

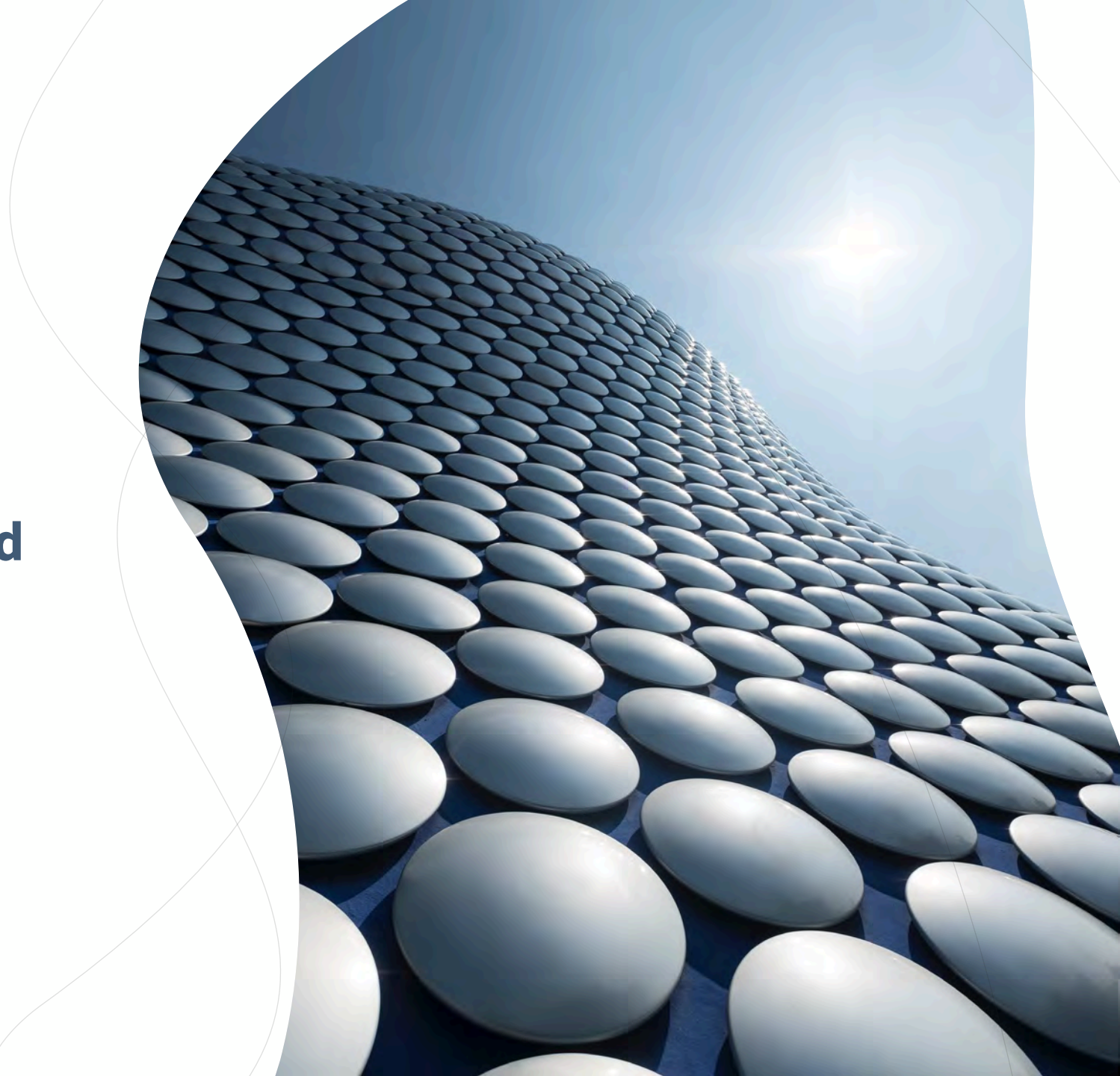
# Module: Digital Architecture

## Week 2

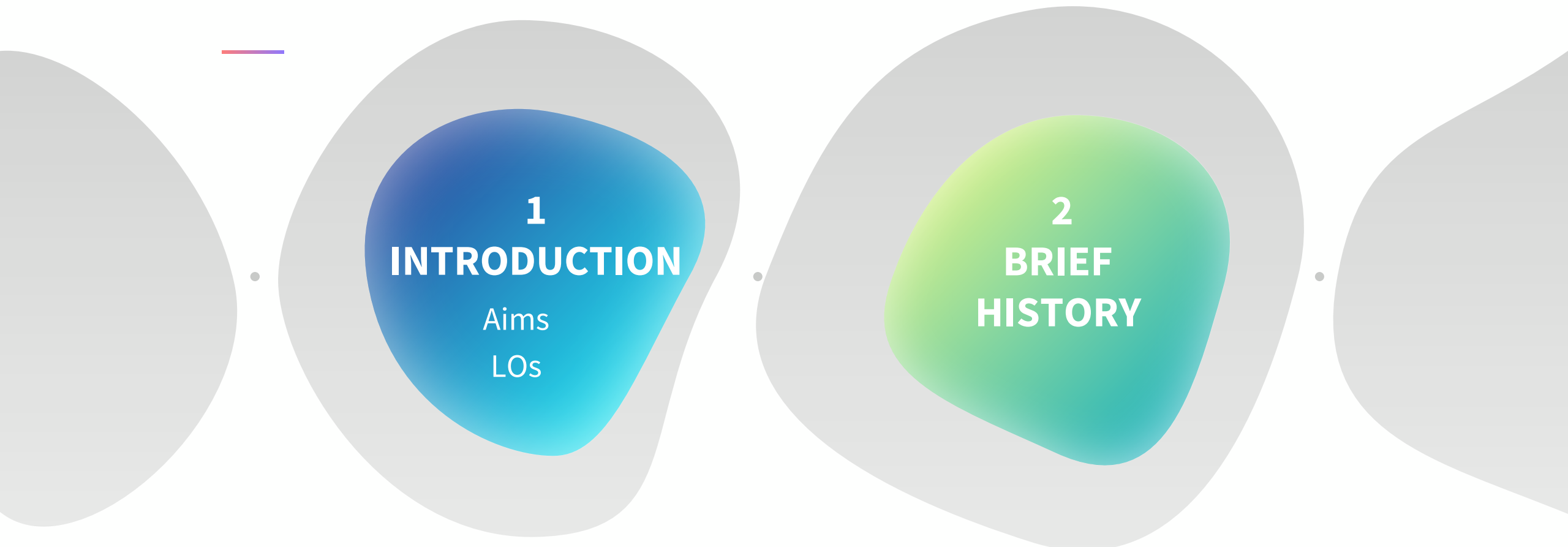
### Historical background and current debate

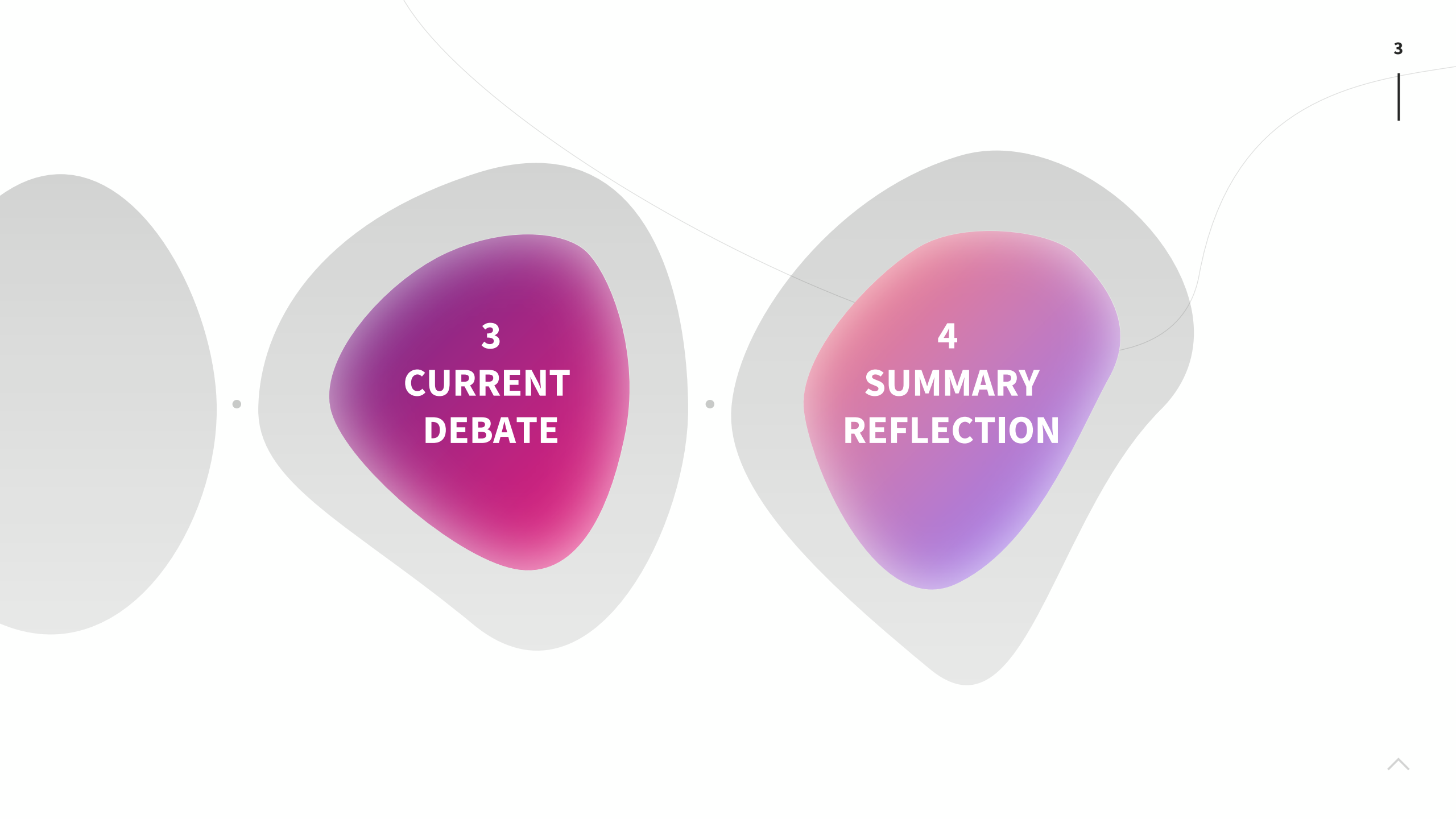
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In the second week we will be looking at the prominent historical events which define this emergent field of computational design.



# Outline





# Aims and objectives

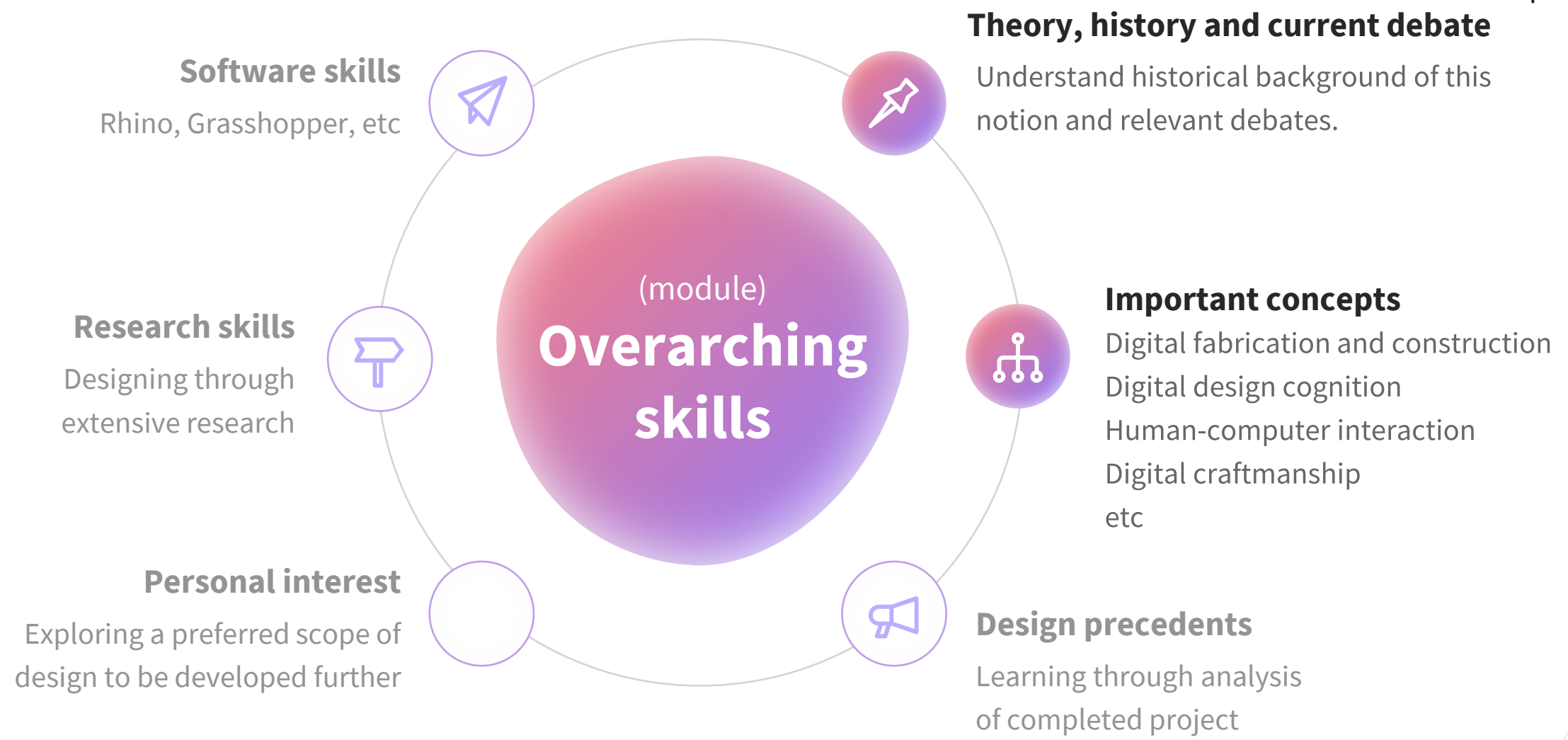
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- To expand **historical background** of this design field.
- To enumerate **current debates**.
- To elicit **key events** related to computational design.
- To enumerate **key concepts** related to development of the fields, in relation with the timeline.

# Learning outcomes

*Students will be able to..*

- 01** Draw **lessons** from historical perspective of the development.  
—
- 02** Iterate **personal stances** on how digital tools are used in designing.  
—
- 03** Become aware of the **current debates**.



# What do we gain from looking back at history?

---

**Crucial understanding what's at stake when designing with computers**

**Looking backward to look to the future**



# Week 1 reflection, from your submissions



Louise F18511012 · 2 days ago

Disqus

1. What are major changes in terms of ways architects think?

With time everything evolves just like designs, everyone is looking for the next best thing, not only in architecture, to make things better and alot more applying to latest culture and technology. Architects of today are working on ways on making buildings go GREEN, a more eco friendly structure. I've also noticed our architecture of today, if I may boldly quote Zaha Hadid "I dont think that architecture is only about shelter. it should be able to excite you, to calm you, to make you think." I feel architects of today put a lot more creative and almost gravity defying ideas. As architects we see a problem and solve it, and with time we solve it better and better with a lot more mind blowing ideas. thats my thoughts on how architects changed.

2. What did you know about digital architecture which previously you didn't know?

As a general as the word is, I thought of digitals being computerized work, the likes of AutoCAD, Revit and many others, I had the basic understanding to Digital, the normal 0 and 1's not coding ofcourse but just sketches done more accurately on a PC. And making life easier for people from around the world to work on the project without having to ship off a hardcopy.

^ | ~ - Reply - Share >



Dikra Sakhi · 5 days ago

Week1-Dikra-F18511013

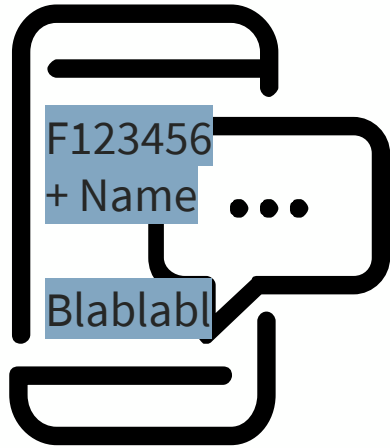
I think the biggest change in the way architects think make and design is technology, because the way architecture has changed over time provides fascinating insight into the evolution of humanity from industrial influence to technological advancement. i think that the biggest impact on architecture in recent years has been the availability of technology, such as computer programming and software. This enables increasingly ambitious projects, from ecological structures to those that seem to defy gravity. I see that in today's new construction methods often involve innovative materials and unusual aesthetics. The first application I learned was AutoCAD at the beginning, it was then Sketchup, but now using ArchiCAD after being discovered, it is the one that I use in my projects the most because it is easier, more accurate, and simpler for me. In this week's lecture, I am very pleased to discover two important applications that I have not heard of before, except that they are grasshopper and rhino. I am excited to learn more about these two apps and use them in my future projects.

^ | ~ - Reply - Share >





# Discussion



D1. Reflect on 'Man-Computer Symbiosis' write-up by Licklider in 1960 (see supporting materials). As per the year of 2022, to what extent did the anticipated symbiosis come true?

D2. What are the key factors of the occurred changes from one decade to the next decade?

<https://miatedjosaputro.com/2022/03/02/dg-week-2-2/>



# Historical background



# How architecture practice was



# Timeline: key events

- Third Industrial Revolution, or referred as “Digital Revolution”



## 1960s

- Utopian thinking
- The Fun Palace project and other utopian thinking projects
- Sketchpad by Ivan Sutherland
- Remote Reality

## 1970s

- Proto-parametricists
- Mark Burry on Gaudi’s models of Sagrada Familia
- The Generator project
- First personal computers became available by the end of 70s

# Timeline: key events

## 1980s

- Autodesk AutoCAD was released in 1982
- Architects began to investigate other forms of experimental practice, from other fields such as aeronautical and automobile.
- Digital tools enabled architects to rationalise form
- Cyberpunk



# Timeline: key events

- First digital turn (Mario Carpo)
- Digital design and fabrication
- Digital mass customization
- The “blob” style

## 1990s

- “Folding in Architecture” in 1993
- “Technological constructions”
- Guggenheim Bilbao as celebrated turning point in architecture, “Bilbao effect”
- Rhinoceros 3D was released in 1992

# Timeline: key events

- Grasshopper was released
- Augmenting reality
- First digital fabrication projects

## 2000s

- Digital design as discipline
- Theoretical body for “digital design”
- Authors such as: Rivka Oxman, Kostas Terzidis, and Toni Kotnik
- Programmed Wall (2006), first successful use of robotic arm to achieve complex curvature

# Timeline: key events

- Larger scale of digital fabrication
- Wiki House
- “Cyber-physical approach”
- “Big Data” revolution
- The “discrete” approach

## 2010s

- Key concepts started to be formalised:
  - Digital architecture
  - Digital tools
  - Algorithmic design
  - Parametric design
  - Generative design
- Second digital turn (Mario Carpo)
- Fourth Industrial Revolution (4IR)





## PRIOR TO 1960s

---

Mario Carpo mentioned that the digital can be traced back to Renaissance era. He illustrates that 3D scanning can be traced back to the development of reproduction and representation since the Renaissance [1].

Antoni Gaudi worked computationally but in analogue way on his **Sagrada Familia** models (1882-1926),

Luigi Moretti, an Italian Architect appeared to be the first to have formulated the concept of **Parametric Architecture** in 1940.

[1] Artforum (2017). Mario Carpo on the Rise of 3-D Technology.  
<https://www.artforum.com/video/mario-carpo-on-the-rise-of-3-d-technology-66940>

## PRIOR TO 1960s

---

In addition, the development of the field is also originated from the birth of computer science in 1920. Pioneers such as **Alan Turing** and **John Von Neumann** are to thank for. In architecture, the concepts of *computing* and *informatics* started to be considered in the **beginning of 1960s**.

# Circa 1960

## About

This exciting area was imagined with a collaboration of man and machine. Utopian thinking encouraged the intellectual experiments by imagining futuristic architecture.



# In computer science

“Man-computer Symbiosis”  
In 1960.

## MAN-COMPUTER SYMBIOSIS



The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today.

—J.C.R. Licklider  
Man-Computer Symbiosis

## Pioneer “Man-computer Symbiosis” in architecture

### Gordon Pask

Pask, G. (1969). The architectural relevance of cybernetics. *Architectural Design*, 39, 494-496.

Common philosophy of architecture and cybernetics.

*Cybernetics: theory that all behaviour (human and machine) is part of a system of feedback loops, includes inputs and outputs. First defined by Norbert Wiener in his book (1947).*

## Utopian thinking and projects

**Utopian spirit** of 60s encourages “intellectual experiments”.

Architects did not possess knowledge in technology or have the technology  
Nor opportunity to put them in practice.

Computing becomes a common ground for **reflections** and **theoretical thinking**.  
Later Frazer (2005) highlighted it as “computing without computers”.

# “Intellectual experiment”

## Fun Palace (1958-1964)

Cedric Price and Joan Littlewood

*“The fun palace was not a building in any conventional sense, but was a socially interactive machine, highly adaptable to the shifting cultural and social conditions.” \**

A model for the 1976 Centre Pompidou

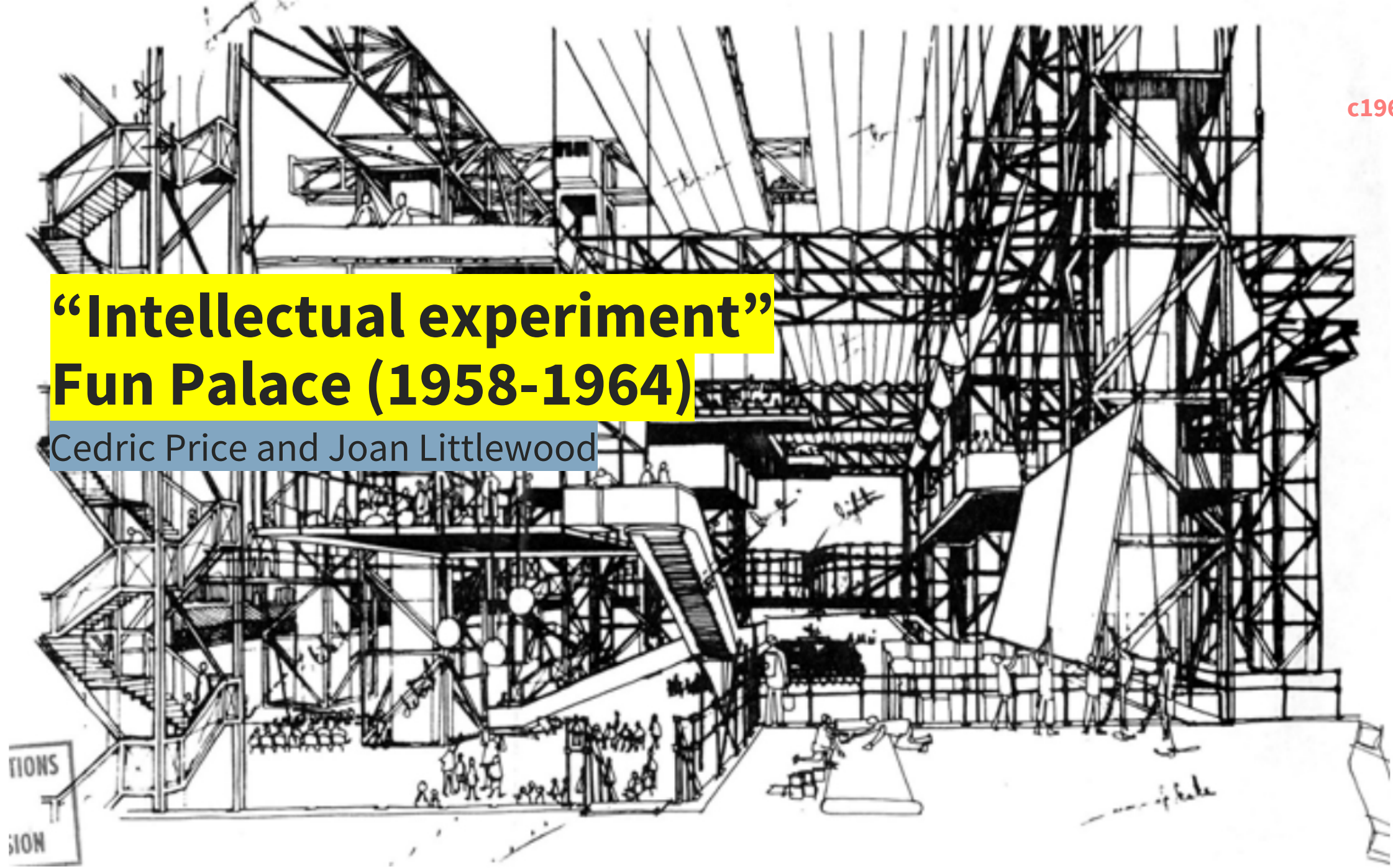
\*Mathews, S. (2005). The Fun Palace: Cedric Price’s experiment in architecture and technology. *Technoetic Arts*, 3, 73-92.



c1960

# “Intellectual experiment” Fun Palace (1958-1964)

Cedric Price and Joan Littlewood





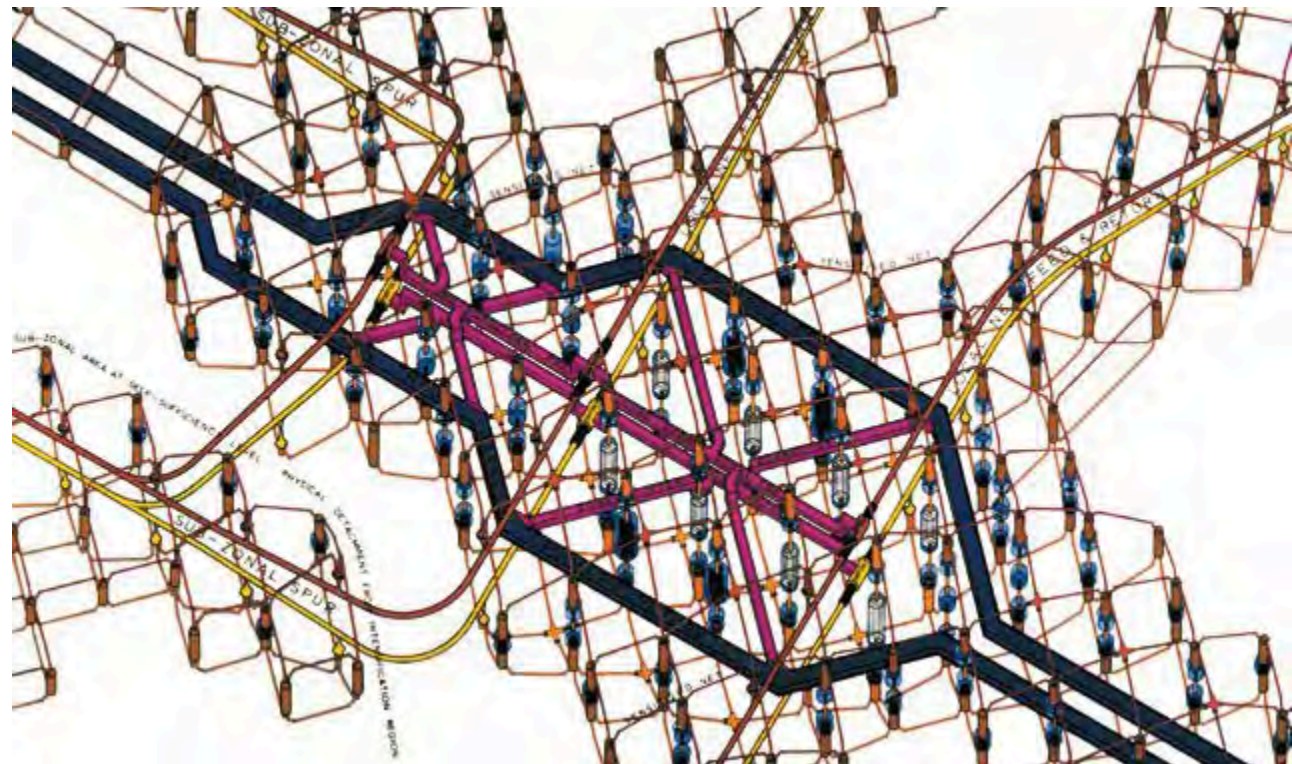
# “Intellectual experiment”

## Computer City (1964)

Dennis Crompton, Archigram

A system of sensors and electronic devices interconnected for the monitoring, control and management of different processes and activities that takes place in the urban environment.

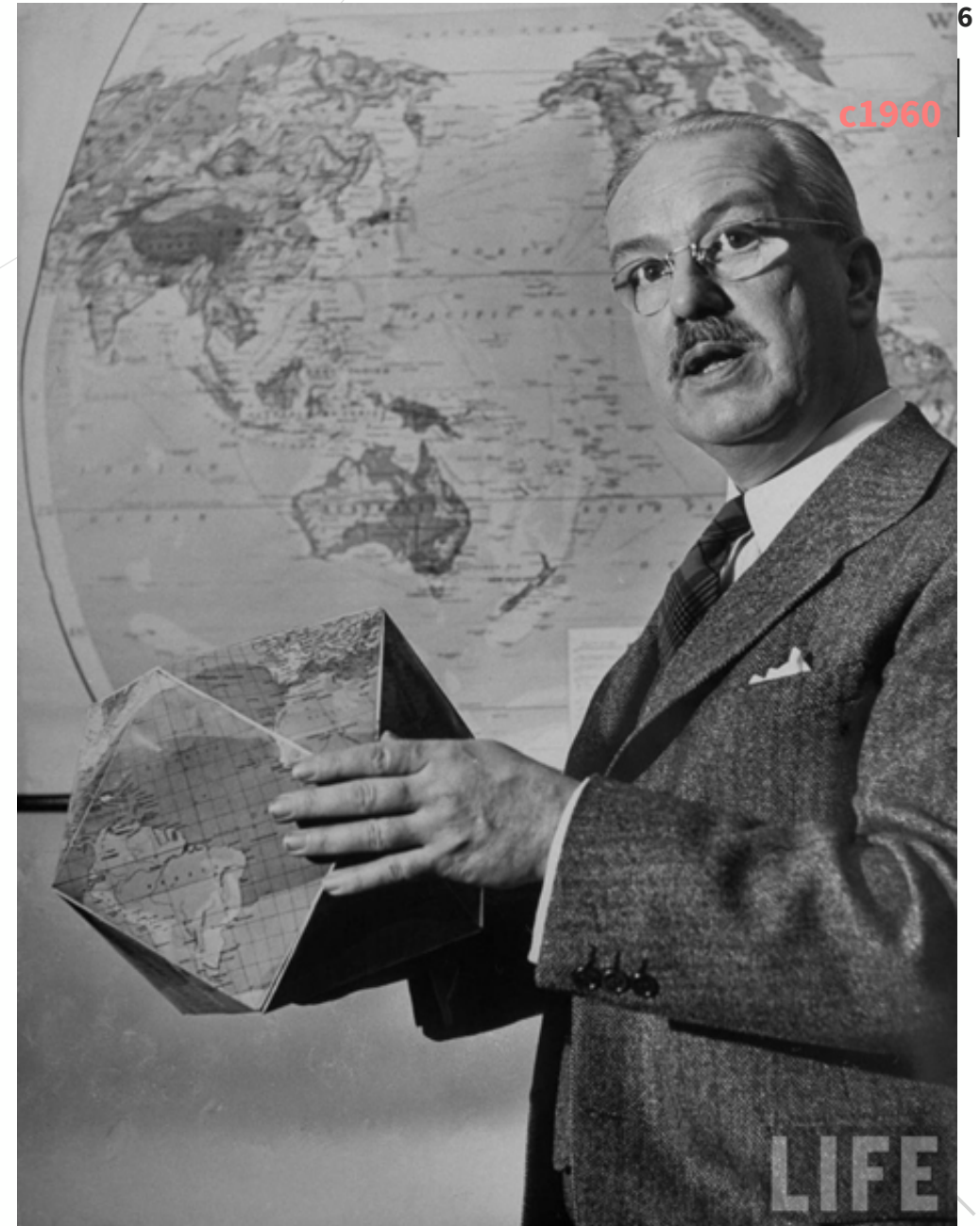
Source: Archigram Archives  
<https://www.archigram.net/portfolio.html>



# “Intellectual experiment” World Game (1967)

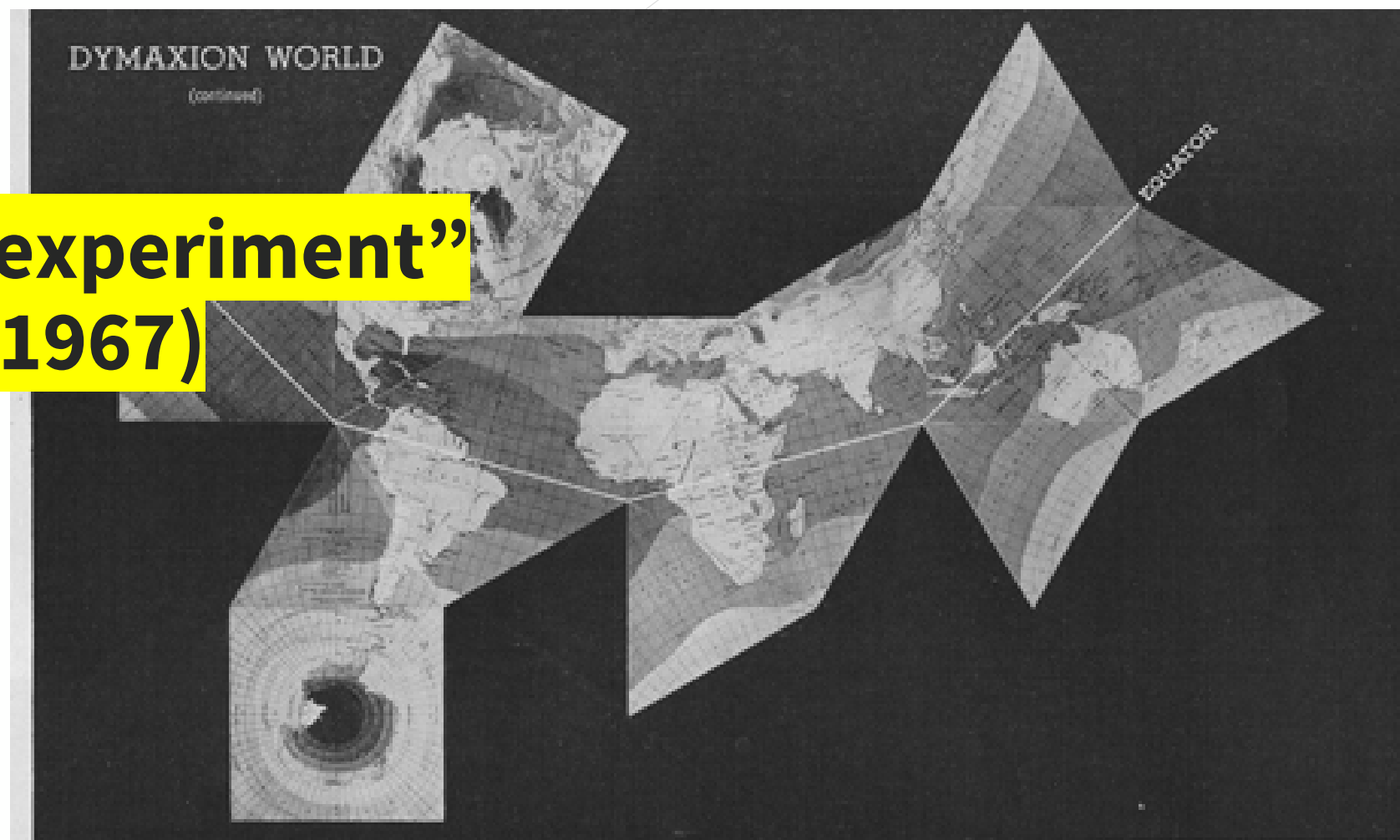
Buckminster Fuller

First considered in 1954. Dymaxion World embodies his effort to resolve the dilemma of how to depict a flat surface this spherical world. Officially presented at the “World Design Science Conference” in 1967.



# “Intellectual experiment” World Game (1967)

Buckminster Fuller



## MERCATOR WORLD

Here the tiles are laid in a pattern that approaches the familiar appearance of the Mercator projection. The equator is a continuous line, orienting the world east to west. Not shown on the true Mercator are the poles,

which appear here. The Mercator is still the best and standard base map of navigation, but its perspective is that of the 16th, not the 20th Century.

This Dymaxion map approximation of the Mercator projection brings character of the Renaissance world into bold relief. Most striking is the vast expanse of

ocean, the world's highway. Through a few hardy explorers hunted a Northwest Passage, the course of empire and trade was southward along the coast of South America and eastward around Good Hope into the Orient. It was in this period that the Dutch cartographers and Papal fiat divided the world in hemispheres,

# Sketchpad (1963)

Ivan Sutherland

Pioneering:  
Computer Graphics and  
Computer Aided Design  
<https://youtu.be/5RyU50qbvzQ>

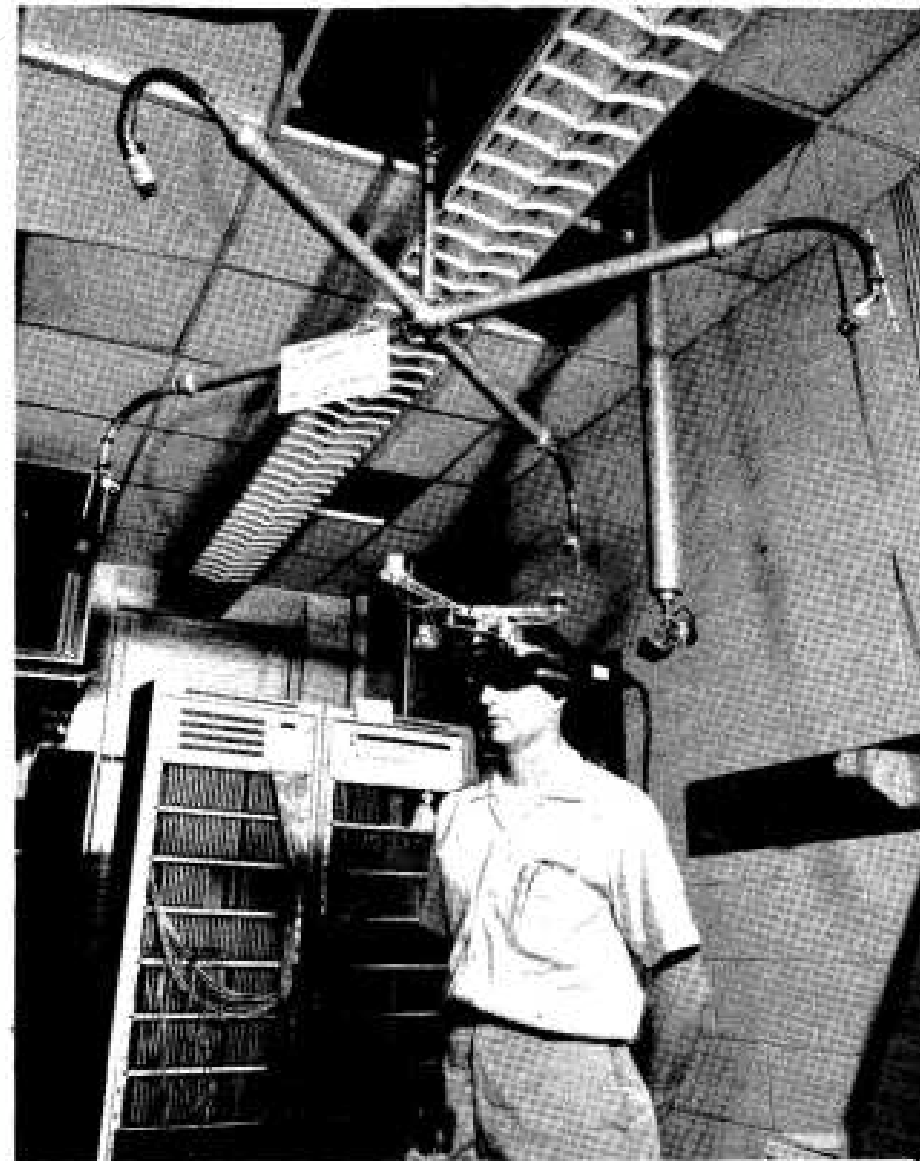


## Remote Reality (1966)

Ivan Sutherland and  
Bob Sproull

Pioneering:  
Virtual Reality,  
Although the name was  
not invented by them

<https://www.i-programmer.info/history/people/329-ivan-sutherland.html?start=1>



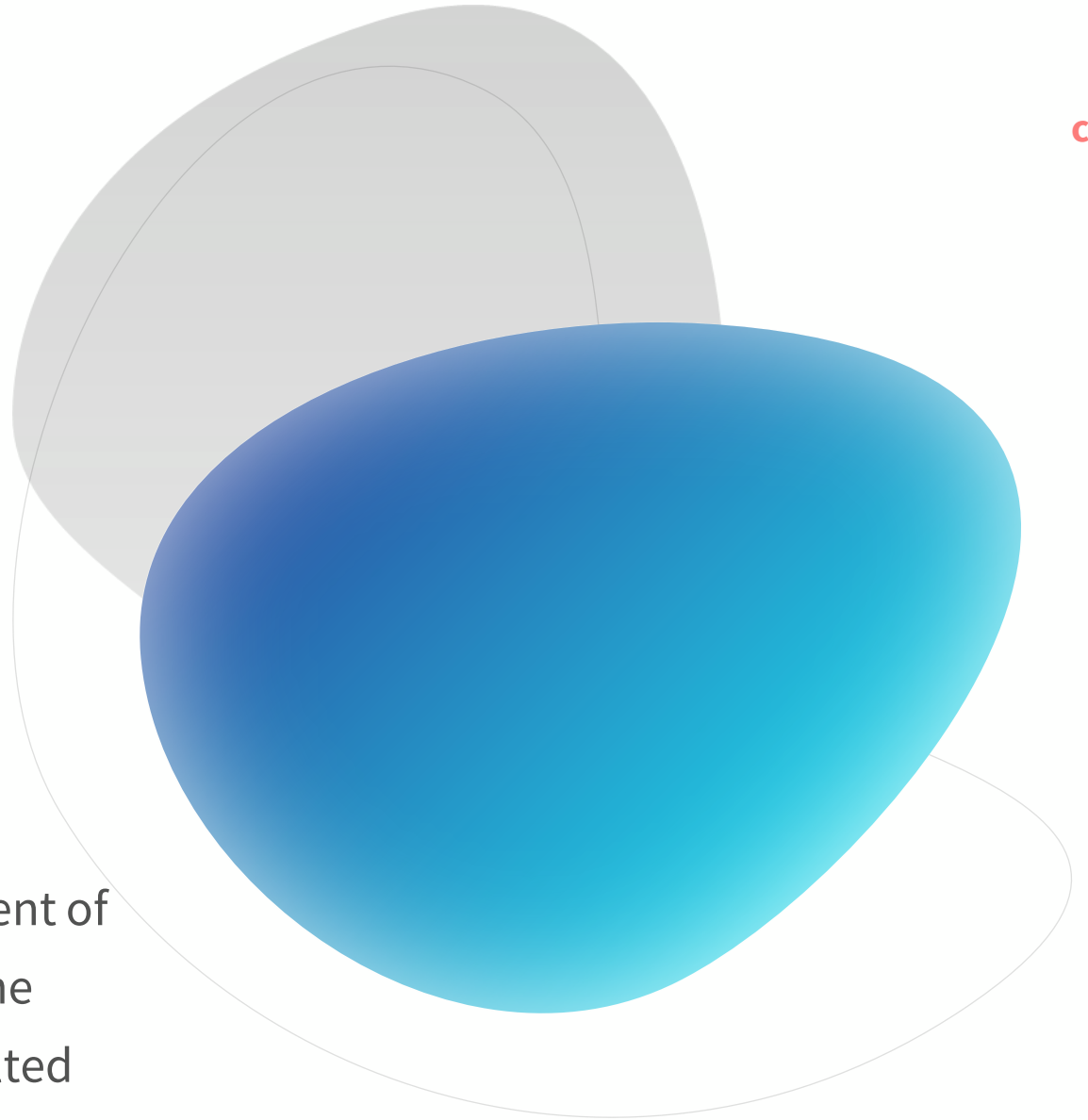
**“How It’s Made”  
Fred Scott (1968)**

**Highlights resistance  
of architectural  
discipline to assimilate  
new technology.**

# Circa 1970

## About

The era focused on mainly development of technological tools. On other hand, the vast development of technology resulted in disconnection between technology and reality.



# Pioneers “Man-computer Symbiosis” in architecture

## Nicholas Negroponte

Computer being the true work partner

A machine capable of interacting with architect  
“Architecture Machine Group” at MIT in 1973





# Proto-parametricists

Access to design technologies was not possible.  
The use of **morphogenetic thinking** in analogue way.  
Proto-parametricists means: using analogue means to compute using parameters.

# Proto-parametricists: Munich Olympic Stadium (1972) Frei Otto

Used complex physical model to analyse, understand, document and compute how these structures were formed and performed. Photographed by precision cameras.

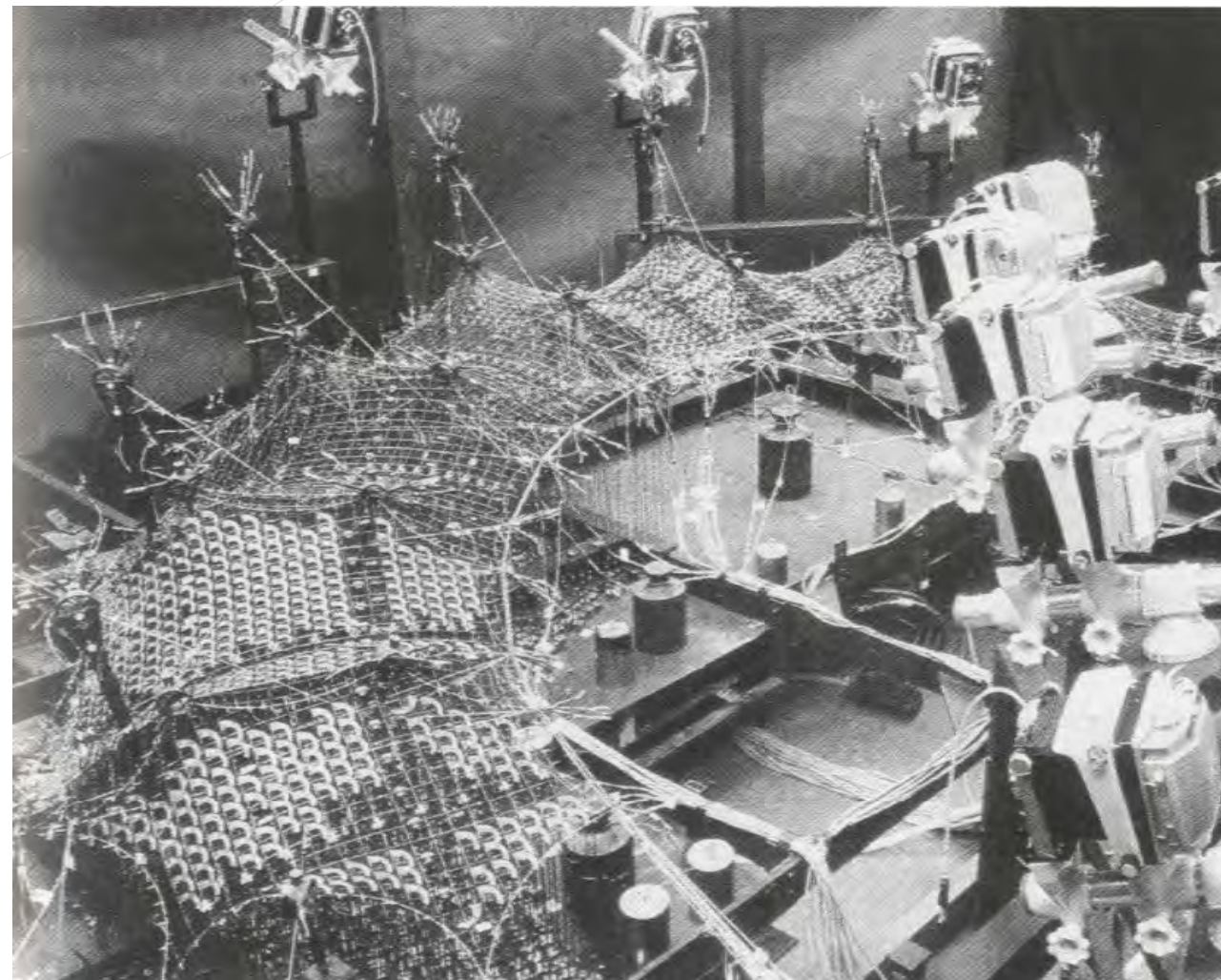


Image source: <https://iam.tugraz.at/workshop14s/2014/03/24/munich-stadium-roofs-by-frei-otto-gunther-behnisch/>

# Personal computer became available to public (1975)

**1976**

Apple I was launched  
First word processing program  
5.25" floppy drive



# The Generator (1976-1979)

**Cedric Price**

**John and Julia Frazer**

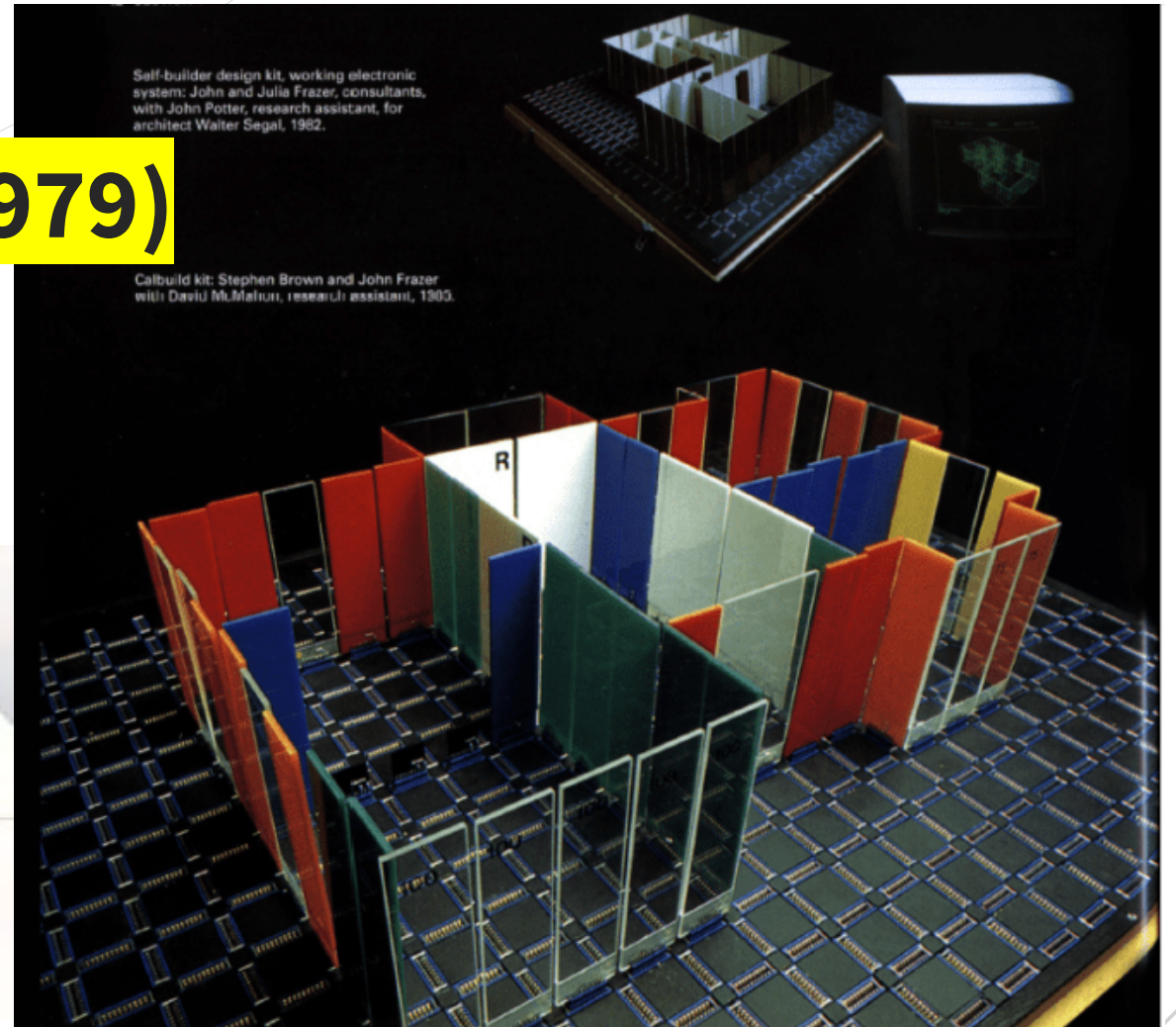
(unbuilt)

Sought to create conditions for shifting, changing personal interactions in a reconfigurable and responsive architecture project.

Notably first intelligent building project

# The Generator (1976-1979)

Cedric Price  
John and Julia Frazer  
(unbuilt)



# Sagrada Familia

## Antoni Gaudi

**In 1979, Mark Burry continued the project.**

**Translated complex geometries from Gaudi's plaster models into workable design**



# Circa 1980

## About

With the economic downturn in mid-1970s and 1980s, architects had to recalibrate the way they practiced. Utilisation of tools borrowed from shipbuilding, aeronautical and automobile industries transformed design practice.



# AutoCAD 1.0 (Release 1) 1982

Sold on floppy disks

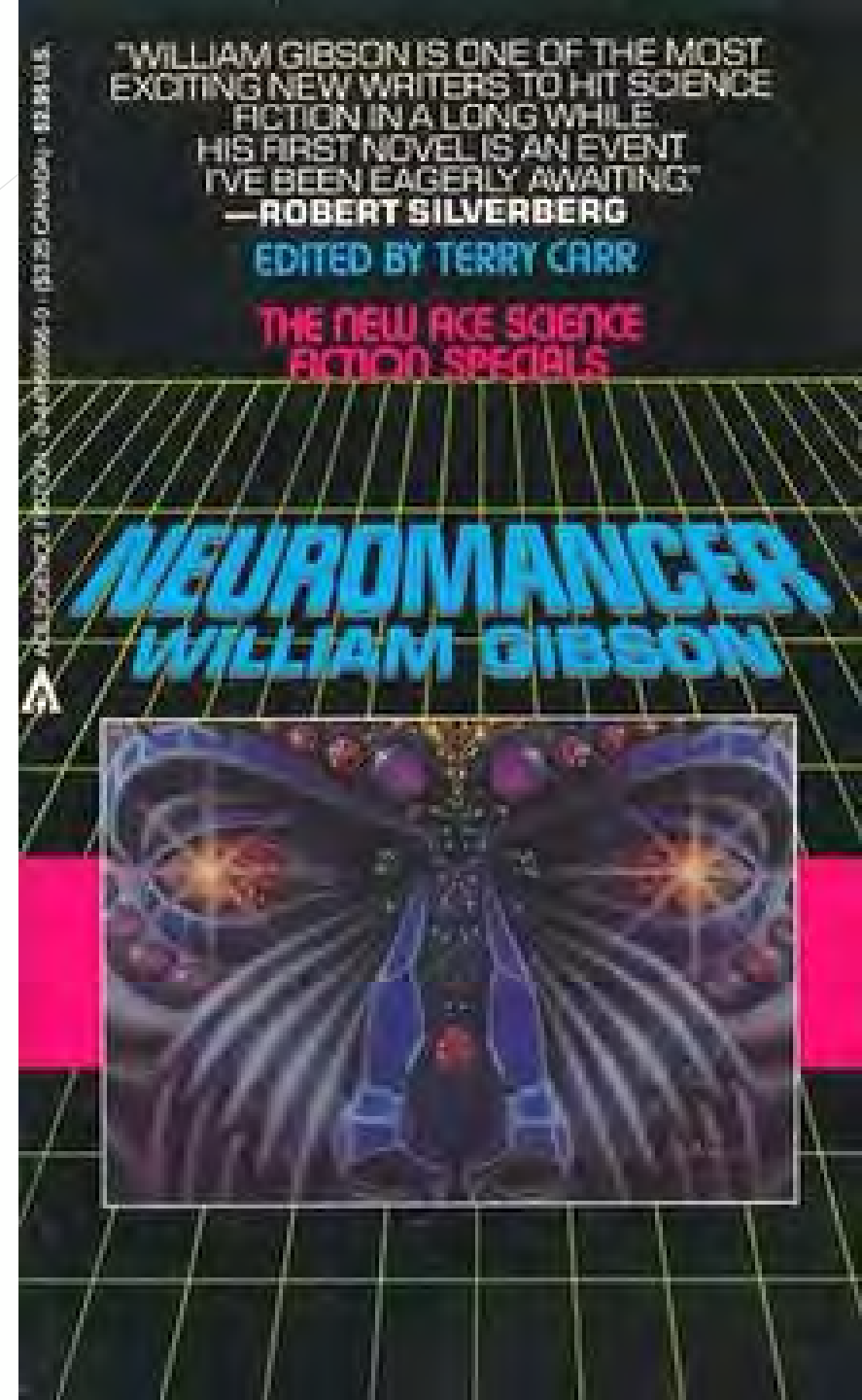




# Cyberspace

“Neuromancer” by  
William Gibson (1984)

Cyberpunk: science  
fiction genre



**Influences from other fields, with CAD exposure.**

**Architects were able to achieve 3D, complex, variable curves using spline instead of 2D lines**

**Architecture firms:  
GregLynn FORM  
FOA  
NOX**



# Peter Eisenman

## Biocenter (1987)

### Frankfurt

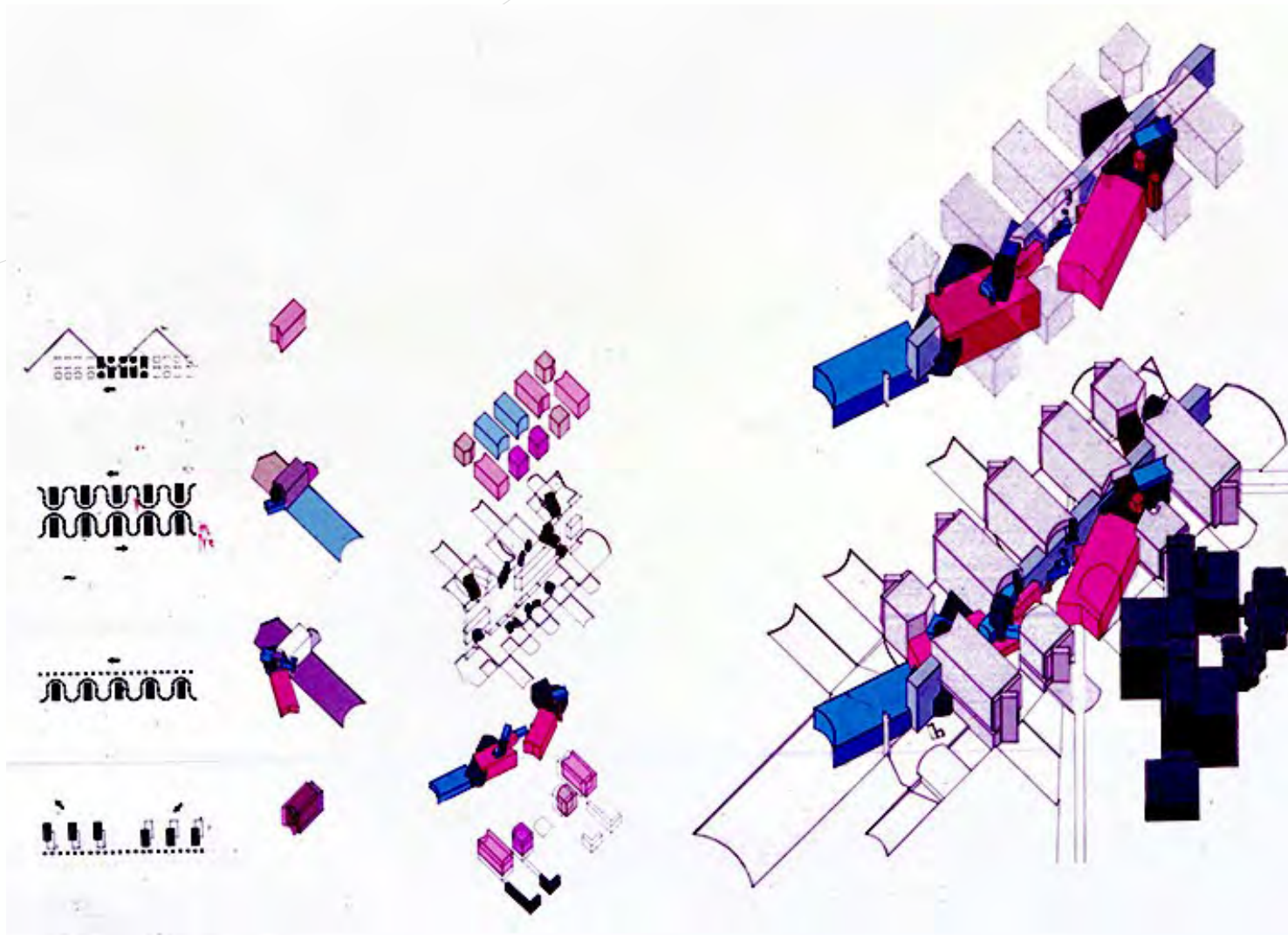
Characterised by manipulation of blocks and grids, generated through abstract steps of operations.

First projects to use computer to code design outputs.



# Peter Eisenman Biocenter (1987) Frankfurt

Symbolising DNA  
process of replication,  
transcription and  
translation.



# Frank Gehry

## Lewis House (1985-1995)

Unbuilt

Physical model → captured in 3D model → physical model produced from 3D model → modified with analogue, intuitive model making → scanned using 3D scanner to further inform digital model\*.



## **Frank Gehry**

**An interface in CATIA software developed by Gehry Technologies.**

**Now called Digital Project, BIM software.**

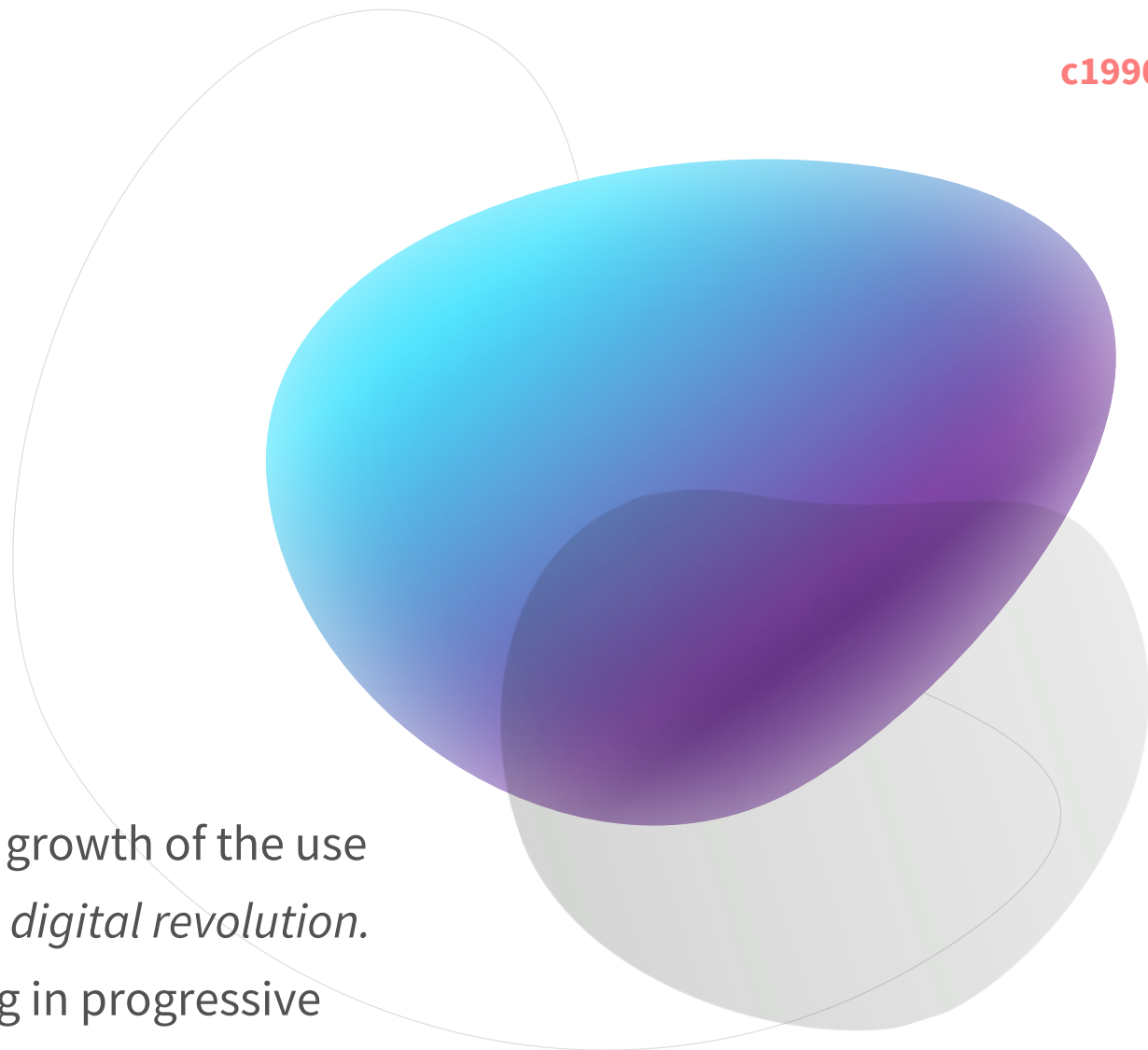
# Circa 1990

c1990

## About

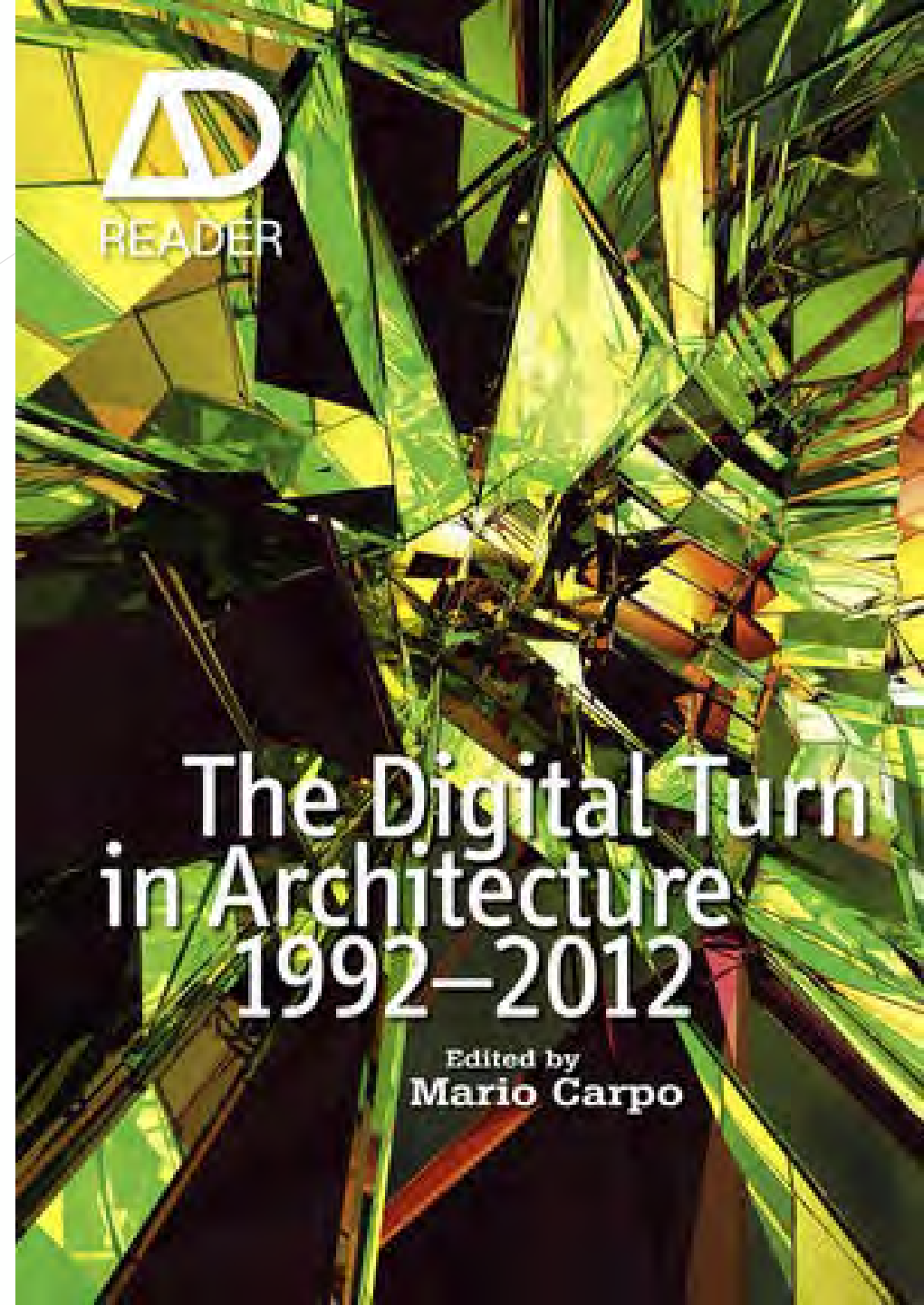


The 1990s showed an unprecedented growth of the use of digital design tools, what we called *digital revolution*. Advances in microprocessors resulting in progressive deduction of computer technology. And in turn become more accessible.



# The first digital turn According to Mario Carpo

Emergence of new digital tectonics parallel with development of **spline modellers**. It allows manipulation of curved lines directly on screen, using graphic interfaces.\*





# Digital design and fabrication

First generation of digitally intelligent designers had idea that, digital design and fabrication should do something else, something that industrial assembly lines do not do.\*

*Carpo, M. (2017). The second digital turn: design beyond intelligence, MIT press.*

Digital fabrication does not utilise mechanical matrixes, casts, stamps, molds or dies. No need to reuse them to reduce their cost. Making digital copies will not make them cheaper.

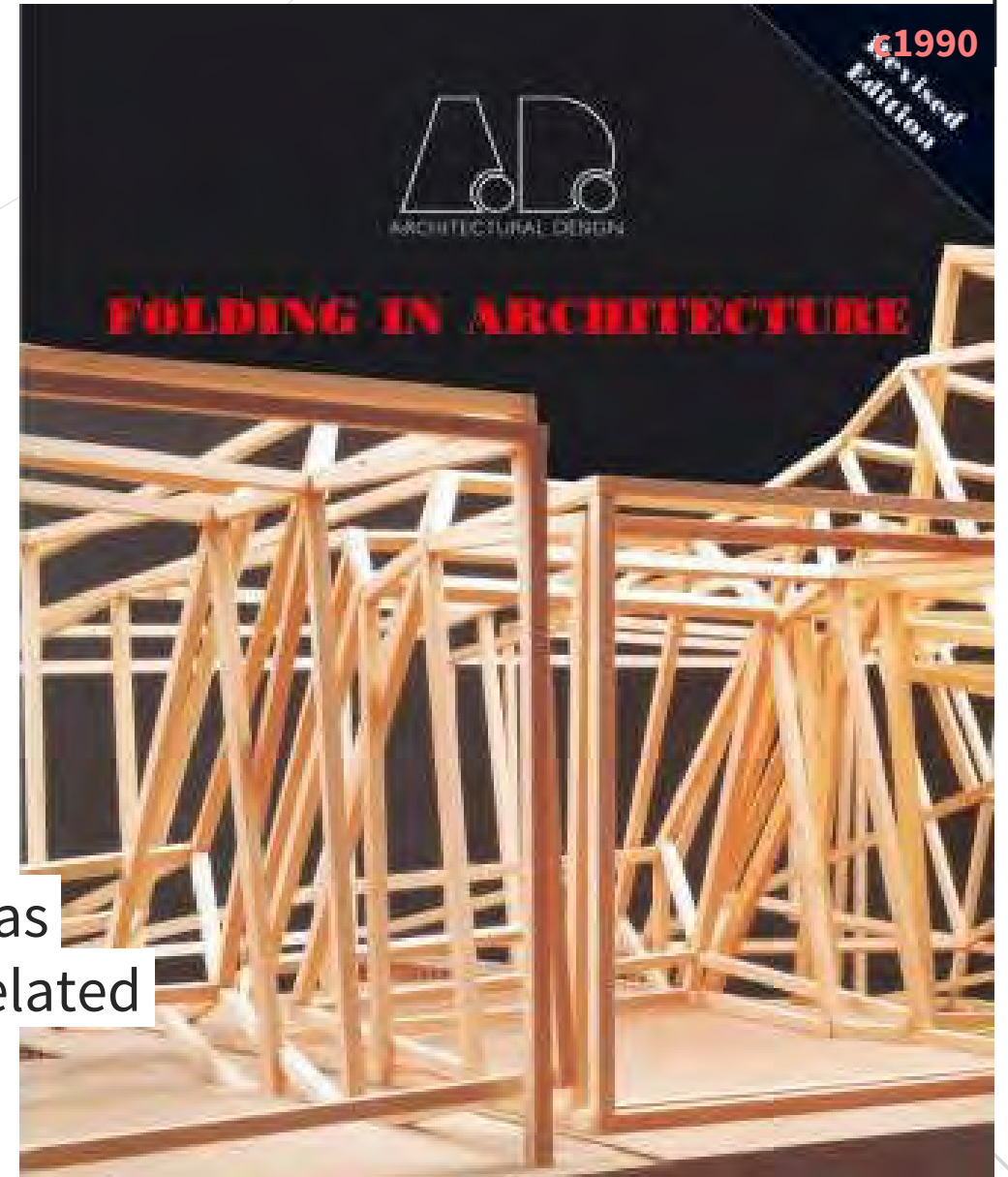
Each item can be different, at no additional cost → **Digital mass customisation** ^

# Folding in Architecture\*

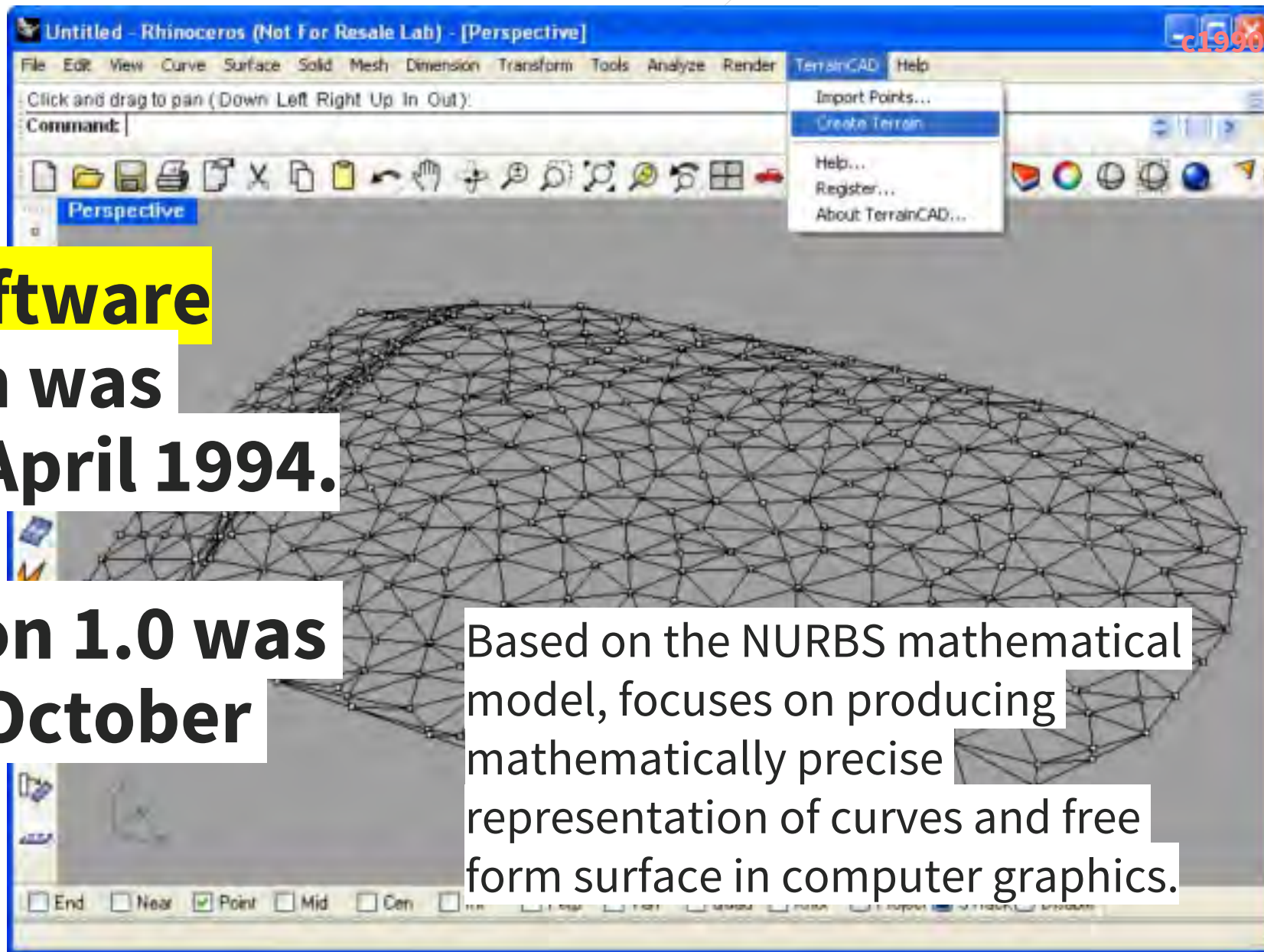
Greg Lynn

## Edited Architectural Design issue

First time that an entire issue of magazine was specially include architecture exploration, related to embodiment of new digital technologies



Lynn, G. (1993). *Folding in architecture*, Academy Editions Limited.



**Rhino 3D software  
Beta version was  
released in April 1994.**

**Rhino version 1.0 was  
released in October  
1998**

Based on the NURBS mathematical model, focuses on producing mathematically precise representation of curves and free form surface in computer graphics.

# The BLOb (Binary Large Objects) style 1995

Greg Lynn

**Style of spline or of digital streamlining**

Curving and non-Euclidean geometries  
Digitally-generated realisations of flows and forces, what Lynn refers as *animate form*.

# The BLOb (Binary Large Objects) style 1997-2001

## Embryological House

Moving from modernist idea of a form based on modules to form based (with potentially unlimited iterations) derived from basic form or primitive.

The House was developed using animation software (Microstation and Maya) and digitally-generated physical model. It was most completely designed in digital form. ^

# The BLOb (Binary Large Objects) style 1997-2001

## Embryological House



<https://www.docam.ca/conservation/embryological-house/GL3ArchSig.html>

**The BLOb (Binary  
Large Objects) style**

**Fresh Water Pavilion  
By Nox Architects  
1998**



# Guggenheim Museum, Bilbao Frank Gehry (1997)

Ground breaking digital tools and its socioeconomic factor, museum's expressive architectural form contributed to regeneration of the area. **The Bilbao Effect.**

It is celebrated as **turning point in architecture**, due to the fact that it was not possible to build without the use of CAD (computer-aided design) software, Digital Project.





# Guggenheim Museum, Bilbao Frank Gehry (1997)

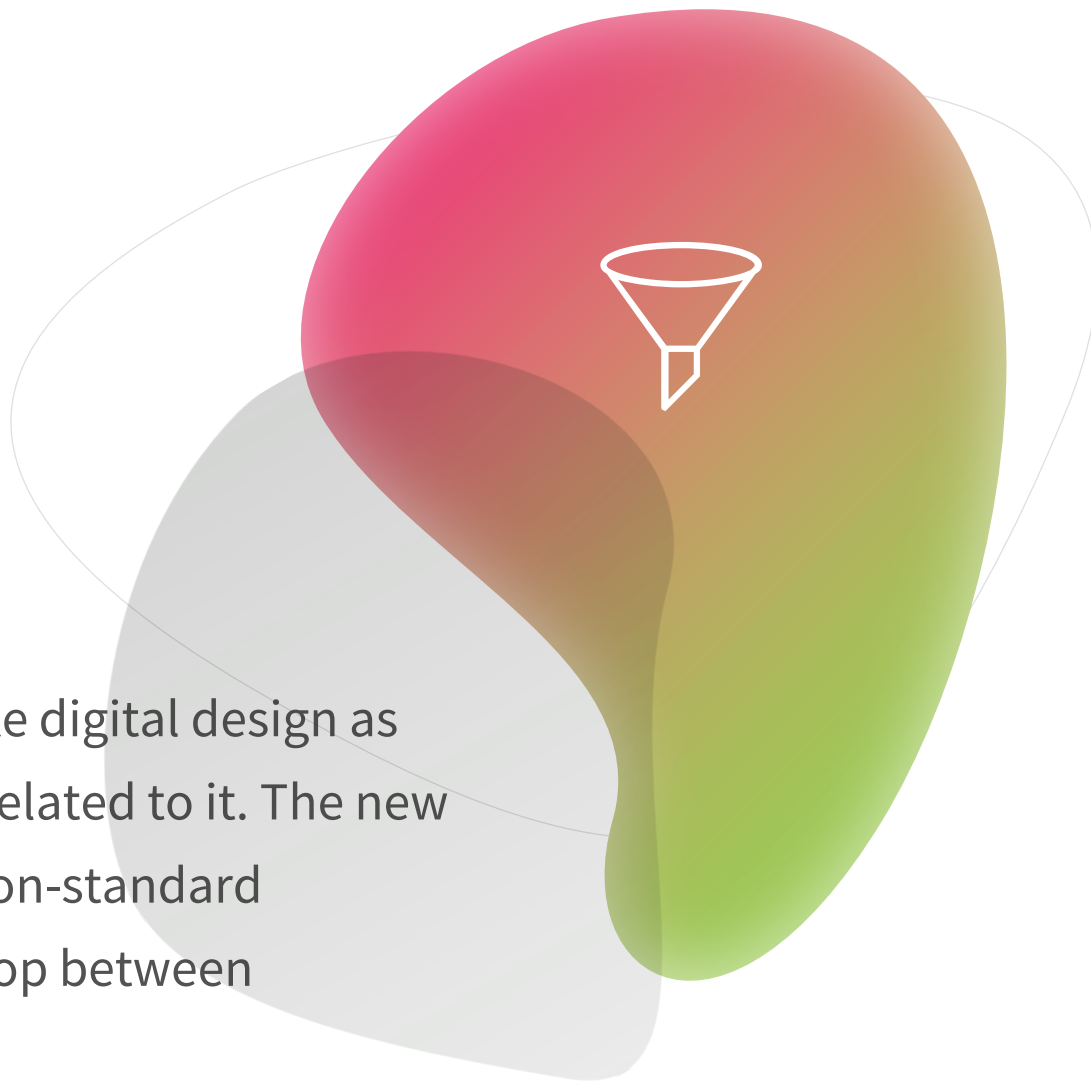
Frank Gehry is considered as a pioneer in “**technological constructions**”, a technology that’s widely used as parametric design tools and BIM today.



# Circa 2000

## About

The 2000s marks the urge to make digital design as discipline and building theories related to it. The new concept is based on two ideas: non-standard architecture and the feedback loop between architecture and digitality.



“

“In the 1980s and 1990s, the computer maintained a cult status; It divided the architecture between **believers and skeptics**, a world of prophets, disciples and enthusiastic converts (...) Today the computer is not a new technology that **must be celebrated or deconstructed**, it is a simple fact ”.

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**Stan Allen (2009)** cited in Arteta (2017)

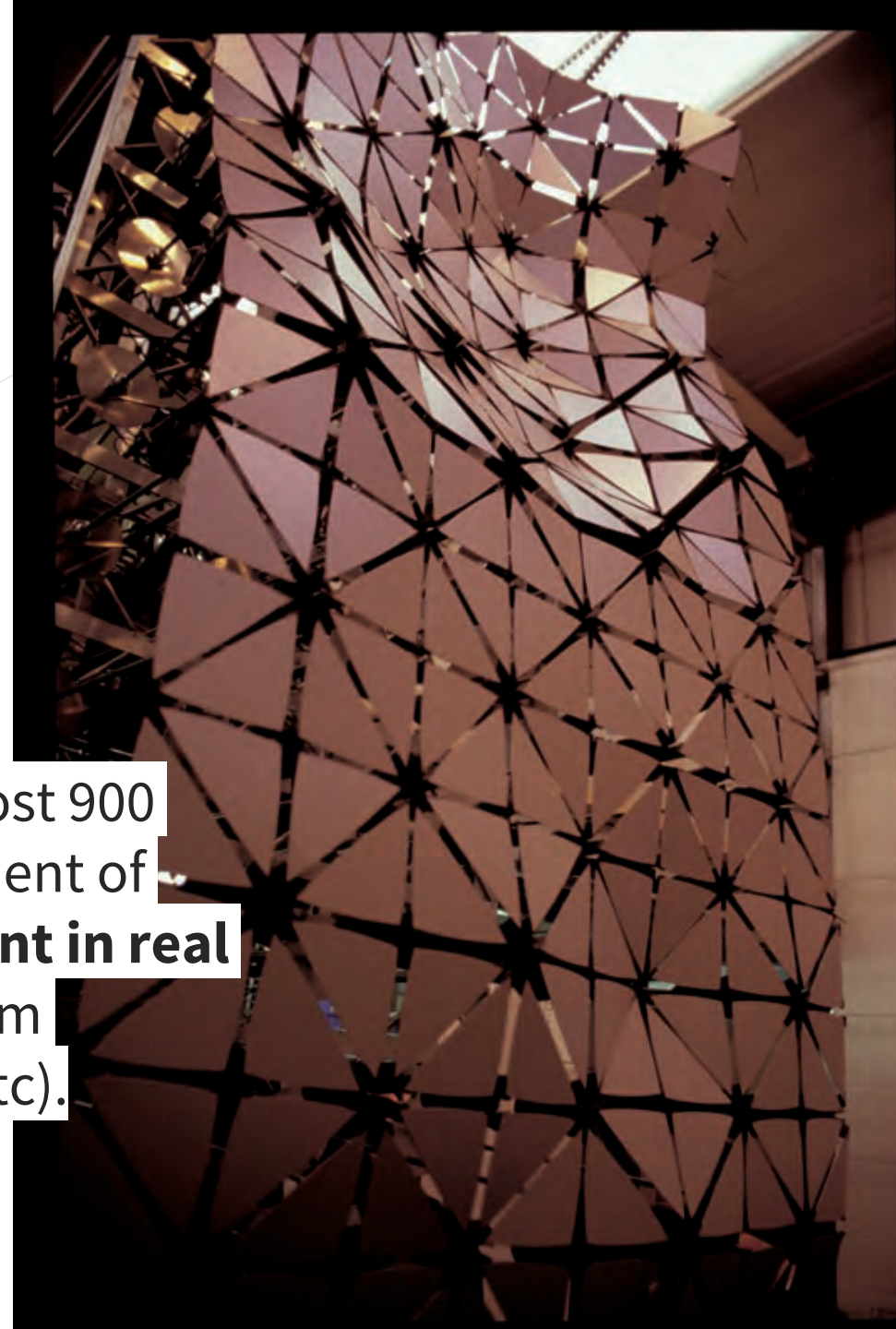
## Augmenting reality

Digital tools enabled architecture to embody fluidity, temporality, movement and change.

It transform **how people move within their built environment**. Architects explored adaptive physical architectural elements.

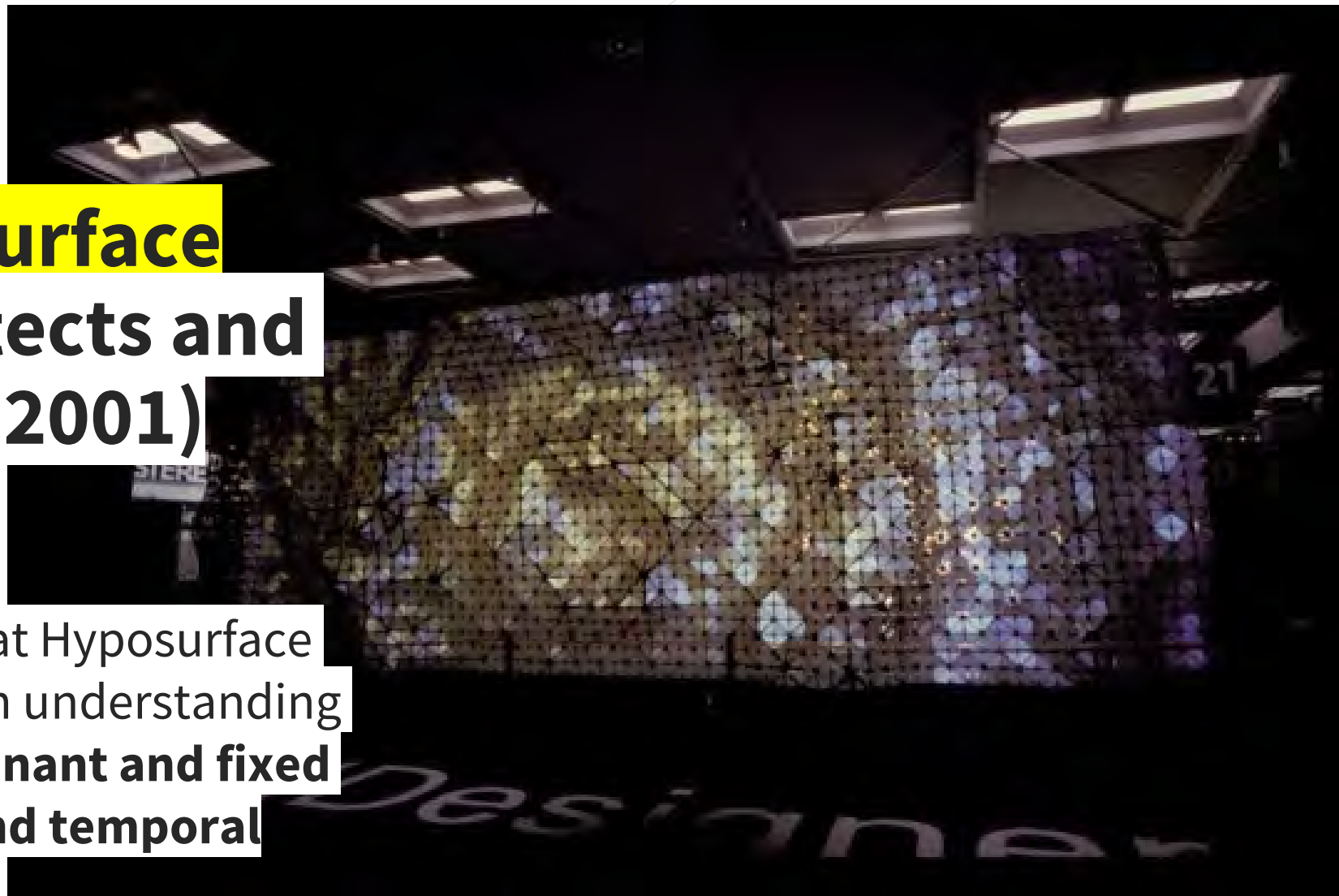
## Aegis Hyposurface dECOi architects and Mark Burry (2001)

**First interactive walls** consisted of almost 900 pneumatic pistons to control the movement of metal components on the wall. **Movement in real time** responses to **electronic stimuli** from environment (movement, sound, light, etc).



# Aegis Hyposurface dECOi architects and Mark Burry (2001)

Mark Burry wrote that Hyposurface represented a shift in understanding space, from **determinant and fixed** to **indeterminate and temporal**



## Digital Fabrication

**A shift from  
consumerism to  
prosumerism  
Small-scale digital  
fabrication machines**

**Digital fabrication technologies such as CNC-milling machines, laser cutter and 3D printers challenged the mechanism of consumer-based market.\***

Claypool, M. (2019). The Digital in Architecture: Then, Now and in the Future. SPACE10



## Digital Fabrication

**Computer power increases exponentially, became more affordable and therefore more accessible.**



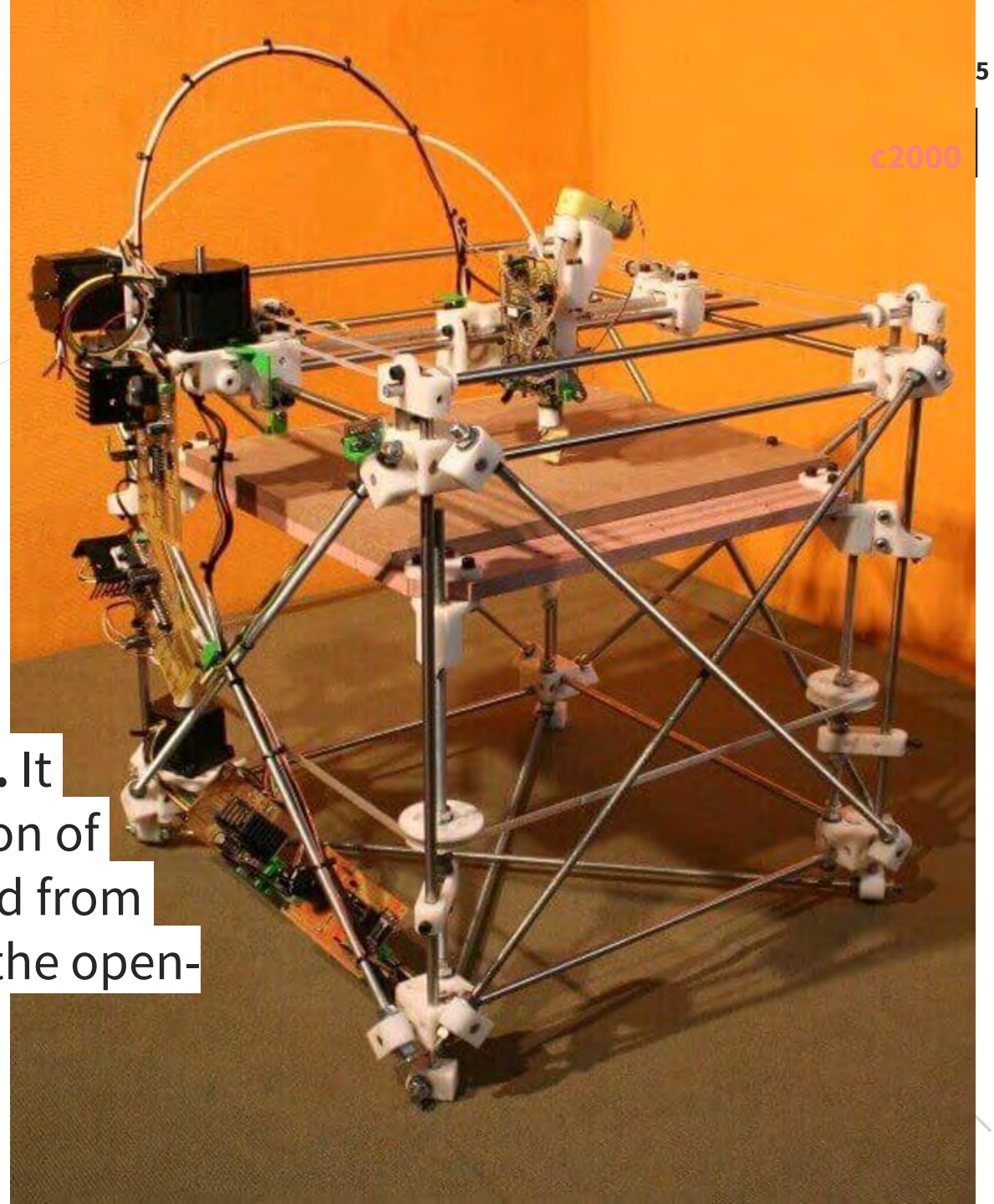
**Darwin**

**2004**

**Adrian Bowyer**

**First open-source desktop 3D printer.** It exemplified the idea of digital fabrication of prosumer. The main idea was originated from *cybernetics* of John von Neumann and the open-source community.

<https://all3dp.com/history-of-the-reprap-project/>



**Olzweg** (2006- unbuilt)

## First architectural proposal to use industrial robot arm

**Olzweg**, the robotic arm would have been placed in the courtyard on a moving platform, perpetually construct a space made out of recycled glass by sliding them in and out the place.

<https://new-territories.com/welostit.htm>

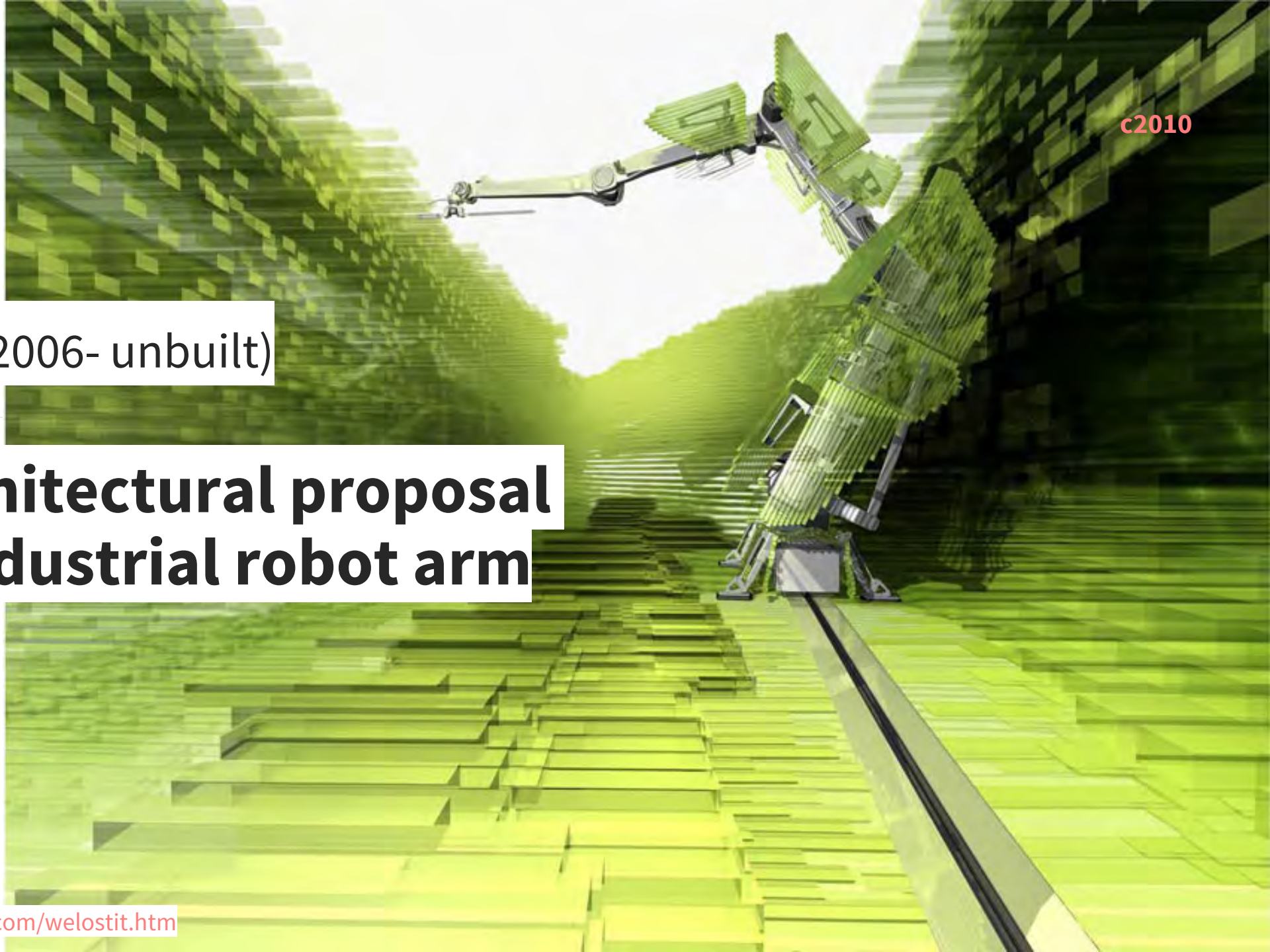


c2010

**Olzweg** (2006- unbuilt)

**First architectural proposal  
to use industrial robot arm**

<https://new-territories.com/welostit.htm>

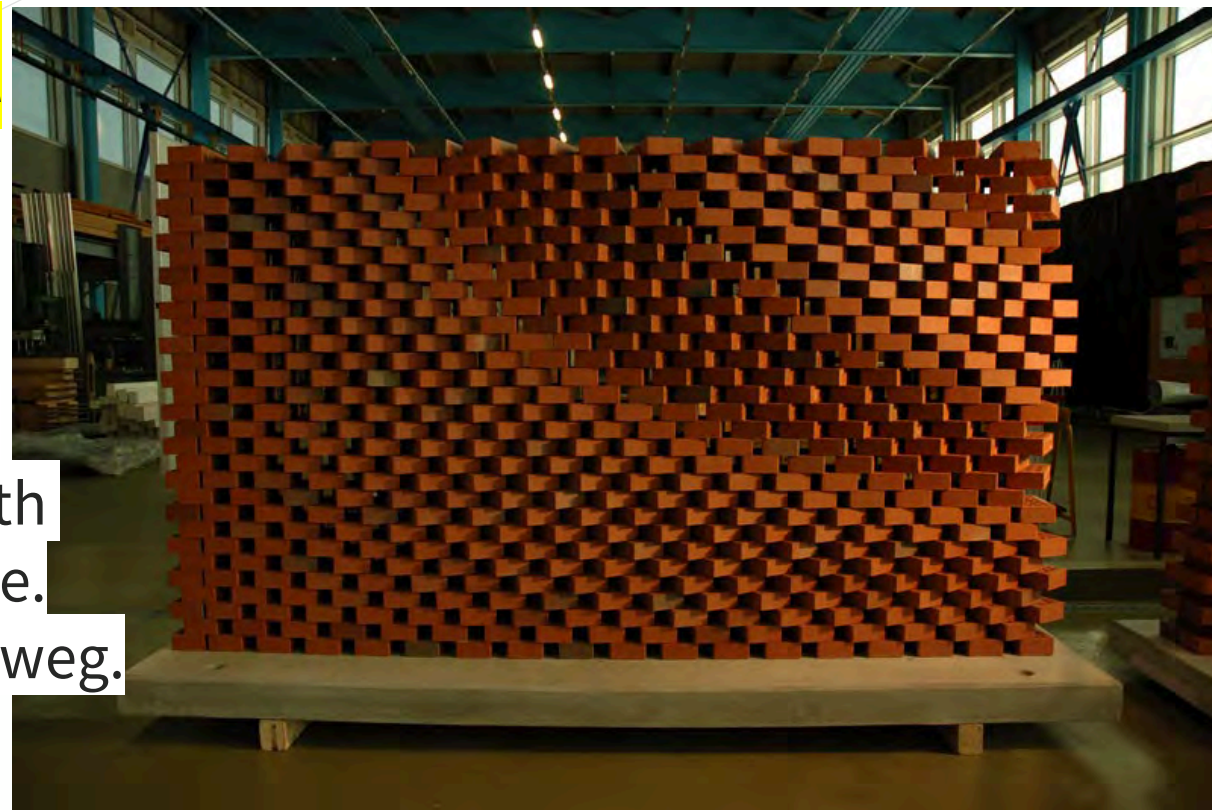


# The Programmed Wall

## ETH Zurich

### 2006

Industrial robot positioned over 400 bricks by using constructive logic, with specific position and rotation in space. The robot is placed similarly with Olzweg.



<https://gramaziokohler.arch.ethz.ch/web/e/lehre/81.html>



c2010

# The Programmed Wall

## ETH Zurich

### 2006



<https://gramaziokohler.arch.ethz.ch/web/e/lehre/81.html>

## fablab

### Location: 1500 registered 'fab labs' in the world

<https://fabfoundation.org/>

Formed in 2009. A Fab Lab, or **digital fabrication laboratory** which provides access to the environment, the skills, the materials and the advanced technology to allow anyone anywhere to make (almost) anything.



**fablab**

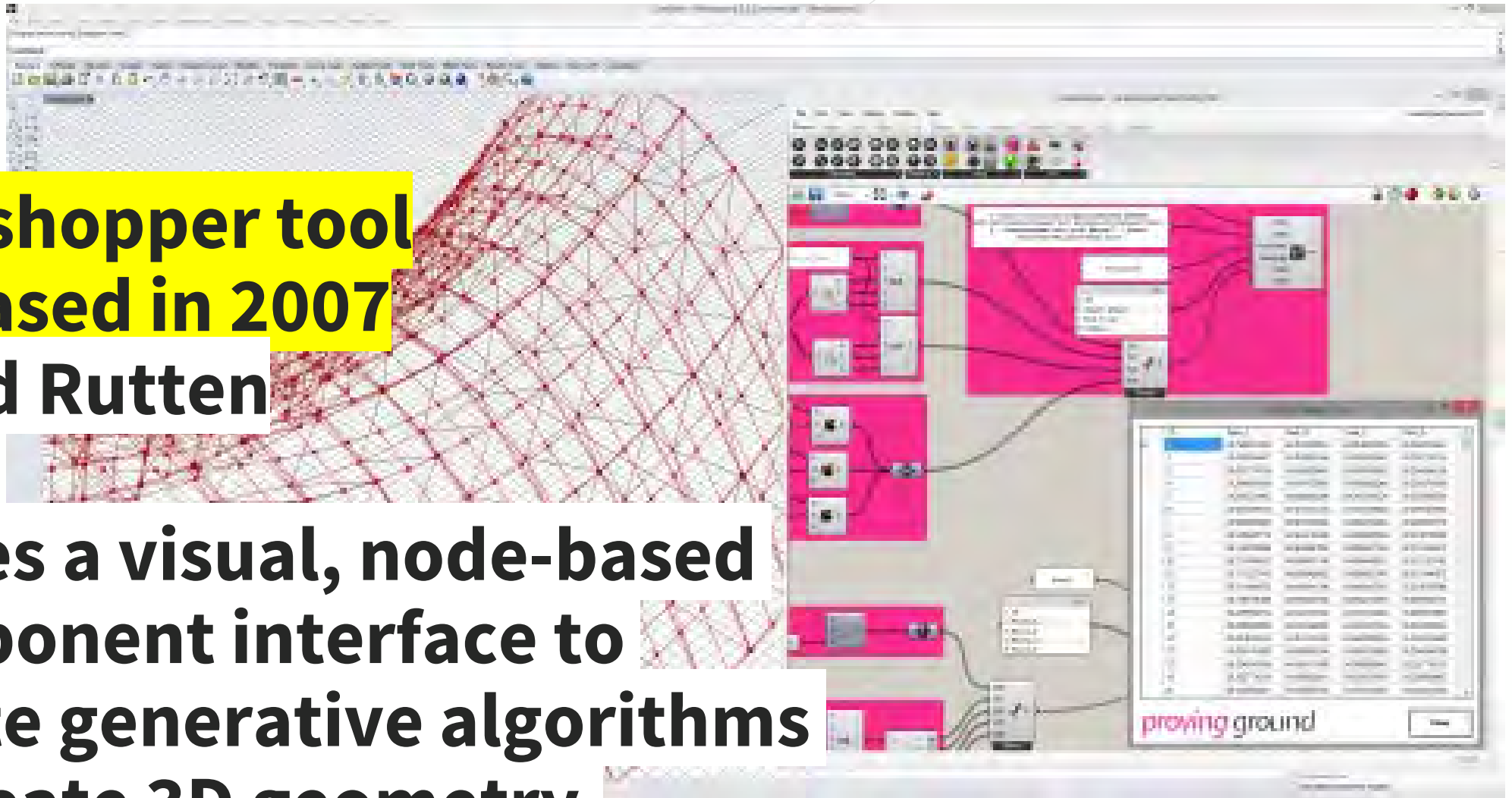
**Location: 1500 registered  
'fab labs' in the world**

<https://fabfoundation.org/>



**Grasshopper tool  
Released in 2007  
David Rutton**

**It uses a visual, node-based  
component interface to  
create generative algorithms  
to create 3D geometry.**

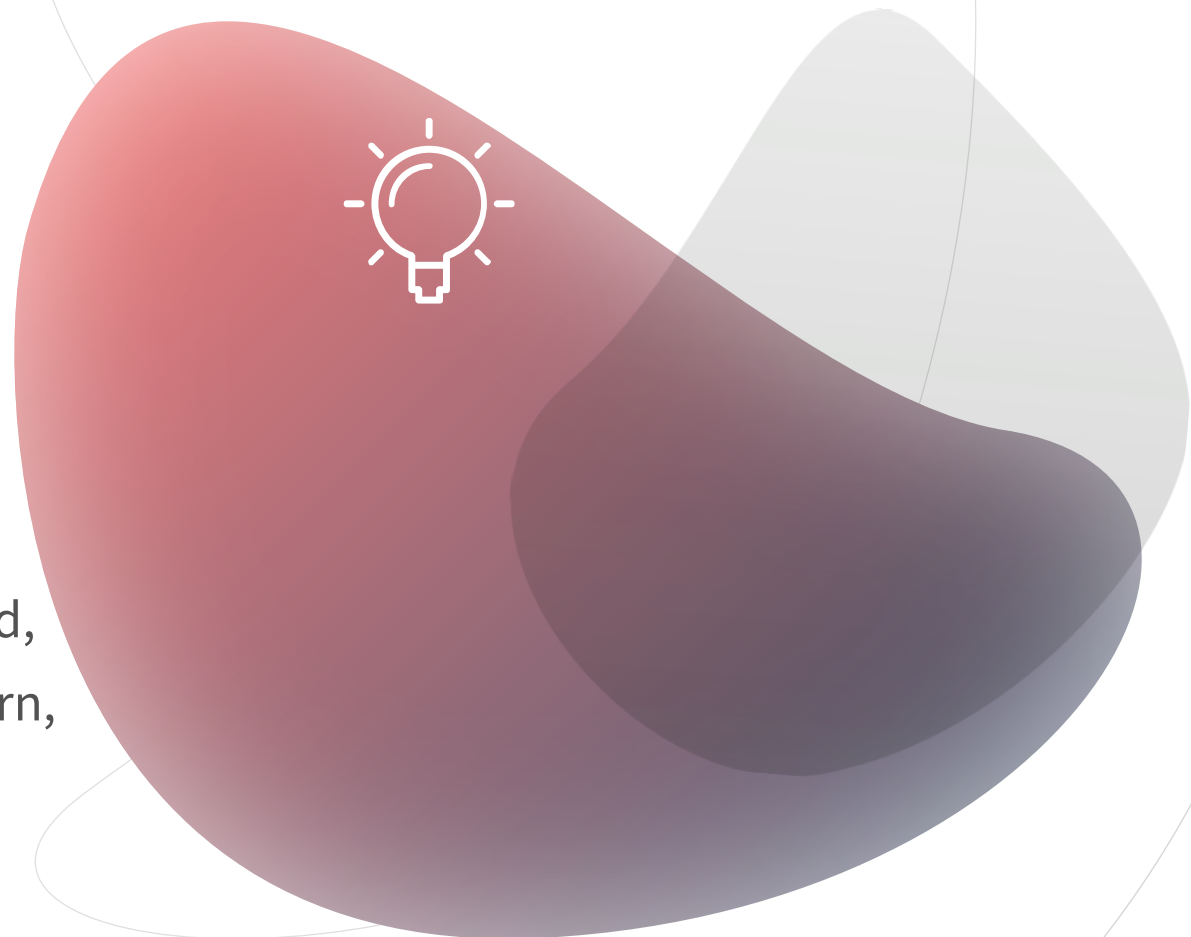




# Circa 2010

## About

The 2010s is when second digital turn started, according to Mario Carpo. During the first turn, it changed the way architects make. The second turn dissipate separations of ways architects think, draw and make.



# Fourth Industrial Revolution (4IT)

The term was coined by Klaus Schwab, published a book in 2016 entitled “The Fourth Industrial Revolution”.

Technological is underway that is blurring the lines between: physical, digital and biological spheres

# The Fourth Industrial Revolution

**Klaus Schwab**

Founder and Executive Chairman,  
World Economic Forum

# Big Data revolution

The effects on architecture industry can be:

1. Clients demand more data from architects
2. Clients demand data from buildings
3. Data changes process as much as it changes the output → architecture practice needs to be re-thought.

[https://www.architectmagazine.com/technology/how-big-data-is-transforming-architecture\\_o](https://www.architectmagazine.com/technology/how-big-data-is-transforming-architecture_o)



# ‘Cyber-physical’ approach 2015

Menges, A. (2015). The New Cyber-Physical Making in Architecture: Computational Construction. *Architectural Design*, 85.

Relationship between virtual and physical data is interlinked using robotic technologies as well as sensor technologies.

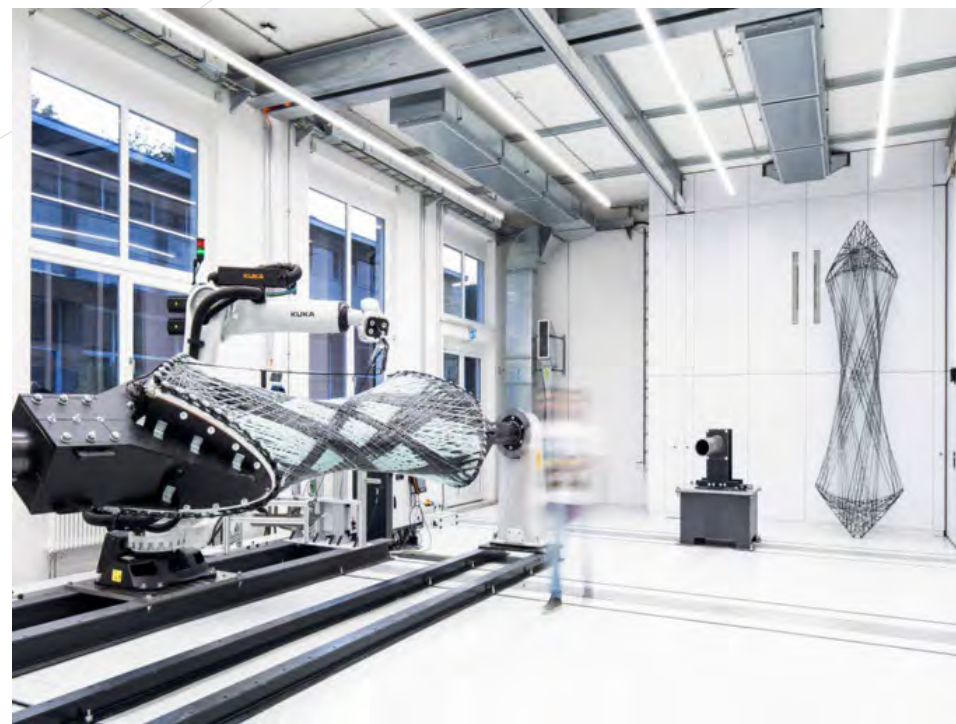
# **‘Cyber-physical’ approach**

## **BUGA Fibre Pavilion 2016**

### **ICD Stuttgart**

Combining cutting edge computational technologies + biomimetic principles = enabling development of truly novel and genuinely digital systems.

<https://www.icd.uni-stuttgart.de/projects/buga-fiber-pavilion/>



The pavilion was made from more than 150k meter of spatially arranged glass fibres and carbon fibres. The building components are produced by robotic approach.



c2010

**‘Cyber-physical’  
approach**

**BUGA Fibre Pavilion 2016**

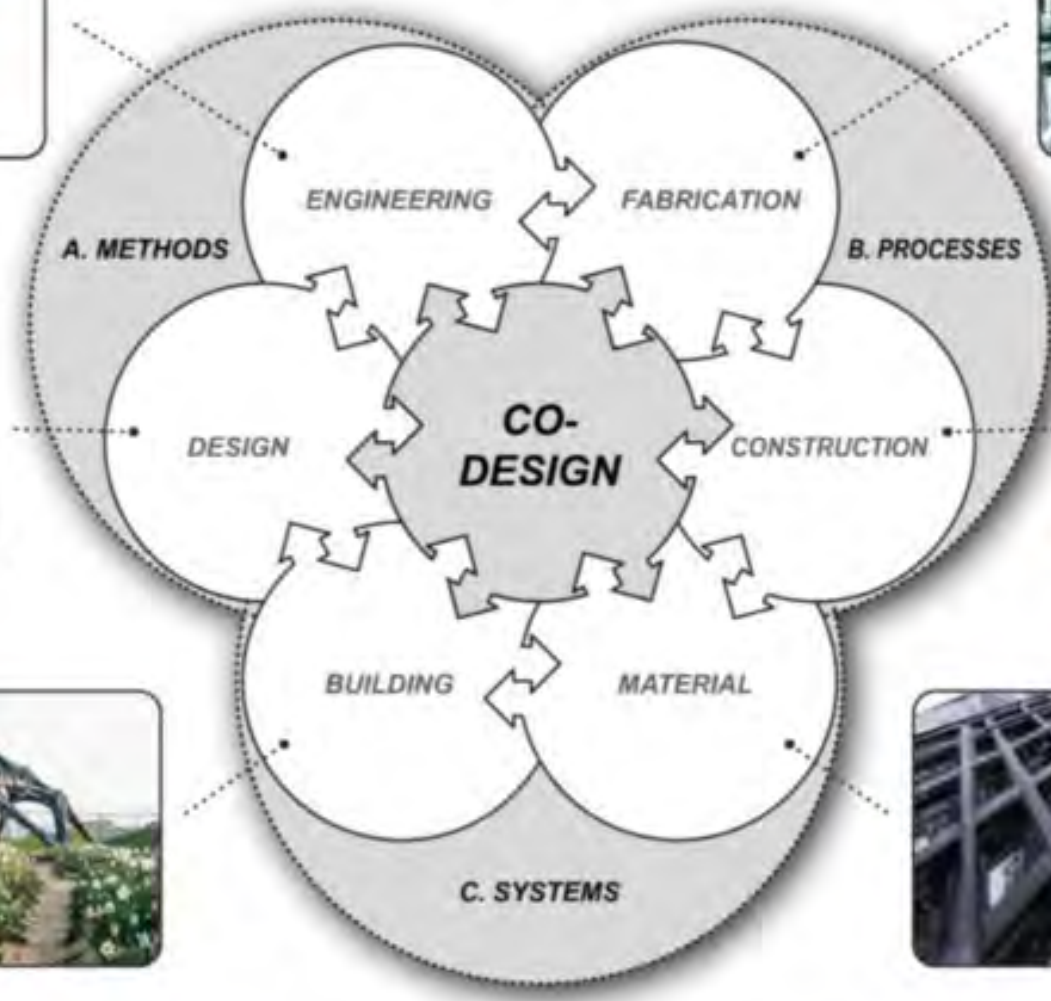
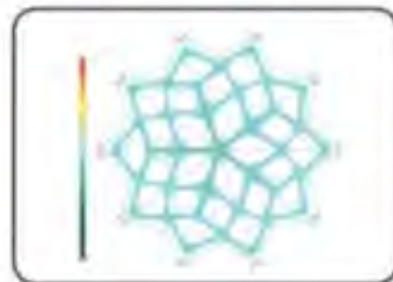
**ICD Stuttgart**



# 'Cyber-physical' approach

## BUGA Fibre Pavilion 2016 ICD Stuttgart

Co-design approach:  
Architectural design,  
structural engineering and  
robotic fabrication are  
developed in continuous  
computational feedback.



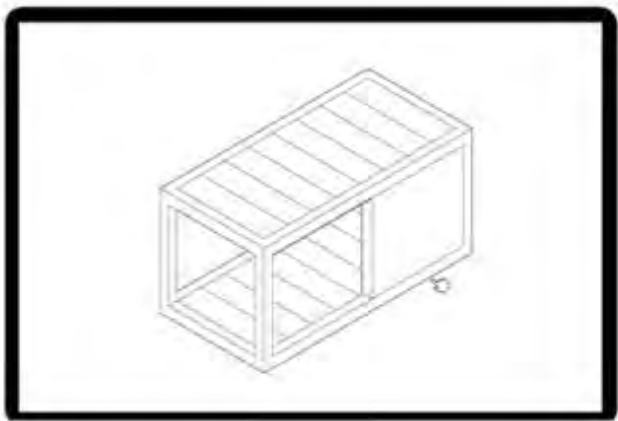
## **WikiHouse** **(2011)**

**It is a digitally-manufactured building system.**

**Aims to make it simple for anyone to design,  
manufacture and assemble customised homes.**

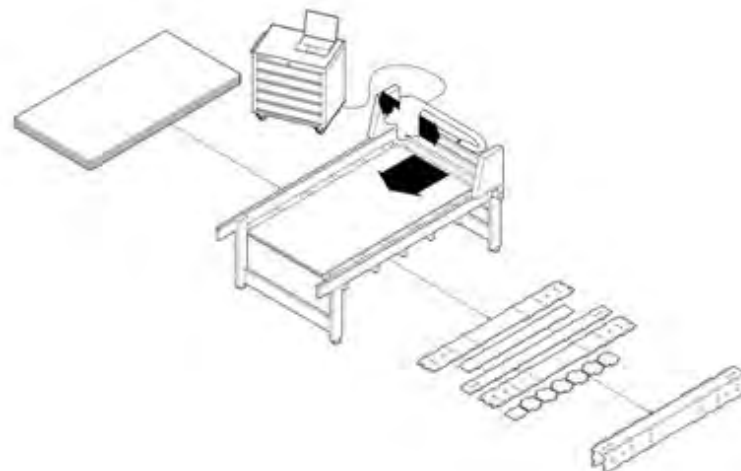


# WikiHouse (2011)



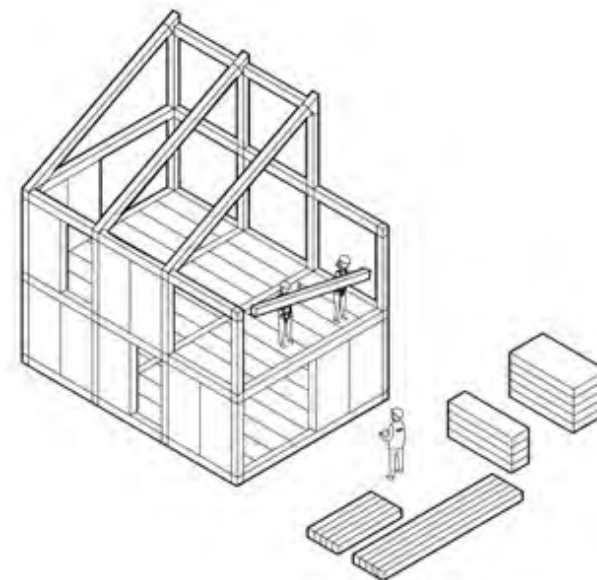
## 1 Digital design

WikiHouse is an adaptable system of standardised parts. This means each house can be unique without costing more. One size doesn't need to fit all



## 2 Local fabrication

WikiHouse doesn't need a large, expensive factory. Components are manufactured by a network of local microfactories using digital fabrication tools.



## 3 Rapid assembly

Homes can be rapidly assembled to millimetre precision, like a flat-pack. Almost anyone can do it, including small businesses and self-builders.

# ‘Discrete’ approach

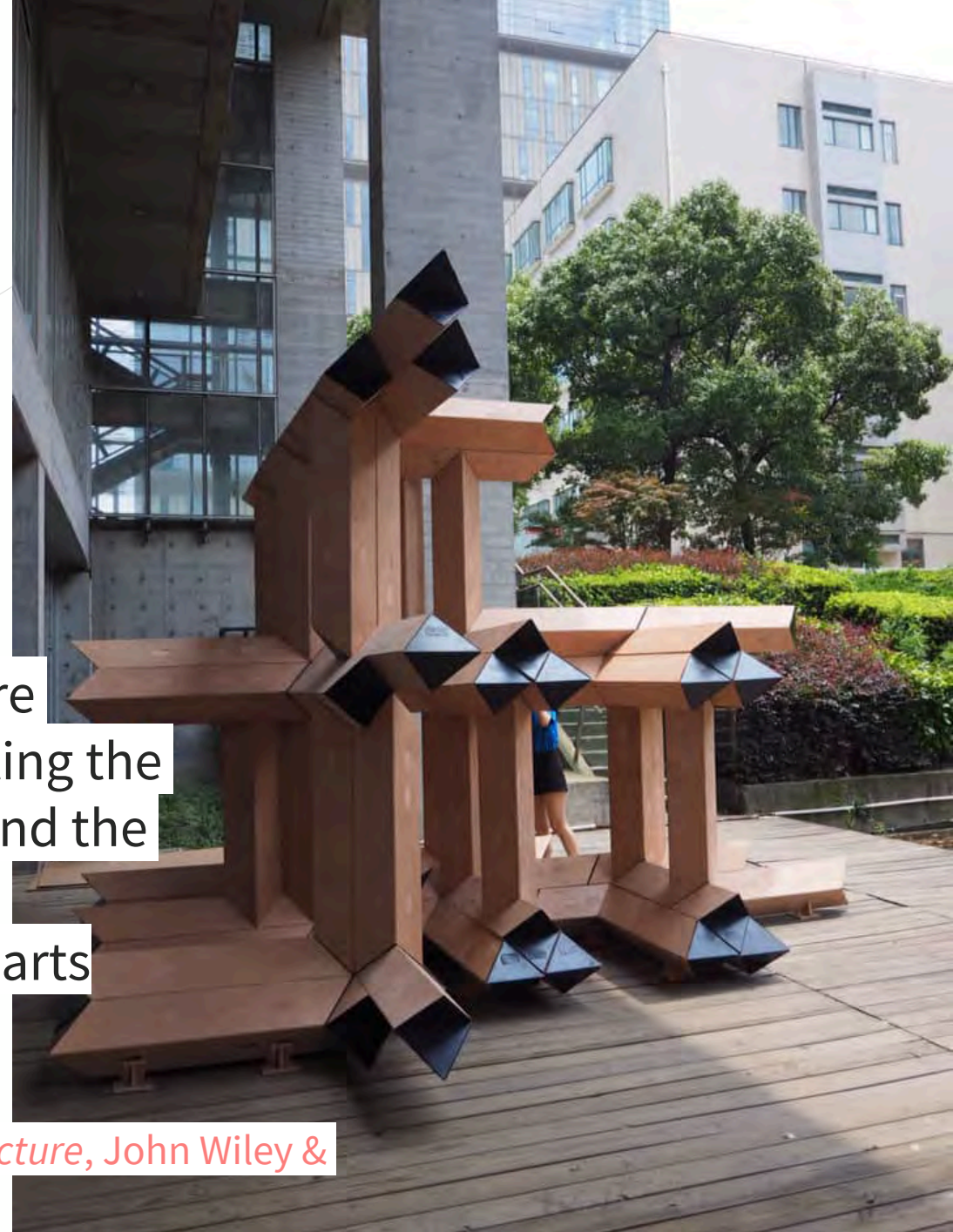
Discreteness

The core of it is the wish to “redefine the entire production chain of architecture by accelerating the notion of discreteness in both computation and the physical assembly of buildings”

Self-similar, serialised and repeatable kit of parts

Voxel

Retsin, G. (2019). *Discrete: Reappraising the Digital in Architecture*, John Wiley & Sons.



c2010

## ‘Discrete’ approach

Self-similar, serialised  
and repeatable kit of  
parts



## Eliminating 'economy of scale'

**Digital mass customisation allows us to mass-produce variations at no extra cost.**

**Thus eliminating economies of scale from a digital design and production workflow.**



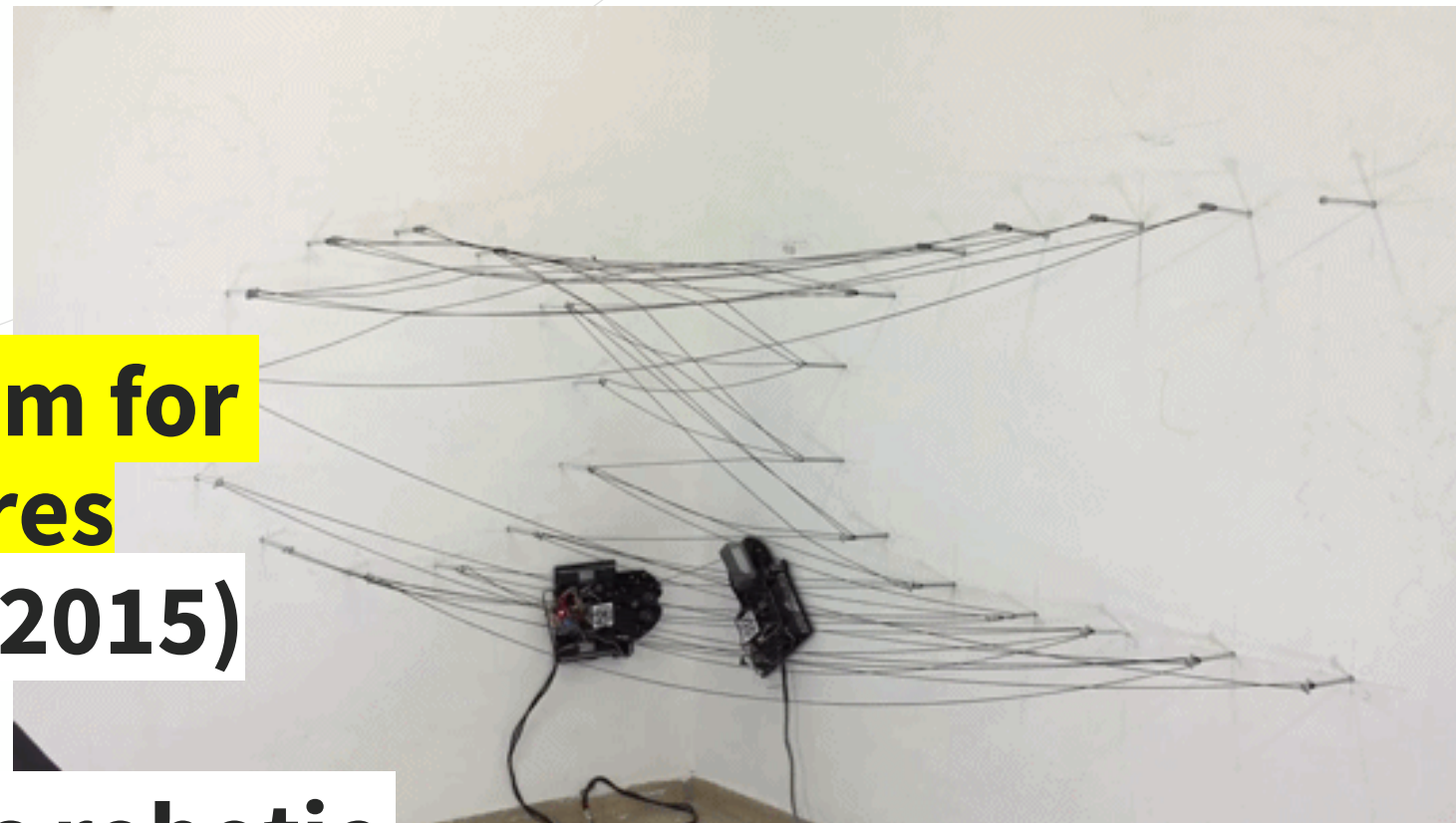
## Key concepts in the field:

- Digital architecture
- Digital tools
- Algorithmic design
- Parametric design
- Generative design

# Mobile Robotic Fabrication System for Filament Structures

Maria Yablonina (2015)

Semi autonomous robotic  
collaboration



# Mobile Robotic Fabrication System for Filament Structures Maria Yablonina (2015)

<https://www.mariayablonina.com/mobile-robotic-fabrication-system>



## **Criticism of parametric design:**

**It is not sensitive to contextual issues, no sympathy of local culture.**

**Complexity of forms demand the use of overly expensive and inefficient production methods.**



# Current concerns

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**Most construction remain analogue, reliant on manual labour.\***

**Although we have been practicing digital tools since 1960s.**

**Japan as pioneer in automated construction technologies.**

**Harnessing drone  
technology for  
construction (deposit  
materials) and site visit.**

**AR (Augmented Reality)  
to deal with imprecision.**

**Ongoing debate** in areas  
of:

**Mobility**

**Labour**

**Customisation**

# Architect Alessandro Bava writes:

01

'How could these innovations in computing be used **to better understand a building's environmental performance**, or the best way to design urban planning interventions, or production and construction processes?

02

How could artificial intelligence including machine learning enable architects to design novel kinds of architecture that can **better respond to the changing world** around it?

03

How can digital tools enable architects and designers to **create better architecture for more people**?'

# Reflections in 2021

## Re **Big Data**

How do we gain the data?

How do we use the data?

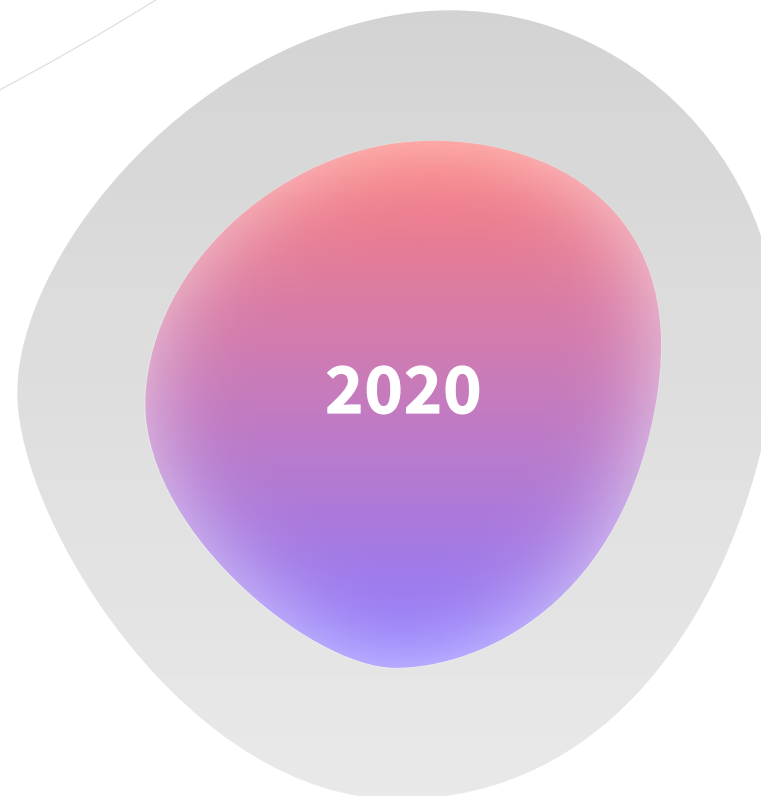
How to we increase validity of data?

How can we communicate data with other stakeholders?

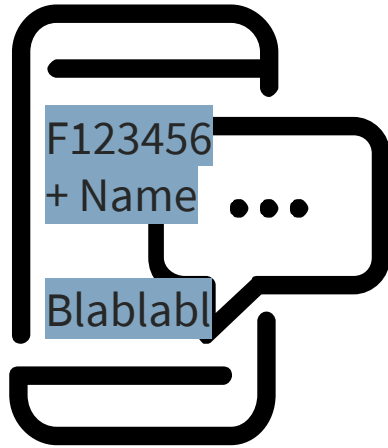
## Re **Others**

How do we make better architecture for people with the use of digital tools?

How do we maximise potentials of technology for the benefit of mankind?



# Discussion



D1. Reflect on 'Man-Computer Symbiosis' write-up by Licklider in 1960 (see supporting materials). As per the year of 2022, to what extent did the anticipated symbiosis come true?

D2. What are the key factors of the occurred changes from one decade to the next decade?

<https://miatedjosaputro.com/2022/03/02/dg-week-2-2/>

# Re-iterating aims and objectives

*Have we achieved these?*

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- To expand **historical background** of this design field.
- To enumerate **current debates**.
- To elicit **key events** related to computational design.
- To enumerate **key concepts** related to development of the fields, in relation with the timeline.