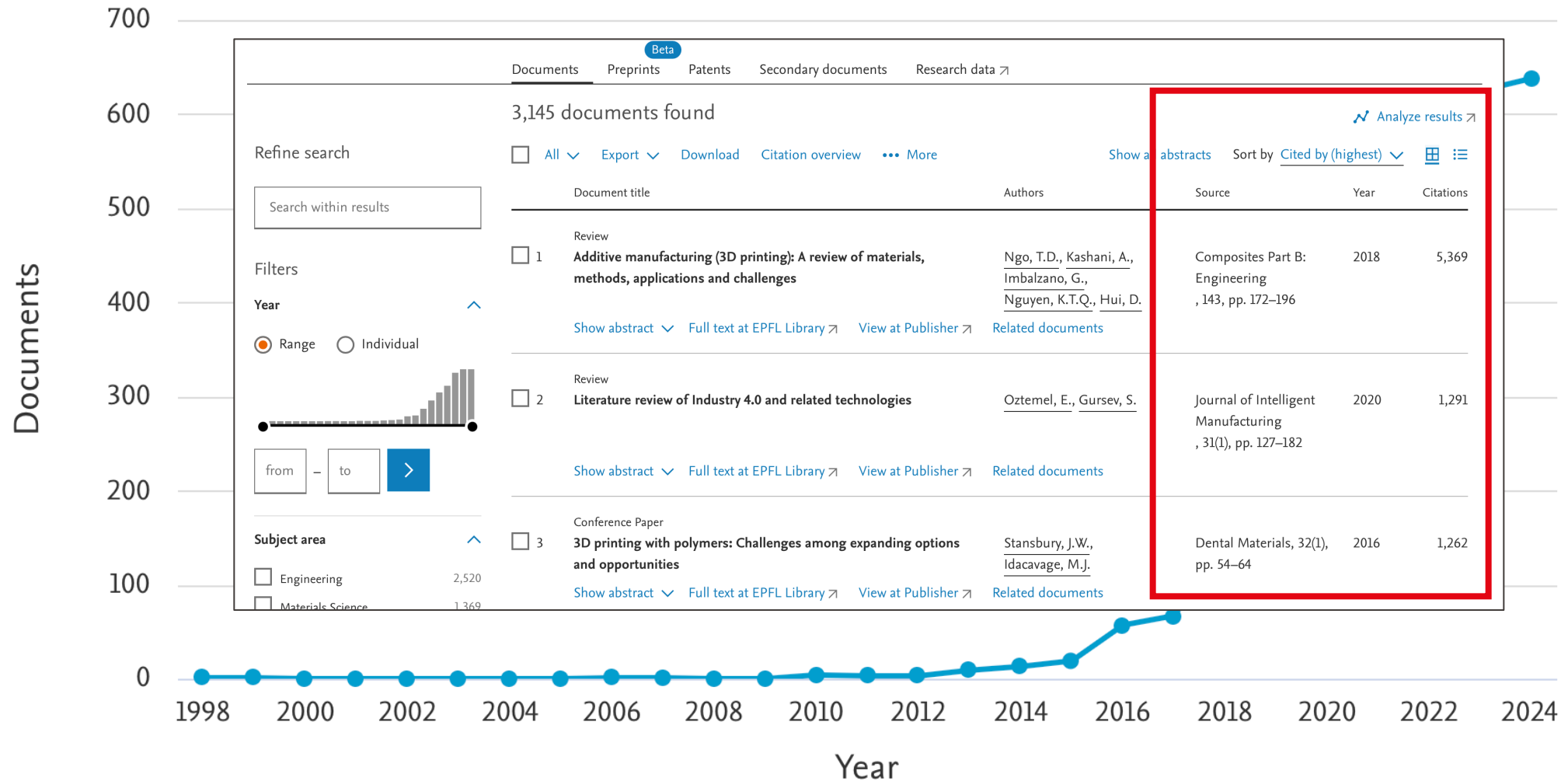
CITED BY

☐ 51	Mobile 3D mapping for surveying earthwork projects using an Unmanned Aerial Vehicle (UAV) system	Siebert, S., Teizer, J.	2014	Automation in Construction 41, pp. 1-14	281
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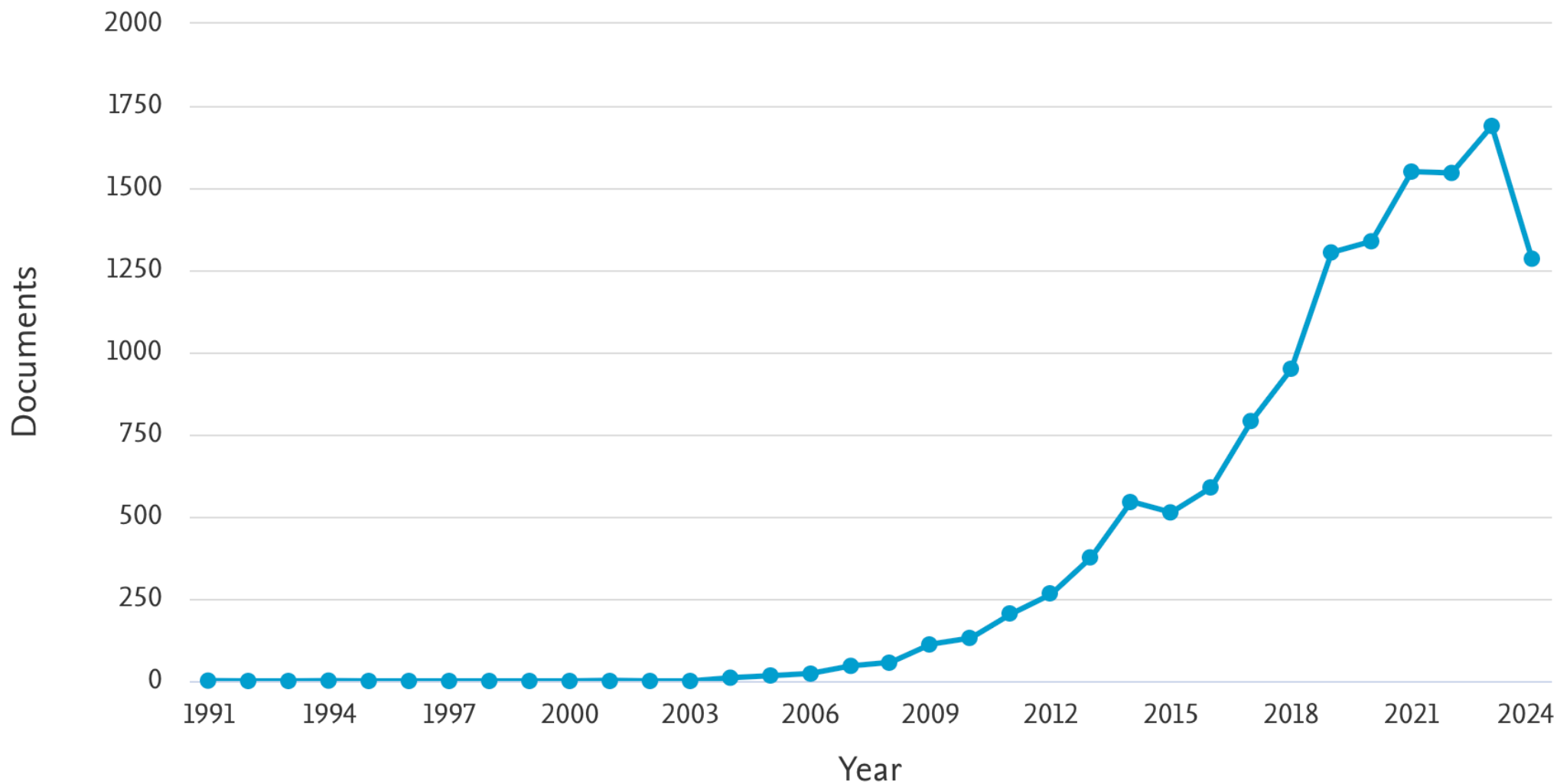
Documents by year



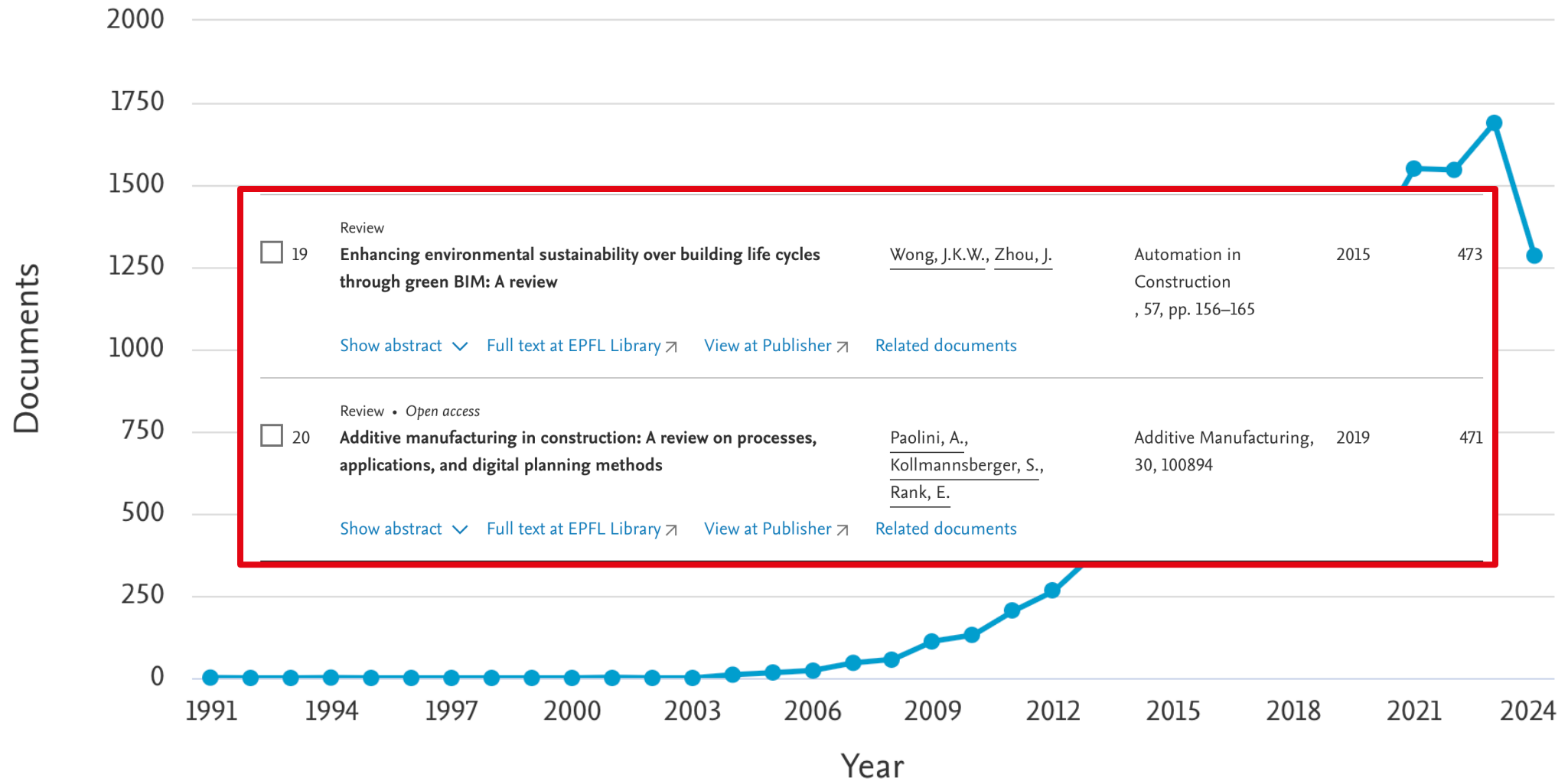
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Structure and Infrastructure Engineering
Volume 12, Issue 10, 2 October 2016, Pages 1267-1280

A framework for 3D traffic noise mapping using data from BIM and GIS integration (Article)

Deng, Y.^a, Cheng, J.C.P.^a [✉](#), Anumba, C.^b [i](#)

^aDepartment of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong

^bDepartment of Architectural Engineering, The Pennsylvania State University, University Park, PA, United States

Abstract

[View references \(43\)](#)

Traffic noise is a major health concern for people living in urban environments. Noise mapping can help evaluating the noise level for certain areas in a city. Traditionally, noise mapping is performed in 2D geographic information system (GIS). The use of 3D GIS is also emerging in noise mapping in recent years. However, the current noise-mapping platforms can only conduct noise evaluation for the outdoor environment and the indoor environment separately. In addition, related information about absorption coefficient and transmission loss (TL) in noise calculation is not properly retrieved and is often replaced with a single value. In this research, building information modelling (BIM) and 3D GIS are integrated in order to combine traffic noise evaluation in both outdoor environments and indoor environments in a single platform. In our developed BIM-GIS integration platform, the built environment is represented in a 3D GIS model that contains information at a high level of detail from BIM. With the integration with BIM, the 3D GIS model now has access to detailed indoor features such as interior walls and interior rooms. Noise evaluation could therefore be performed at a room level in the developed platform. Essential parameters such as absorption coefficient and TL can be extracted directly from BIM for noise calculation. The 3D GIS model is connected with detailed BIM so that any changes in the indoor and outdoor features can be reflected to each other. The Italian C.N.R model is modified and applied in the platform to conduct noise calculation. This paper presents the details for the development of the noise-mapping BIM-GIS platform based on ArcGIS. Two use cases were analysed to show the role of such platform in the decision-making process of both urban planning and interior design. © 2016 Taylor & Francis.

SciVal Topic Prominence [i](#)

Topic: [Noise pollution](#) | [Acoustic noise](#) | [Noise map](#)

Prominence percentile: 91.552 [i](#)

Metrics [?](#)

[View all metrics](#)

25 [Citations in Scopus](#)

96th percentile

3.89 [Field-Weighted Citation Impact](#)



PlumX Metrics

Usage, Captures, Mentions,
Social Media and Citations
beyond Scopus.

Cited by 25 documents

[Integration of BIM and GIS: IFC geometry transformation to shapefile using enhanced open-source approach](#)

Zhu, J. , Wang, X. , Chen, M.
(2019) *Automation in Construction*

[OutDet: an algorithm for extracting the outer surfaces of building information models for integration with geographic information systems](#)

Zhou, X. , Zhao, J. , Wang, J.
(2019) *International Journal of Geographical Information Science*

[Integration of BIM and GIS in sustainable built environment: A review and bibliometric analysis](#)

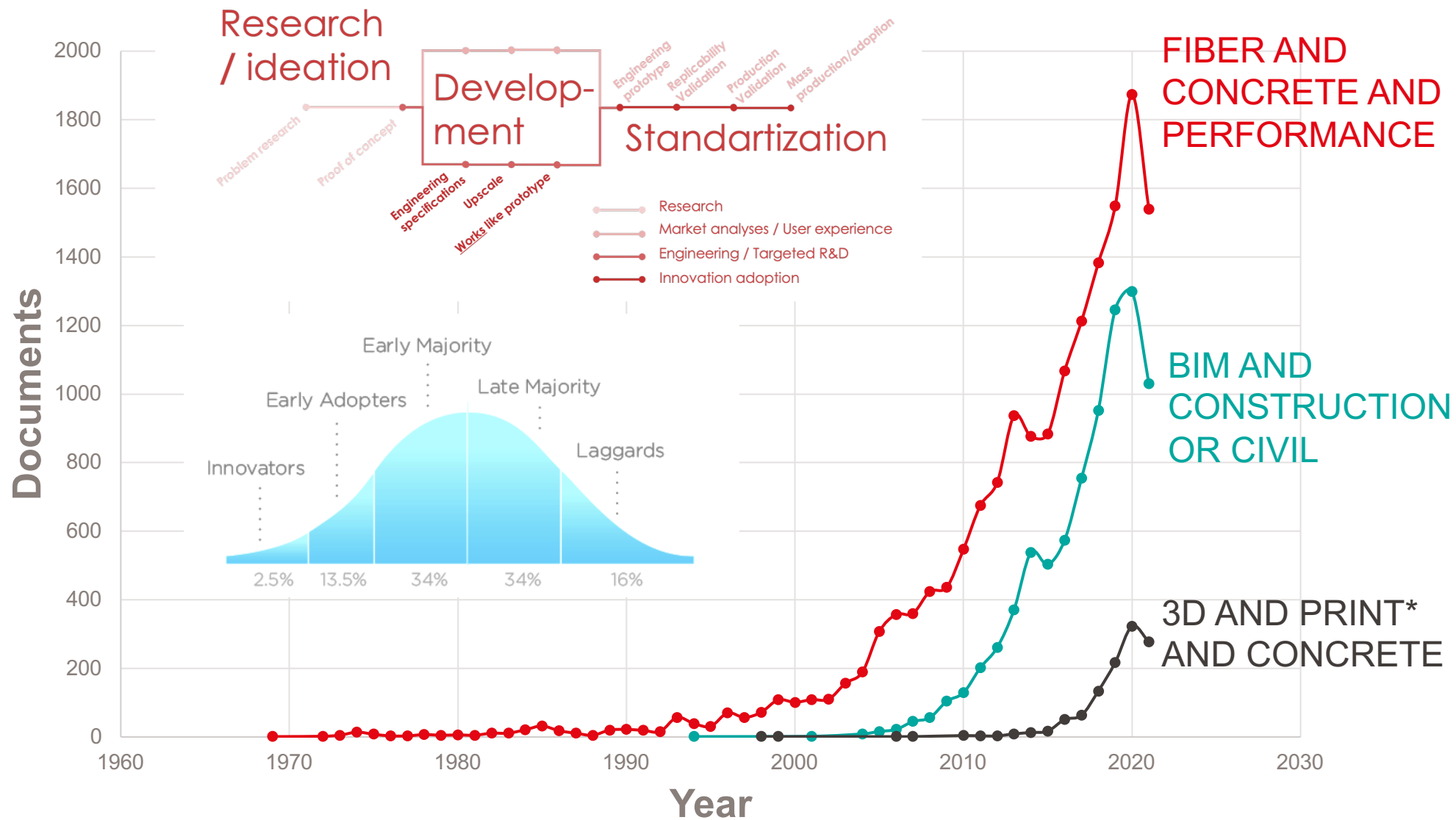
Wang, H. , Pan, Y. , Luo, X.
(2019) *Automation in Construction*

Choose a vertical

Innovation for construction and the environment course code: CIVIL-424 Program of Week 14-18/12/2020	
Indicative Title	
Monitoring and management of air quality and emissions from construction sites	
LiDAR-based tunneling operations and monitoring	
BIM-based secondary raw materials database	
On the use of recycled plastics in construction	
Alternatives for targeted monitoring of various ageing infrastructures	
Dam Safety through structural health monitoring	
Novel nozzle for 3D printed reinforced concrete	
Wind-powered built environments	
FRC-based paraseismic reinforcements	
Optimization of energy consumption in buildings via hardware-software innovation	
Futuristic pavements for urban zones	
Temporary and modular critical infrastructures	

EPFL Innovation for construction and the environment course code: CIVIL-424 Program of Week 11/12/2023	
TITLE	
SmartRefurb	
Circular Design for Demolition and Deconstruction	
Heat pumps & photovoltaics	
Advancing Moon and Mars explorations with innovative 3D printing	
Biorock	
Evolving Concrete: Innovative Strategies for Enhancing Reuse and Recycling	
Smart Drone-Based system For Automatic Accident Monitoring	

Innovation for construction and the environment course code: CIVIL-424 Program of Week 12-16/12/2022	
Indicative Title	
Automated excavation	
Solar farms on Dams	
Recycled concrete and its innovations in civil engineering	
Low CO2 clinker fabrications	
WIM - Waste Information Modeling	
Next-gen road and pavement construction	
Implementing LCA tools in BIM softwares	
Global Environmental cost of construction sites	
Use of incinerator bottom ash (IBA) in combination with bio-concrete in construction	



Search for examples, trends and opportunities

- www.scopus.com (literature database)
- www.espacenet.com (patent documents)
- www.crunchbase.com (Discover innovative companies and the people behind them)

McKinsey&Company

MCKINSEY GLOBAL INSTITUTE

REINVENTING CONSTRUCTION: A ROUTE TO HIGHER PRODUCTIVITY

FEBRUARY 2017

IN COLLABORATION WITH
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EXECUTIVE SUMMARY

Reports by McKinsey&Co

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