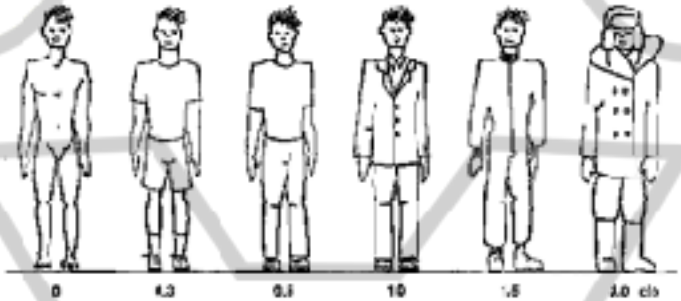
UNIVERSITÀ DEGLI STUDI FIRENZE
Scuola di Architettura

MULTIMEDIA | ARCHITECTURE | INTERACTION

ADAPTIVE BUILDINGS FOR GREEN ARCHITECTURE.
Examples, technologies and new materials

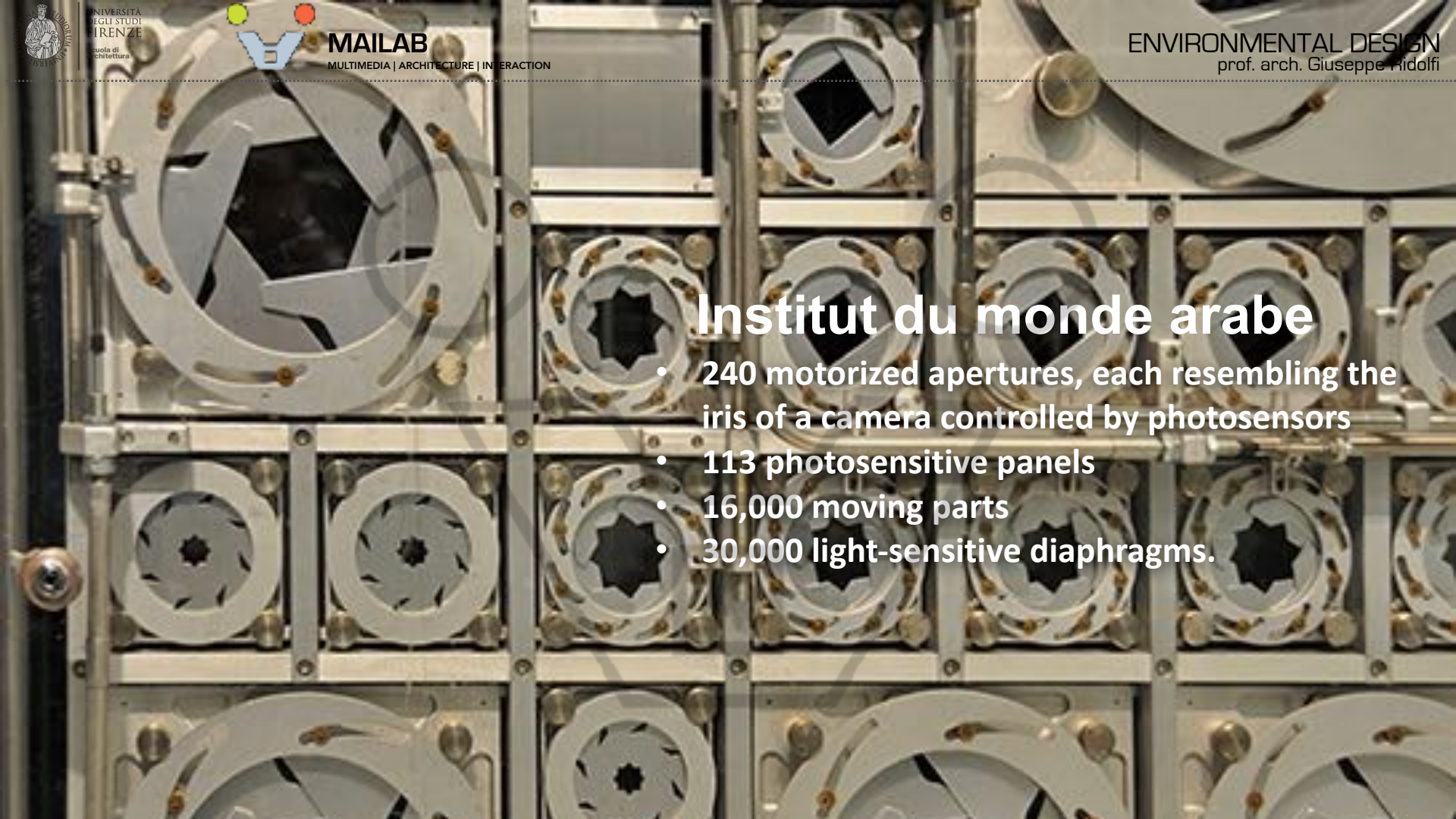
prof. arch. Giuseppe Ridolfi PhD



architecture not responding to people but people responding to architecture

ADAPTIVE

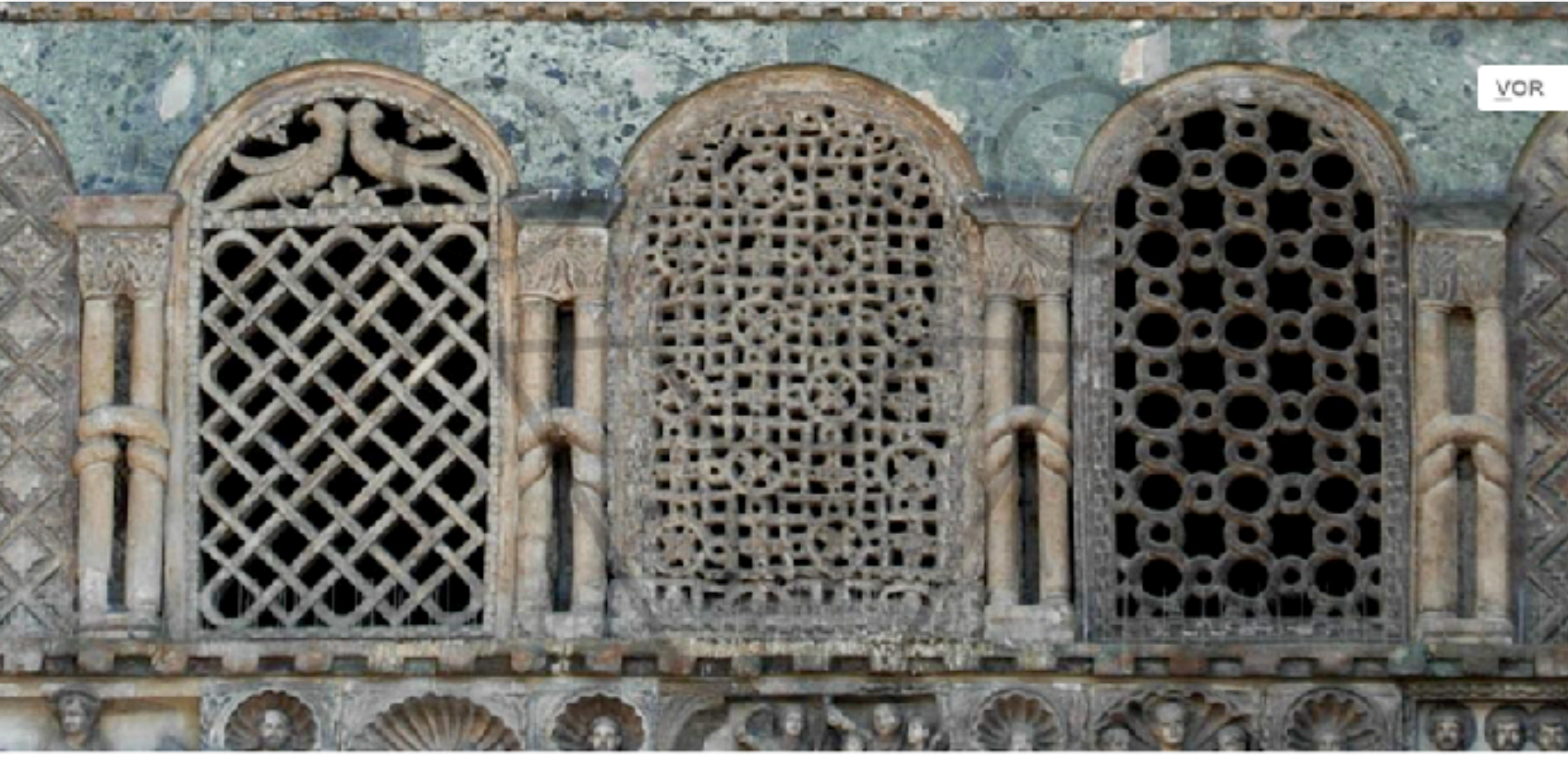
RESPONSIVE
PERFORMATIVE
DYNAMIC
KINETIC
ROBOTIC
INTELLIGENT
SMART



Institut du monde arabe

- 240 motorized apertures, each resembling the iris of a camera controlled by photosensors
- 113 photosensitive panels
- 16,000 moving parts
- 30,000 light-sensitive diaphragms.

MASHRABIYA



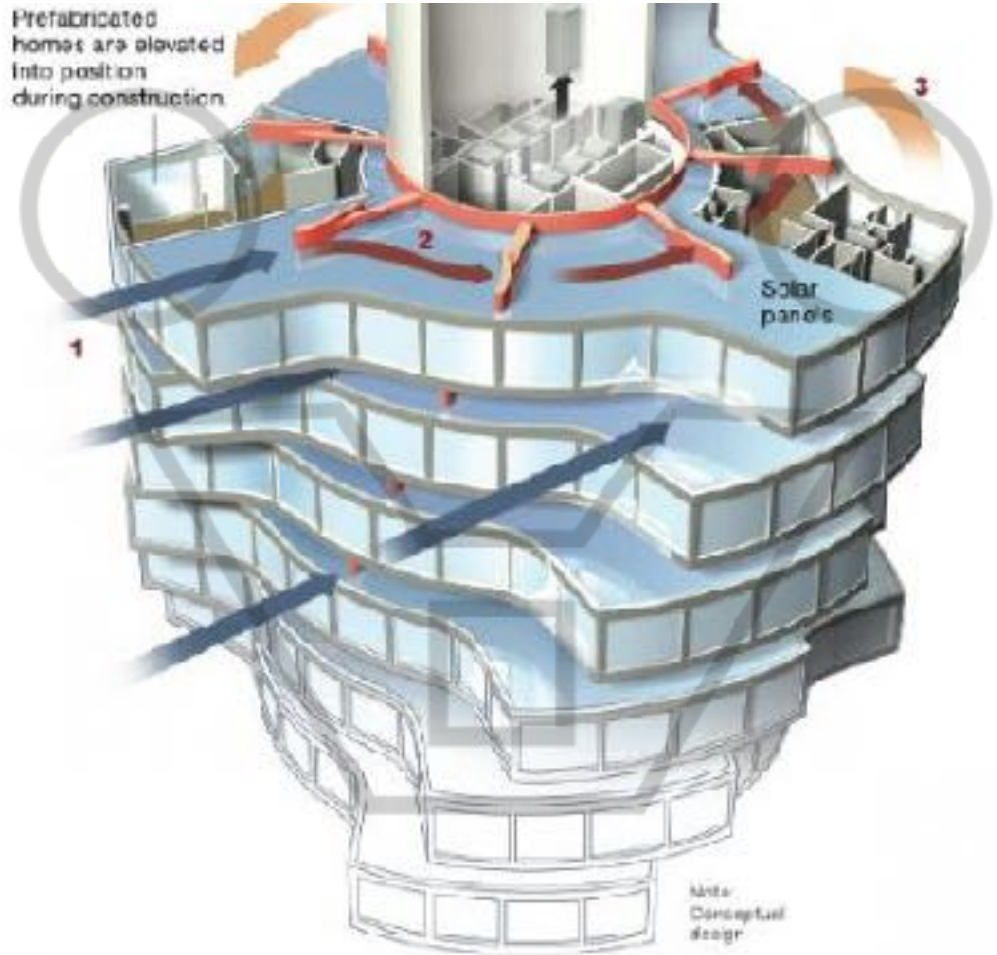
Portale di ingresso alla Basilica di San Marco di Venezia. Foto: Raffaello Galiotto

Ignazio Gardella, Dispensario di Alessandria, 1933-38-MAIN FACADE

Ignazio Gardella, Dispensario di Alessandria, 1933-38
dettagli

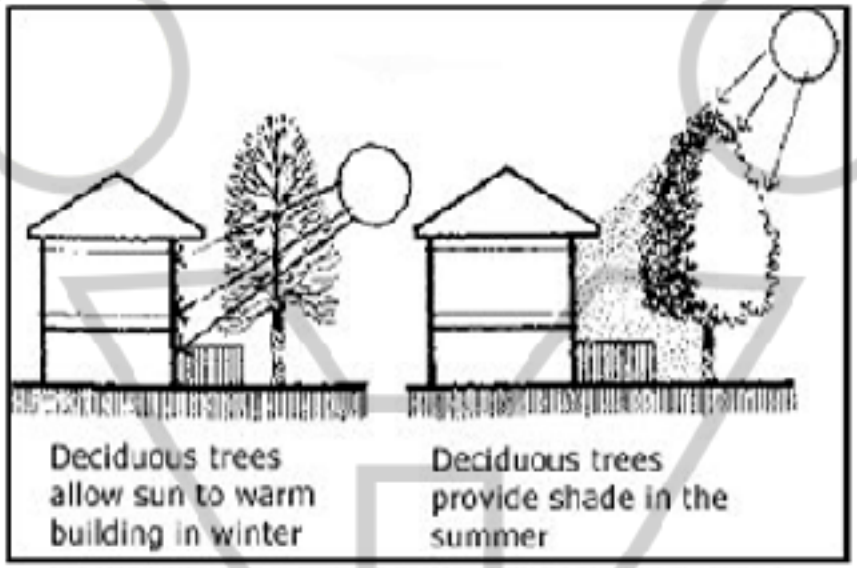
Dynamic Architecture
David Fisher

DA VINCI TOWER in DUBAI, David Fisher

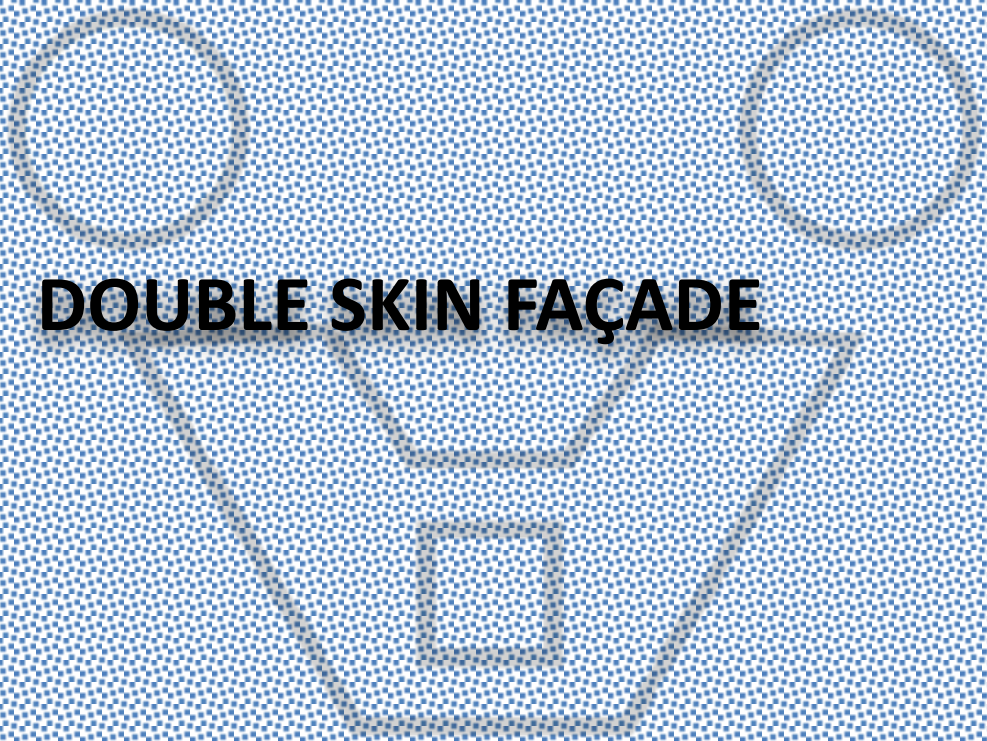

Prefabricated homes are elevated into position during construction
1
2
3
Solar panels

Bruno de Franco, **Suite Vollard**, 2001, Curitiba,Brazil. Constructed by Moro Construções Civis LTDA, and Fritz Georg Gehbauer.

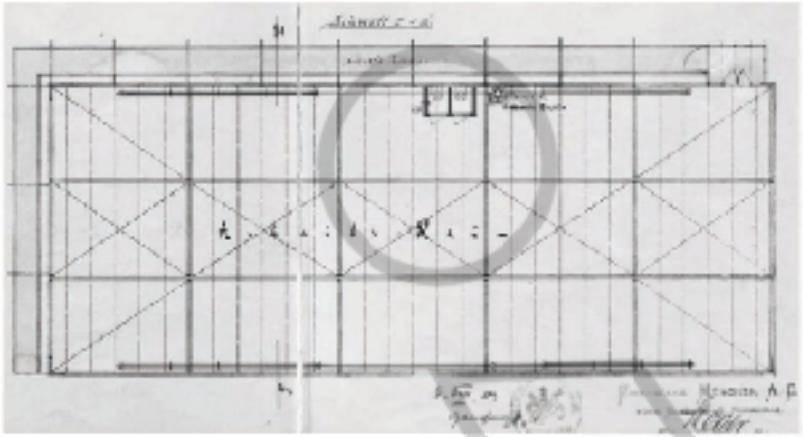
PASSIVE BUILDING ADAPTATION

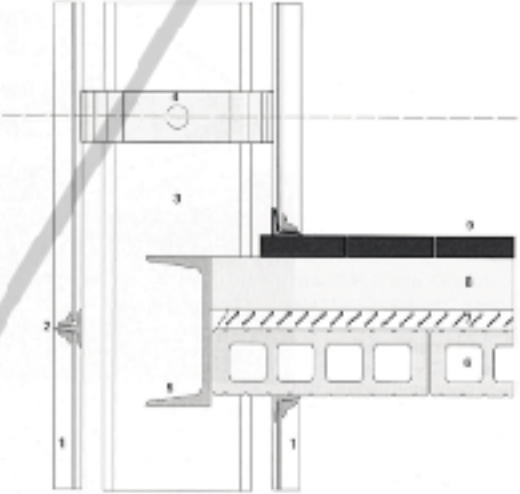

Deciduous trees allow sun to warm building in winter
Deciduous trees provice shade in the summer

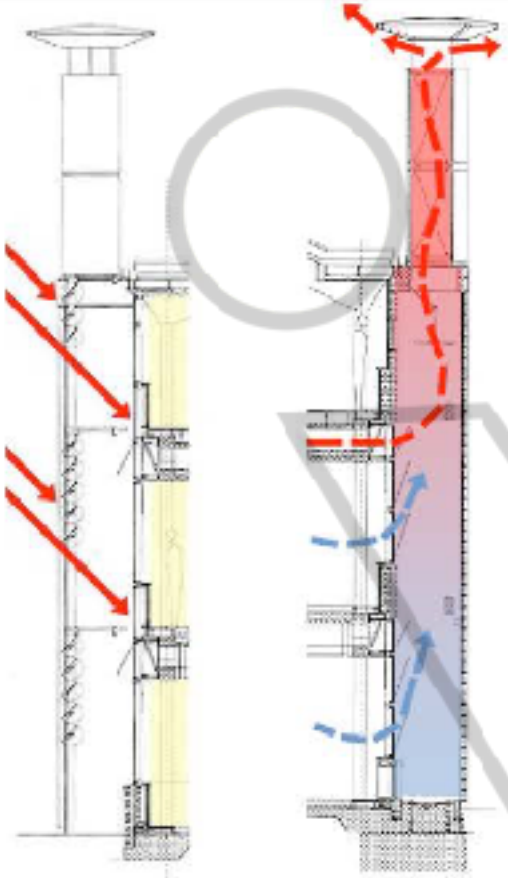
DOUBLE SKIN FAÇADE



THE FIRST EXAMPLE: STEIFF FACTORY in GIENGEN 1903




Fassadendetail
1 Kathedralglas 3 mm
30x20 und 35x25 mm
3 Vertikalstütze des
Haupttragwerks
4 Befestigungslasche
für Vorhangfassade
5 Querträger
6 Ausfachung
Hourdis-Elemente
7 Ausgleichsschicht
Zementestrich
8 Konterlattung



Cross section through the glazed facade (left) and the ventilation stack (right)

Exterior view of south façade (top)

Floor plan of cellular offices on the north side and open plan on the south side (bottom)

Building Research Establishment

Building: Environmental Building, Building Research Establishment

Location: Garston, UK

System: Operable solar shading and stack ventilation.

Architect: Feilden Clegg

Completion: 1990/1992

Project Description: Low-rise, low-energy office building for 100 people with stack ventilation, cross ventilation, and operable shading systems on the south building facade.

A key feature of this building is the integration between natural ventilation and daylighting strategies. The floor plan (shaded in yellow in the picture to the left) is divided into open-plan and cellular offices allowing cross ventilation in the open plan arrangement while the deep-plan cellular offices are located on the north side with simple sided natural ventilation. A shallow open-office plan is coupled to highly glazed façade. A wave-form ceiling structure is used. At the high point of the wave, a clerestory window allows daylight to effectively penetrate the space. A duct providing space conditioning and ventilation was placed within a hollow core at the low point of the wave-form structure.

For shading, translucent motorized external glass louvers (Colt International) are controlled by the building management system and can be overridden by the occupants. The glass louvers can be rotated to diffuse direct solar or to a horizontal position for view.

A stack ventilation system was designed as an alternative ventilation strategy for the open plan offices during extreme cooling conditions. Vertical chimneys were designed to draw air through the duct in the wave-form structure as well as through bottom-hung, hopper, tilted windows. The exteriors of the stacks are glazed with colored glass. Rooms allowing daylight admission. Low-resistance propeller fans were mounted at the top floor level, to provide minimum ventilation and to flush internal heat gains during the night.

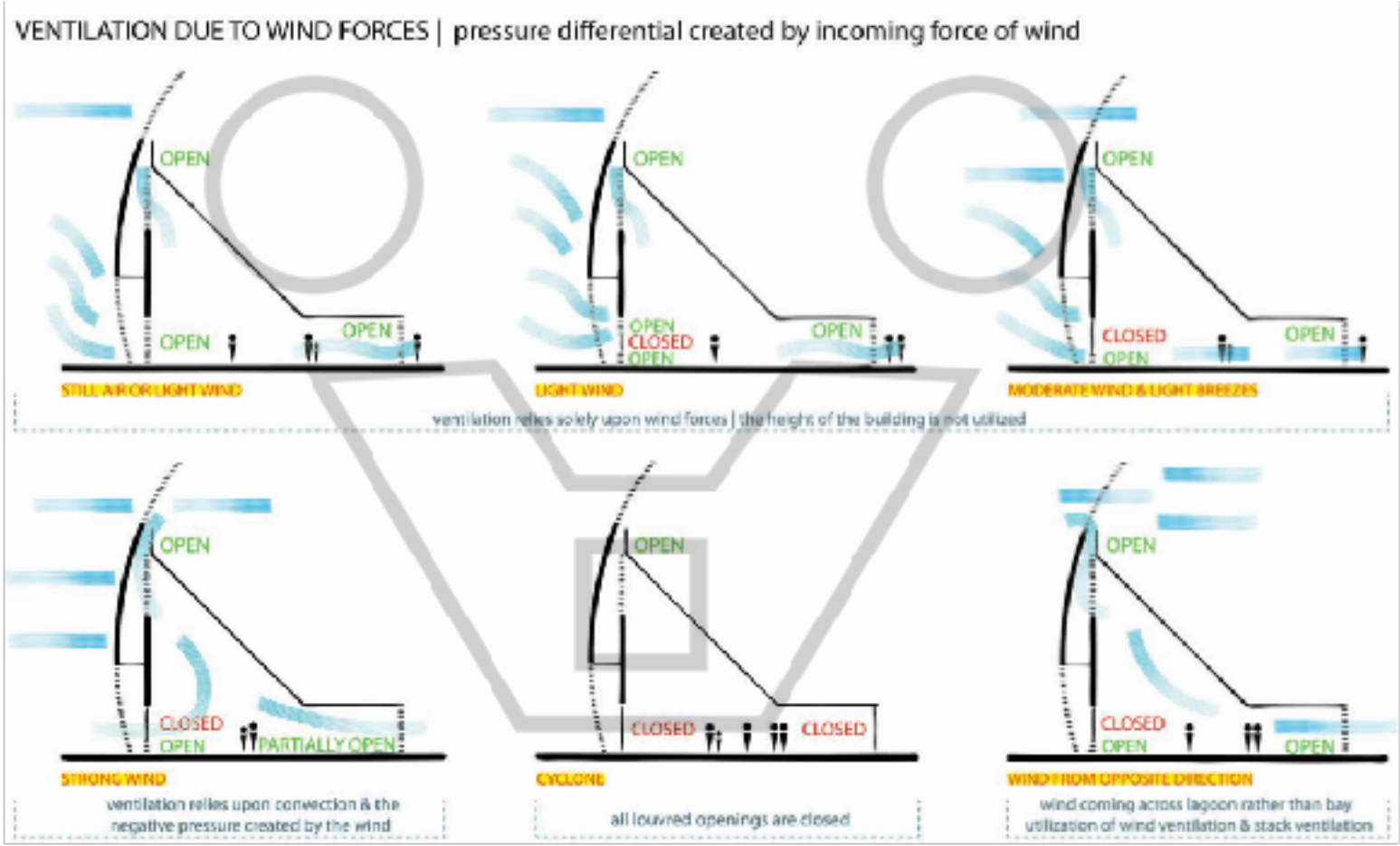
Reference

Roaf, S. editor, 1998, Green buildings pay, London E&FN Spon.

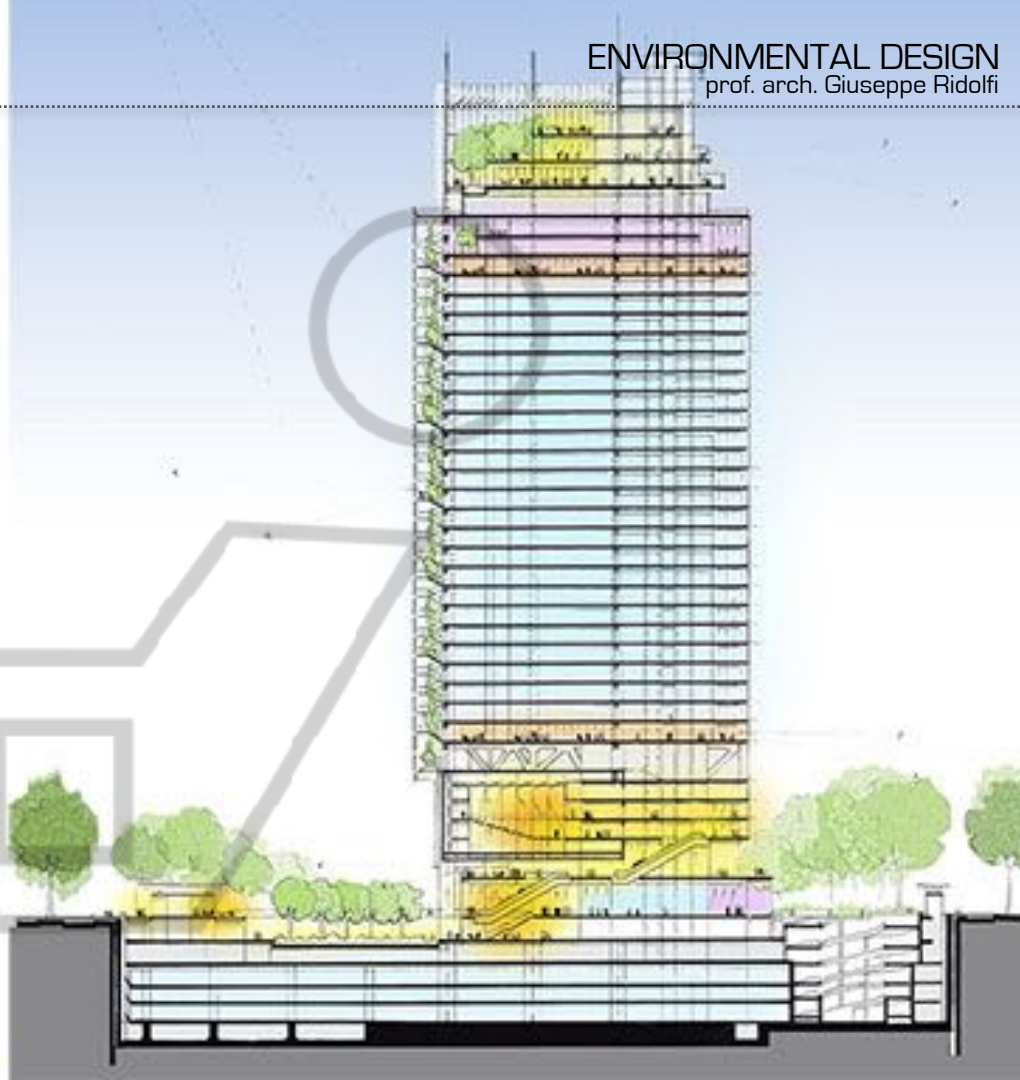
Hybrid System:
The hybrid system combines various aspects of the above systems and is used to classify building sys that do not "fit" into a precise category. Such buildings may use a layer of screens or non-glazed mate on either the inside or outside of the primary environmental barrier. The Tjibaou Center in New Calec by Renzo Piano may be used to characterize this type of Hybrid system.

Figure 6:
Cross section of the Tjibaou Center by Piano illustrating the use of a hybrid system

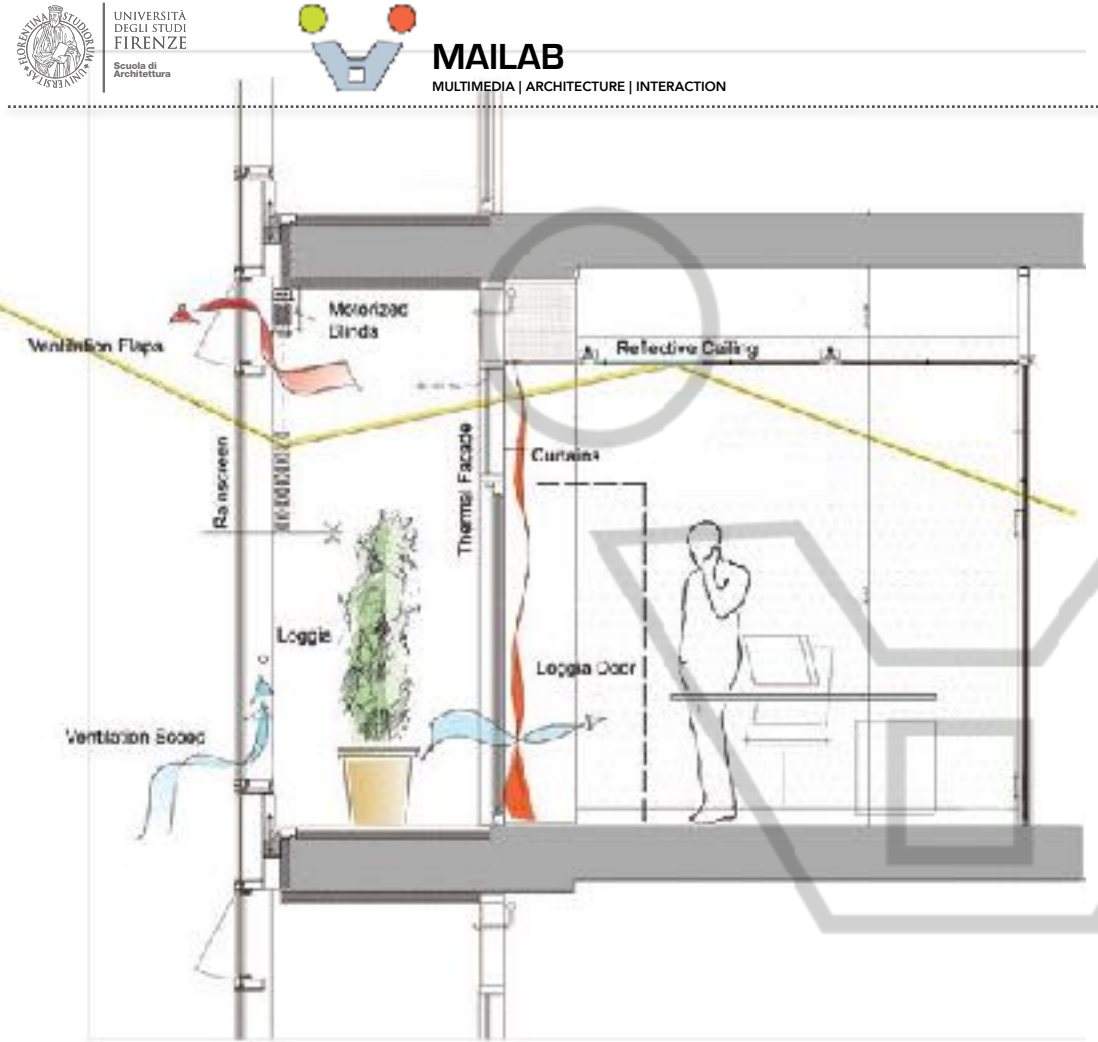
R. Piano (1995-98) , **Jean-Marie Tjibaou Cultural Centre**, Nouméa, Tinu Peninsula, New Caledonia

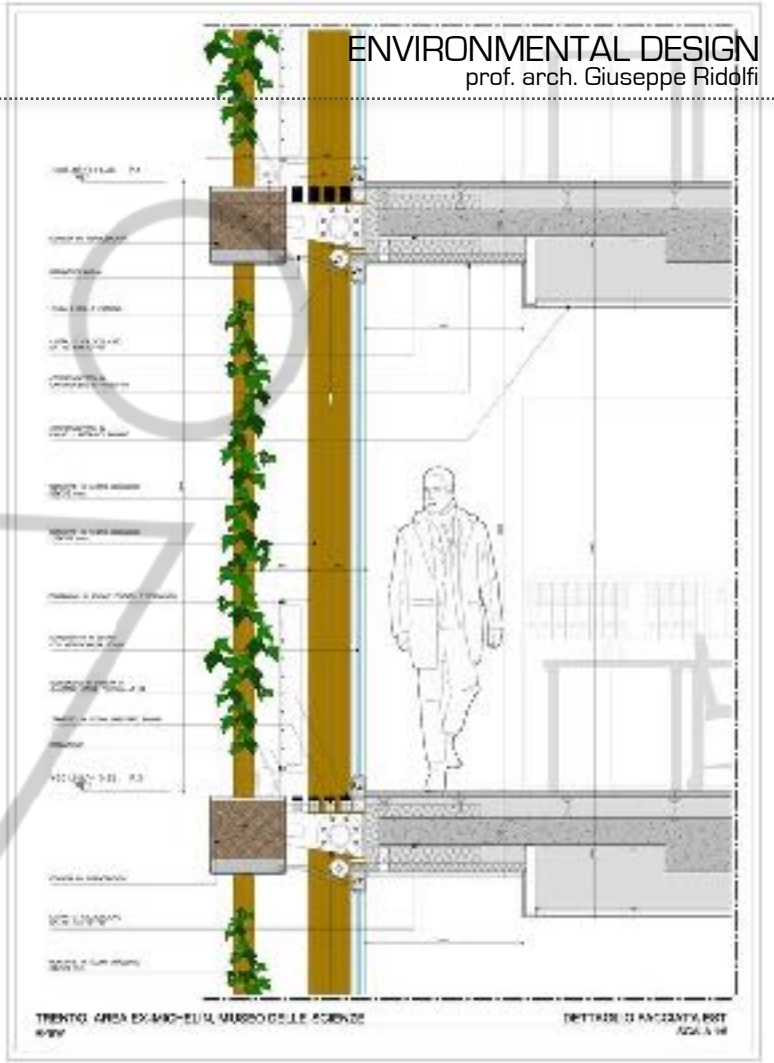

VENTILATION DUE TO WIND FORCES | pressure differential created by incoming force of wind
OPEN
OPEN
OPEN
STILL AIR OR LIGHT WIND
OPEN
OPEN
CLOSED
OPEN
OPEN
LIGHT WIND
OPEN
CLOSED
OPEN
OPEN
MODERATE WIND & LIGHT BREEZES
ventilation relies solely upon wind forces | the height of the building is not utilized
OPEN
CLOSED
OPEN
PARTIALLY OPEN
STRONG WIND
ventilation relies upon convection & the negative pressure created by the wind
OPEN
CLOSED
CLOSED
CYCLONE
all louvred openings are closed
OPEN
CLOSED
OPEN
OPEN
WIND FROM OPPOSITE DIRECTION
wind coming across lagoon rather than bay utilization of wind ventilation & stack ventilation

RPBW (2008-14), Centro direzionale Intesa, Torino



RPBW (2008-13), MuSe-Museo delle Scienze di Trento, Trento

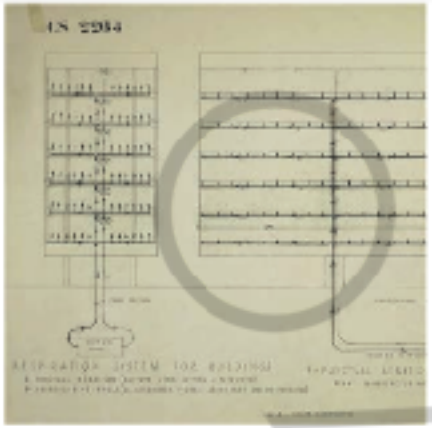


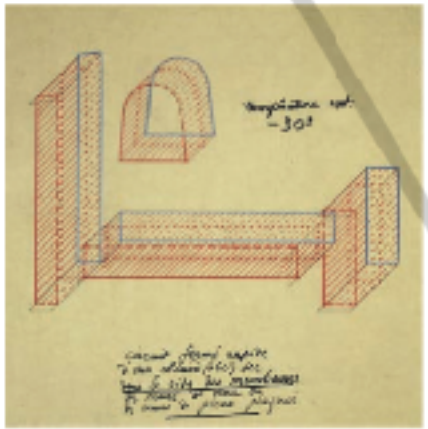


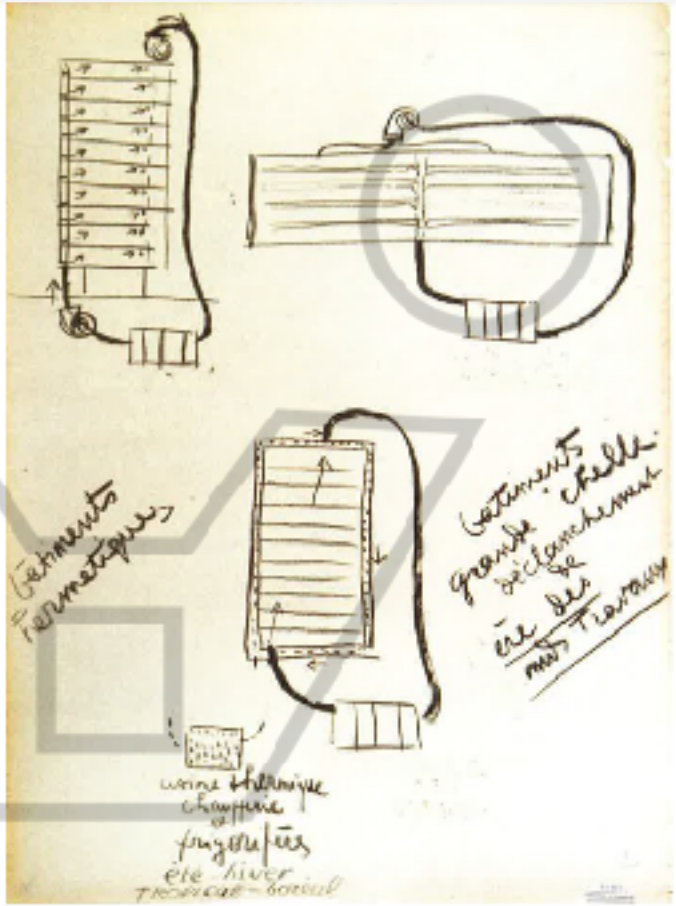
RPBW (2008-13), MuSe-Museo delle Scienze di Trento, Trento

RPBW (2008-13), MuSe-Museo delle Scienze di Trento, Trento

la machine-à-habiter





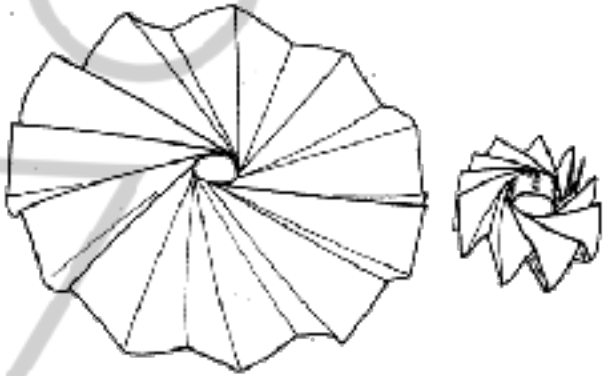


Mur neutralisant' and 'Respiration exacte'
A partial version of the mechanical ventilation system (Aerateur ponctuelle) used by Gustave Lyon at the Plaisir theatre and in other French auditoria

AHR (formerly Aedas UK) (2009-12), **Al Bahr Towers**, Abu Dhabi City, United Arab Emirates

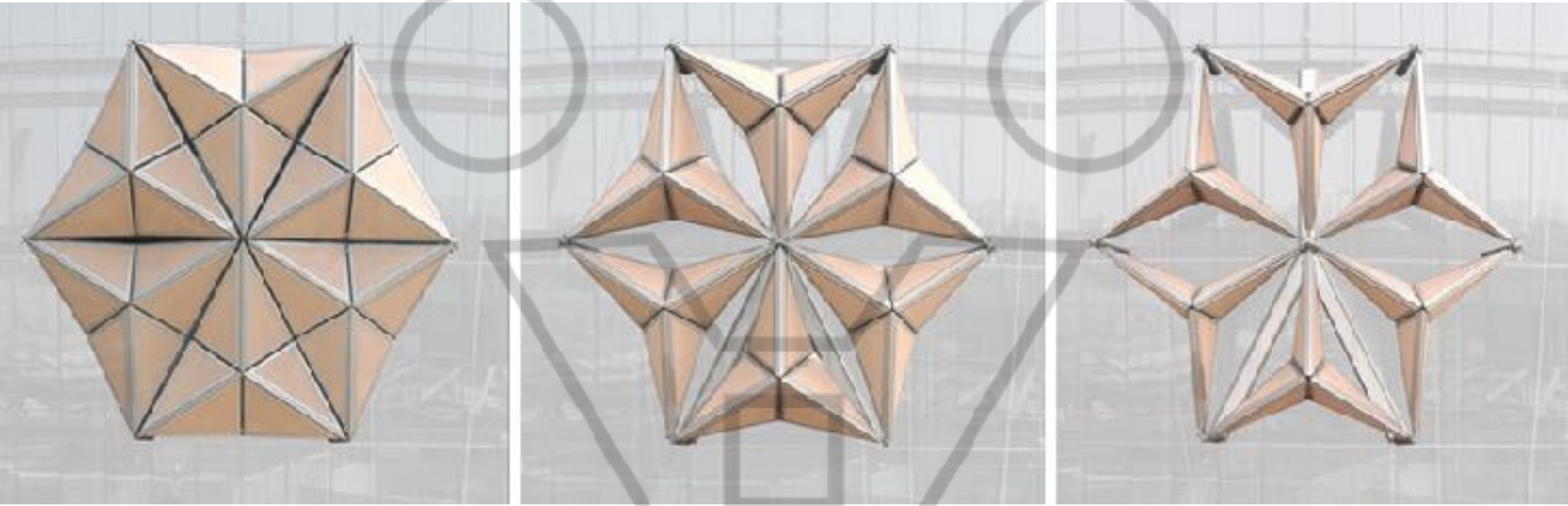
2,000 umbrellas

ORIGAMI AND DEPLOYABLE ARCHITECTURES

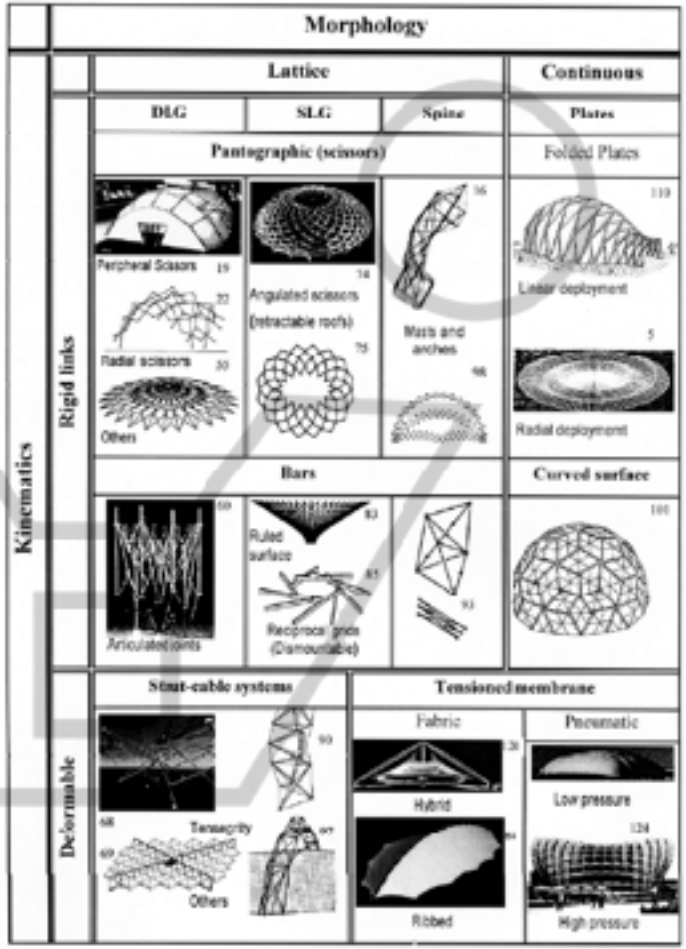


Ron Resch and his Deployable Origami

AHR (formerly Aedas UK) (2009-12), **Al Bahr Towers**, Abu Dhabi City, United Arab Emirates



AHR (formerly Aedas UK) (2009-12), **Al Bahr Towers**, Abu Dhabi City, United Arab Emirates



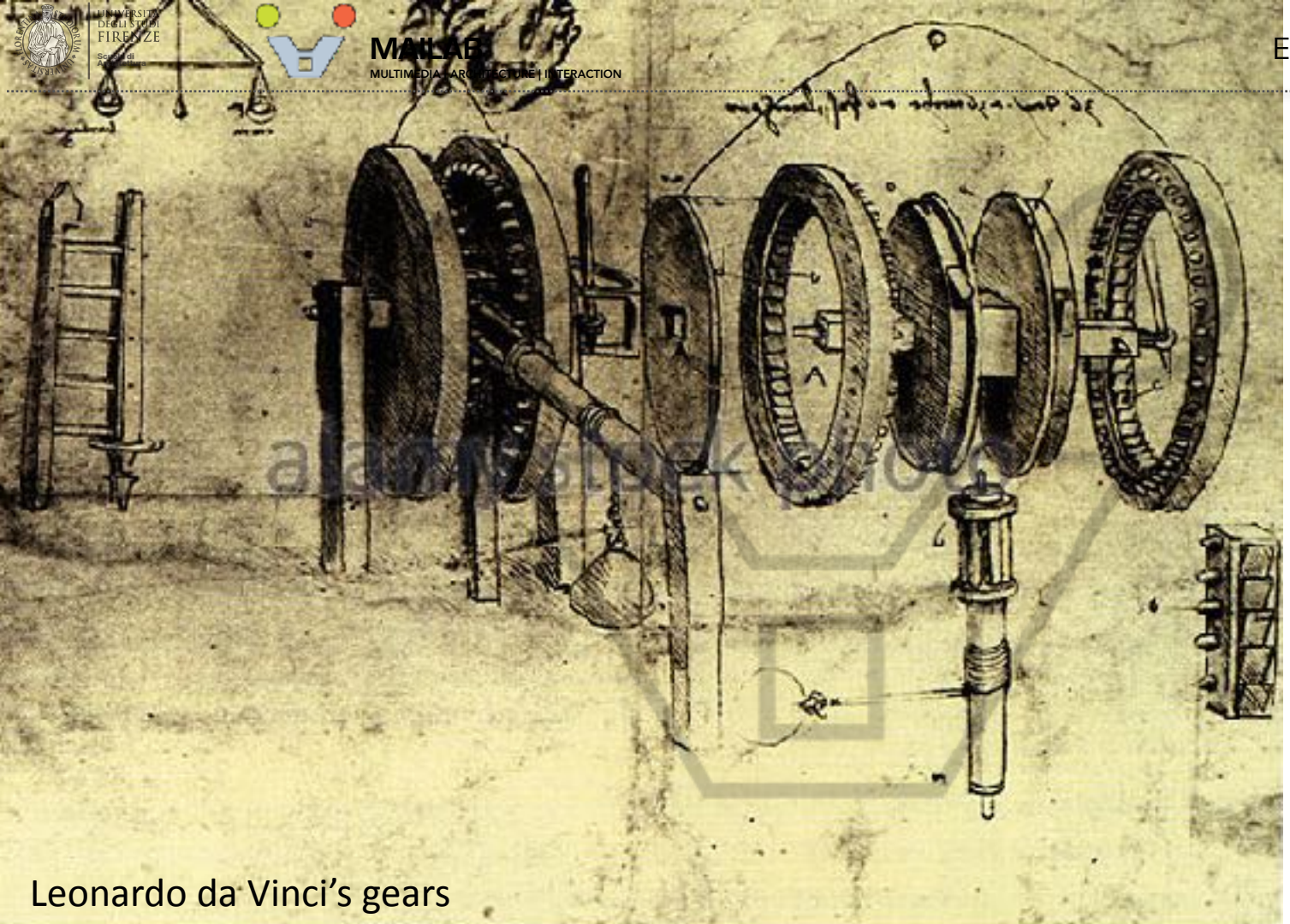
Variable Geometry Structures

Hanaor A. and Levy R., 2001. , Classification of VGSs on the basis on their morphological and kinematic characteristics

DEPLOYABILITY:
GEARS & SMART ACTUATORS

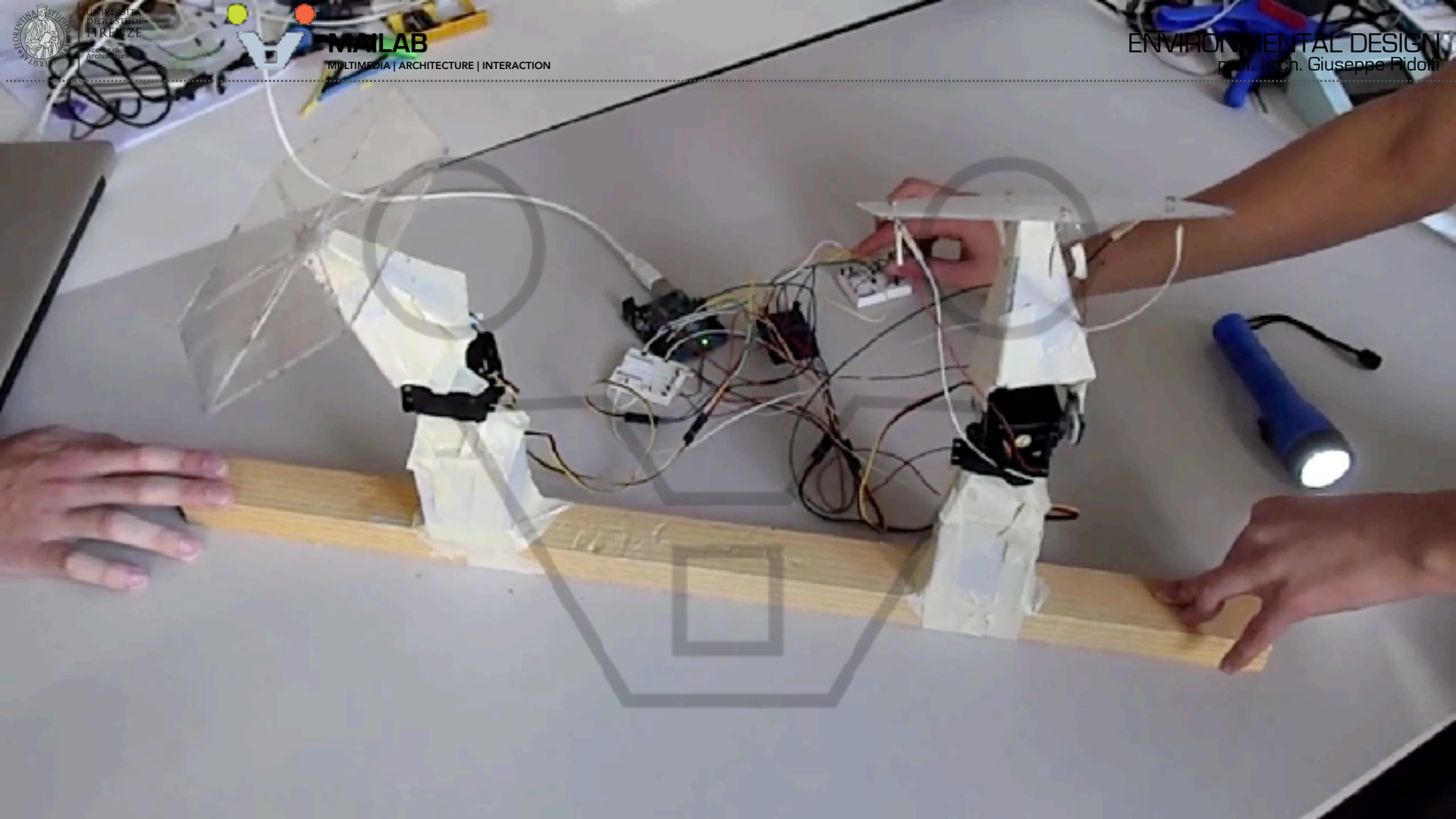
servos
pneumatic
smart metal alloy
nanotechnologies

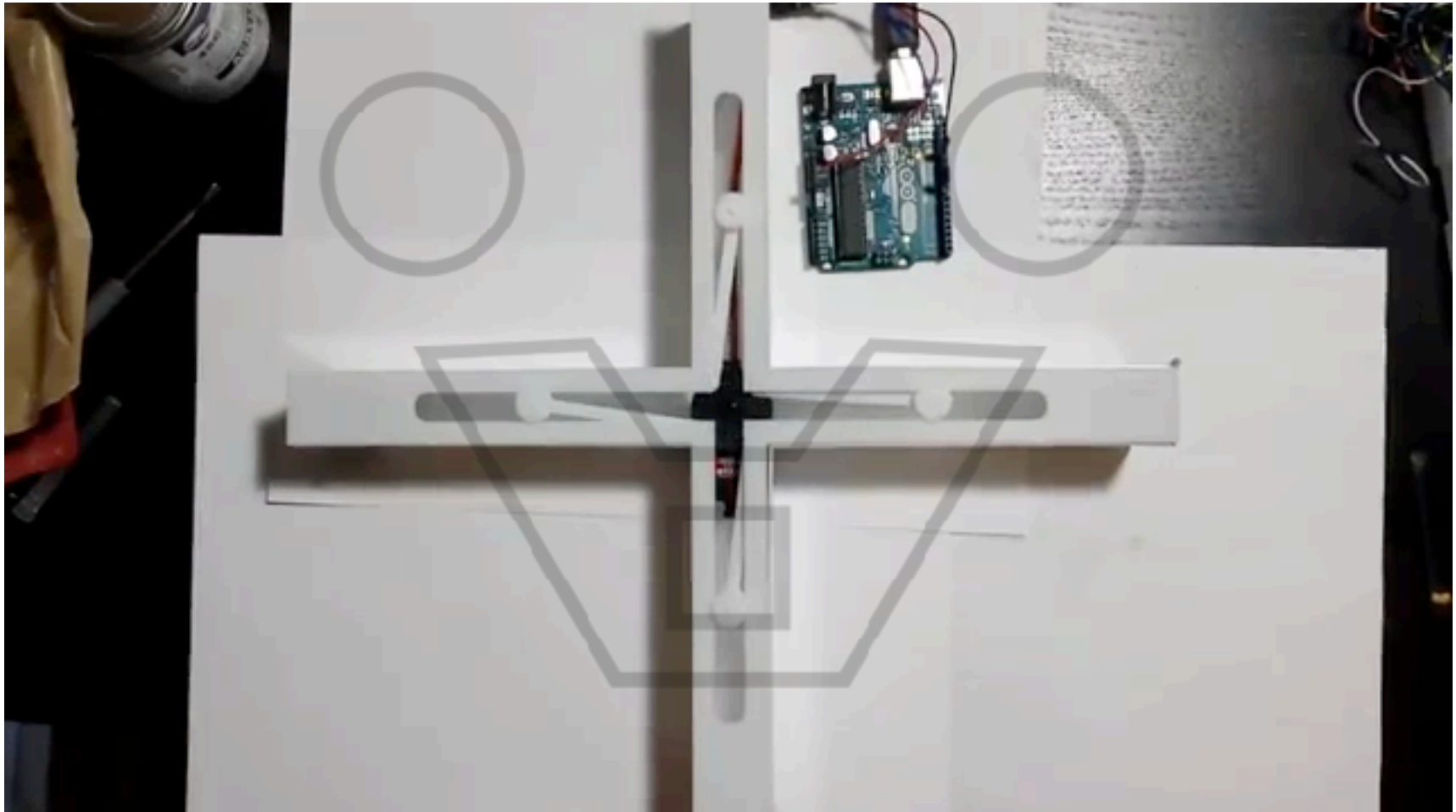
SERVOS
linear & rotating actuators

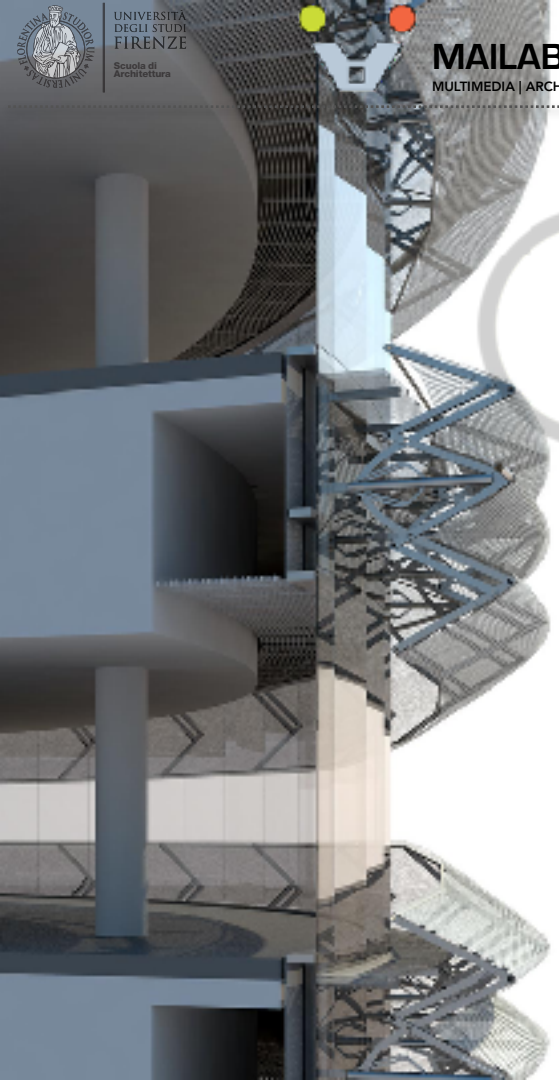


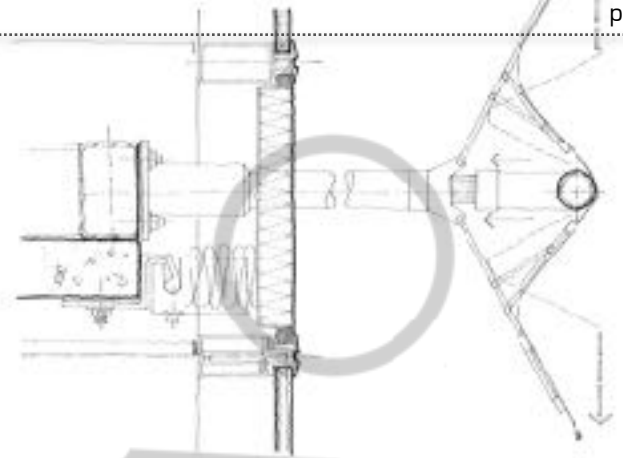
Leonardo da Vinci's gears

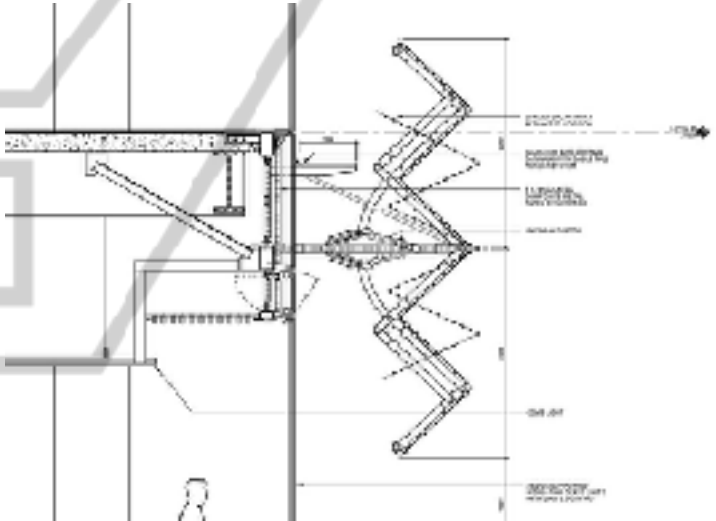

KINETIC WALL
14th International Architecture Exhibition





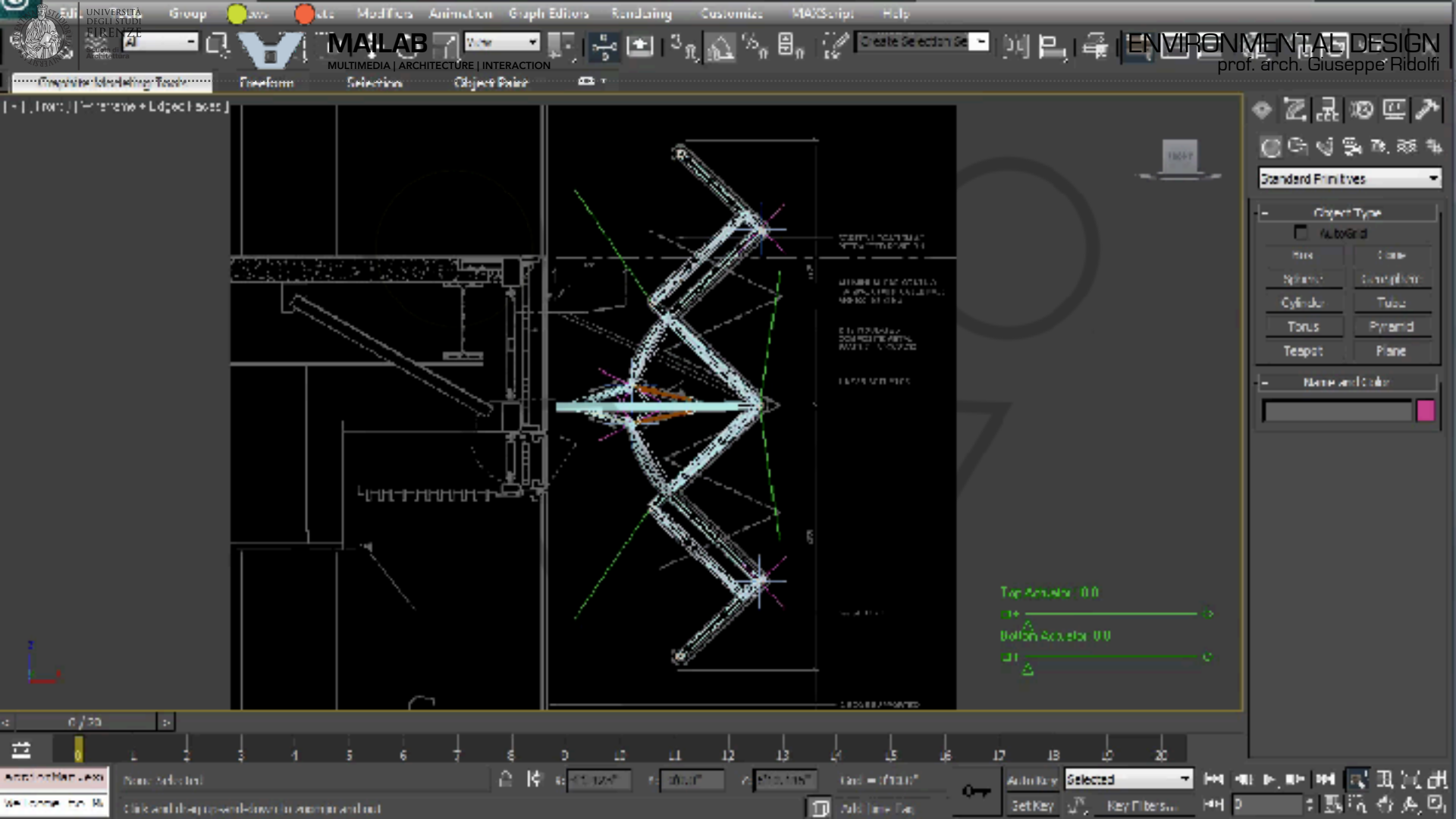


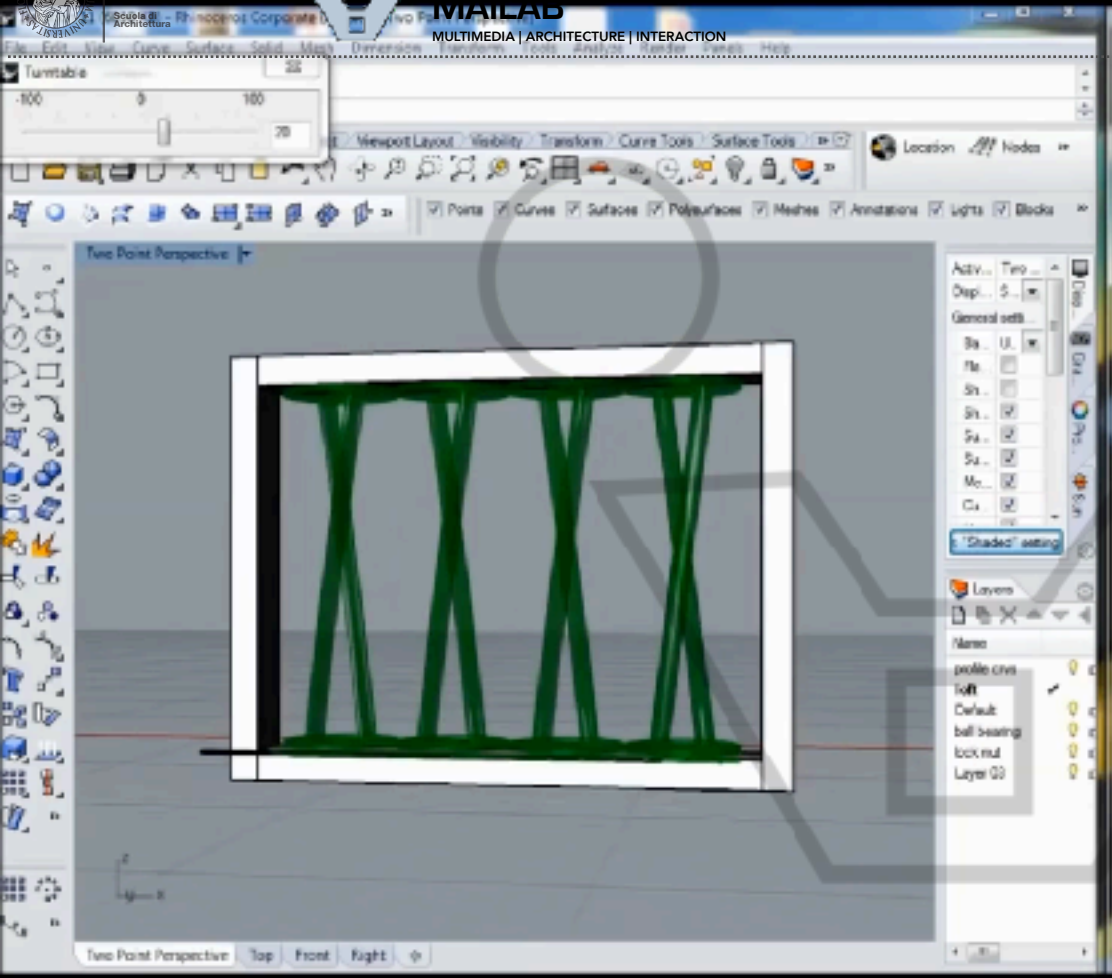


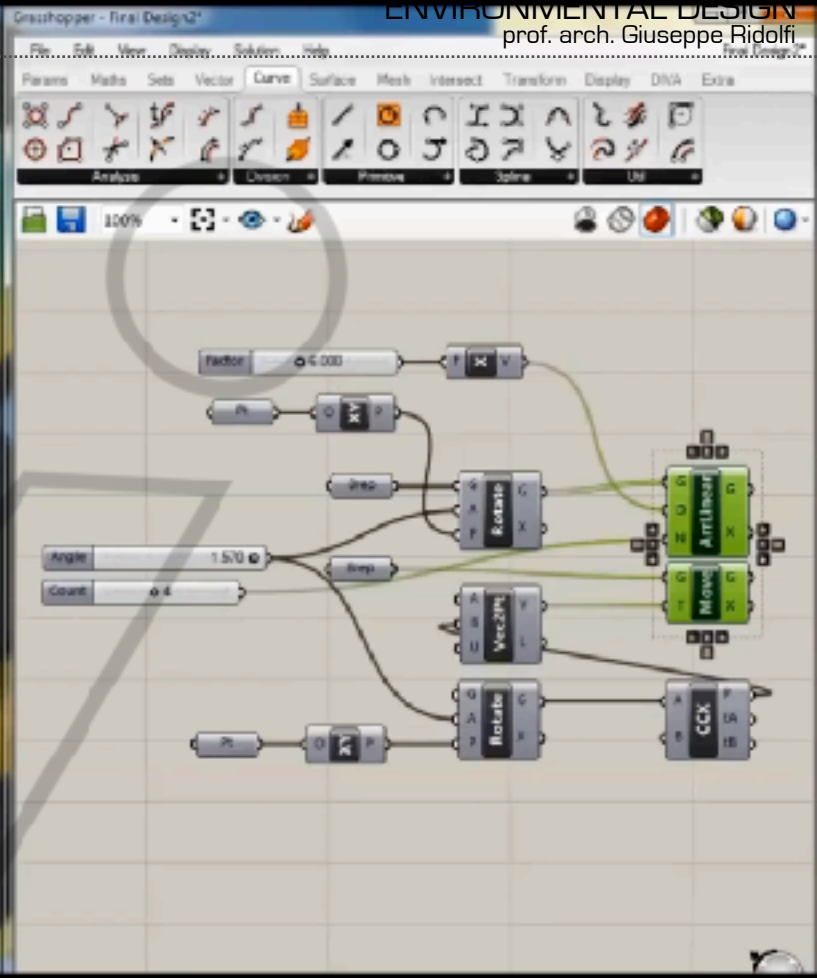


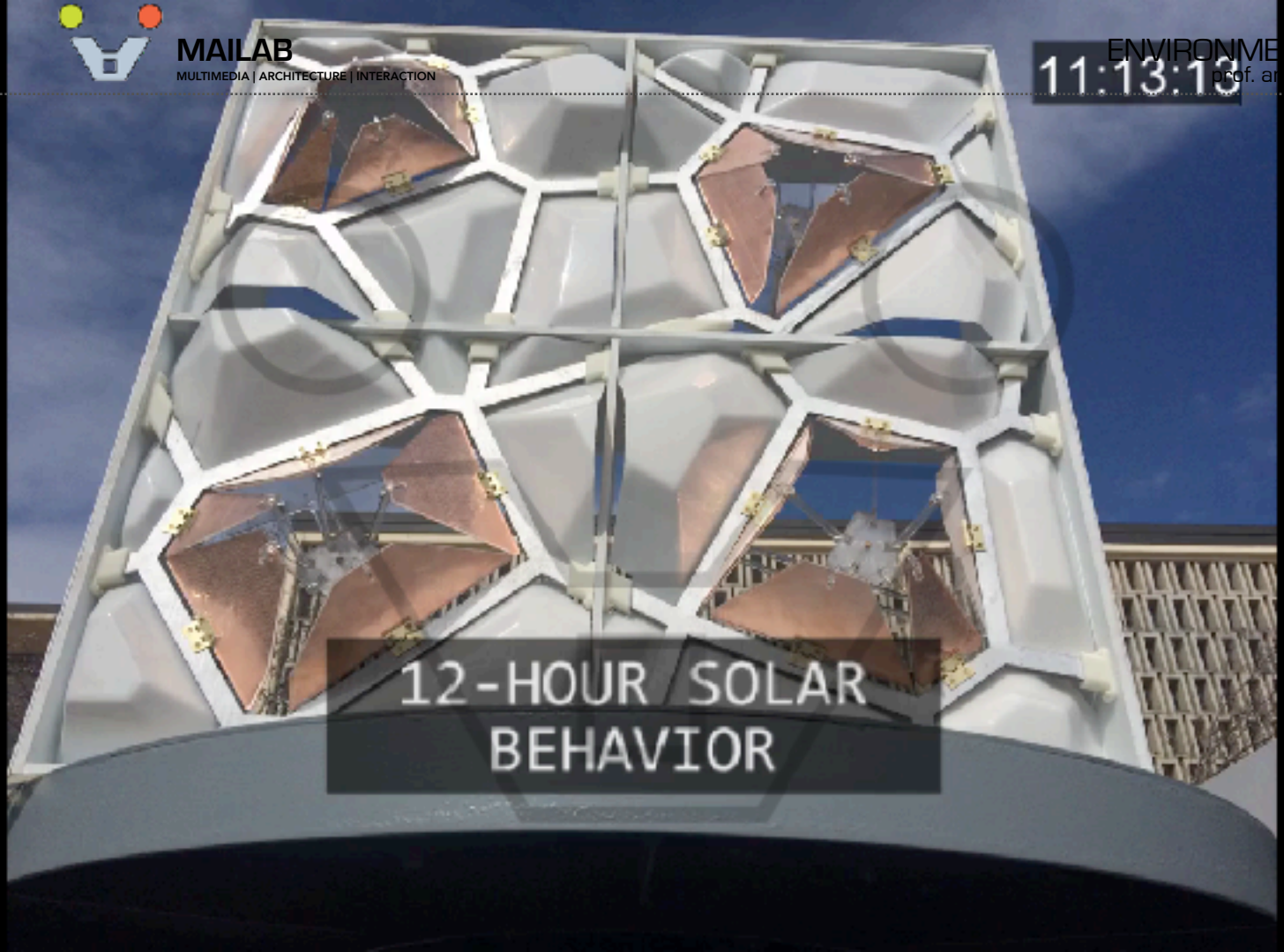
from character animation
inverse kinematics
wire parameters animation constraints
originally intended for use in character within 3ds Max .

AUTODESK 3DS MAX
INVENTOR
SOLIDWORKS
Bongo
KANGAROO

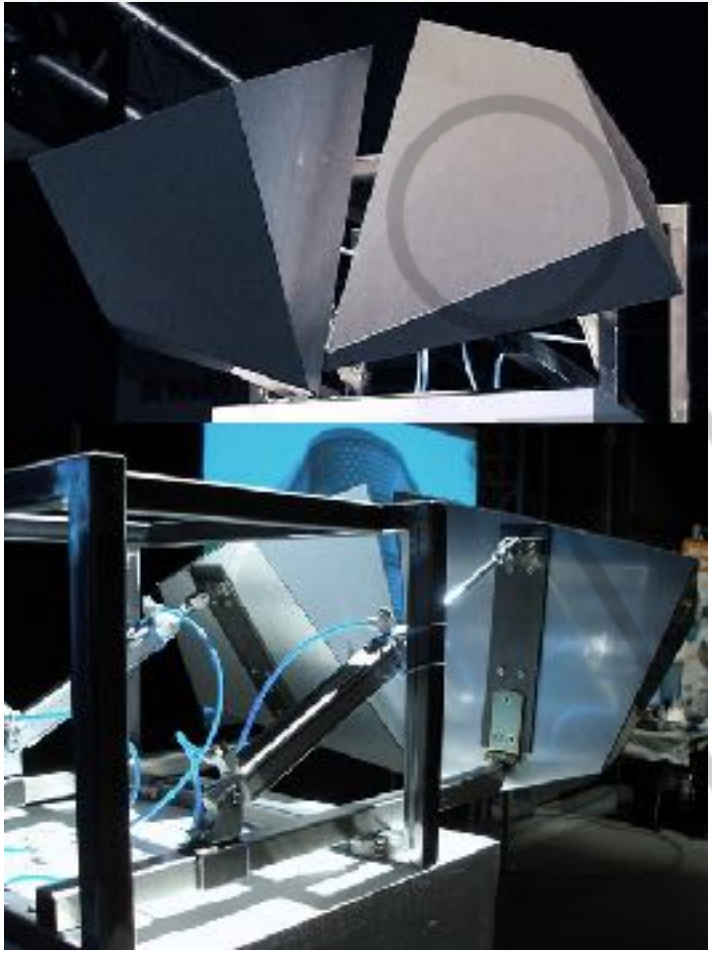

Edit
Group
Views
Create
Modifiers
Animation
Graph Editors
Rendering
Customize
MAXScript
Help
Freeform
Selection
Object Paint
Standard Primitives
Object Type
AutoGrid
Box
Cone
Sphere
GeoSphere
Cylinder
Tube
Torus
Pyramid
Teapot
Plane
Name and Color


Turntable
Two Point Perspective
Top
Front
Right
Layers


Grasshopper - Final Design2*
Curve
Surface
Mesh
Intersect
Transform
Display
Factor
Angle
1.570
Count
4
Rotate
Rotate
CCX

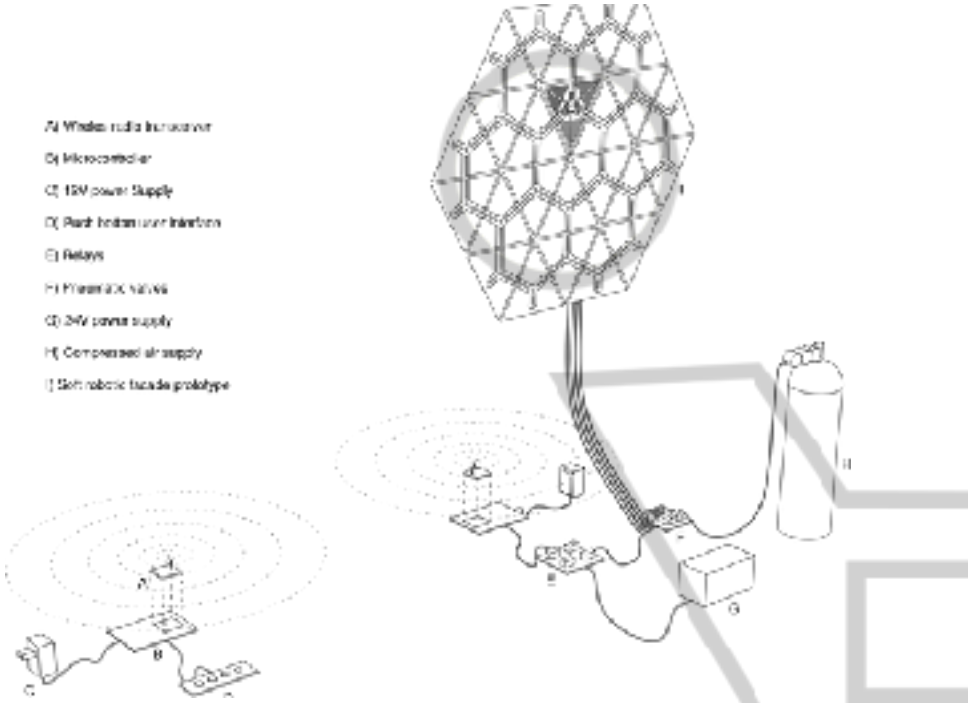

11:13:13
12-HOUR SOLAR
BEHAVIOR

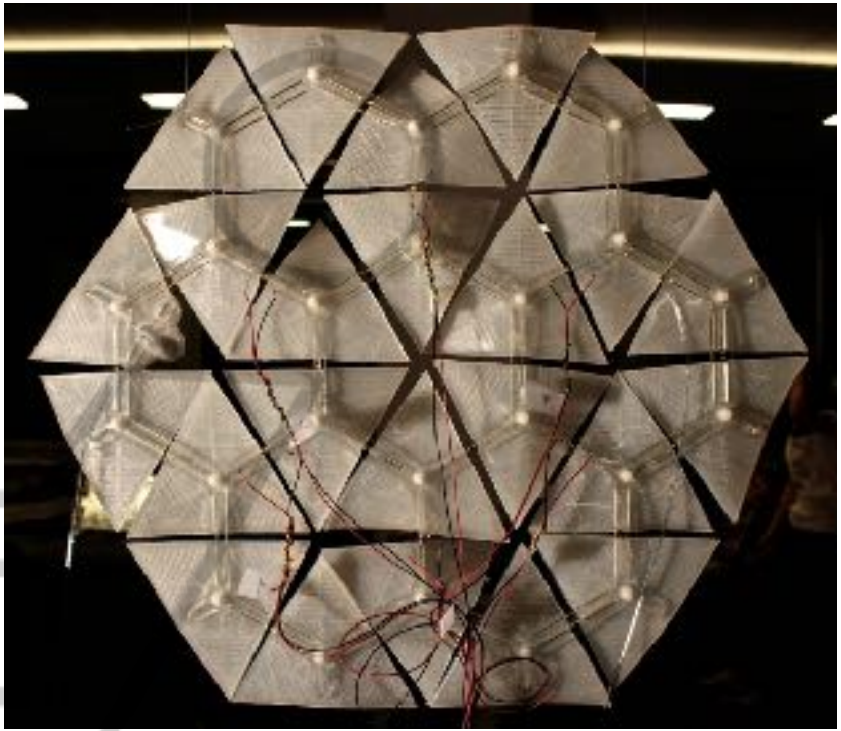
PNEUMATIC



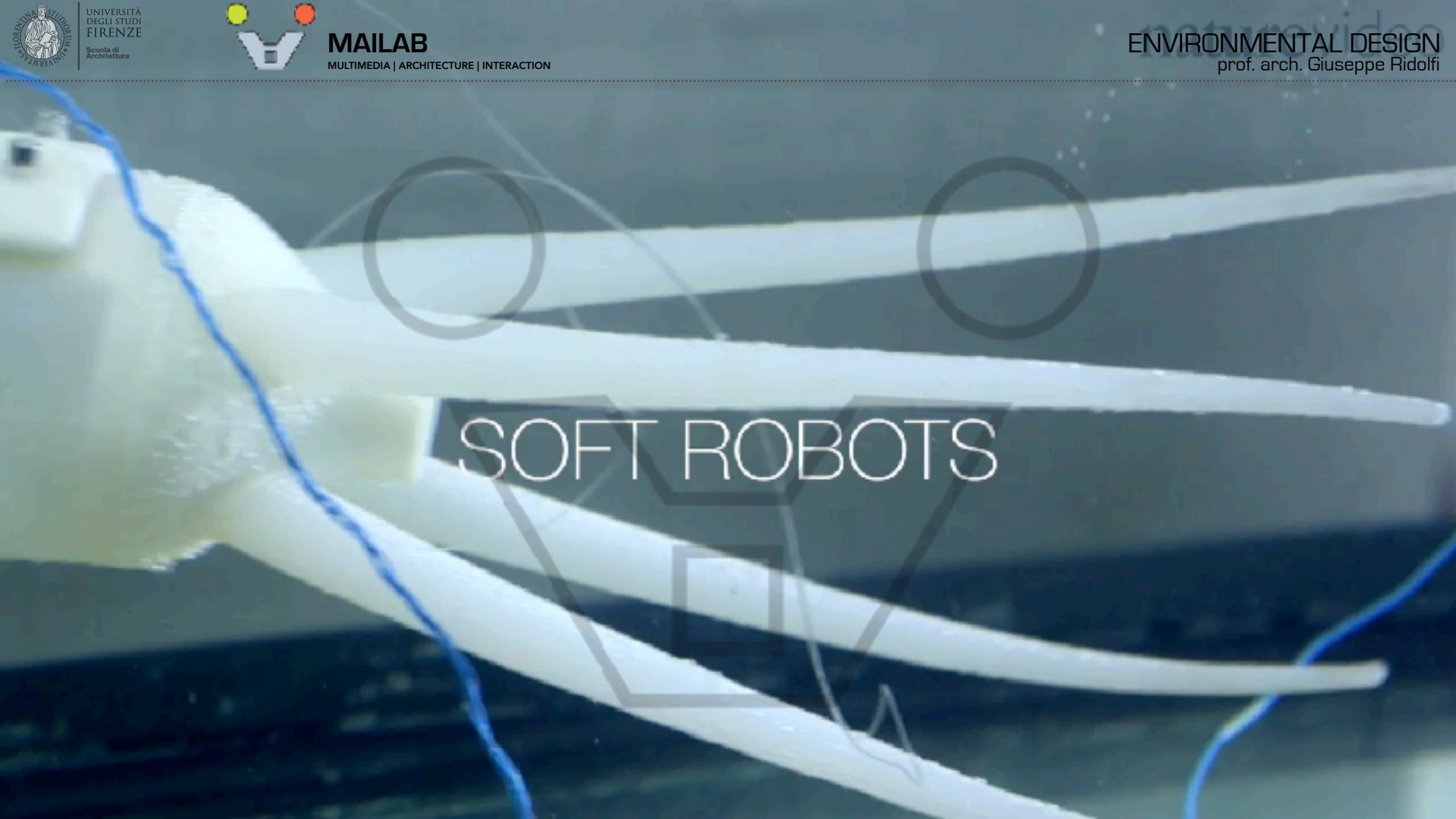
PNEUMATIC PISTONS

A) Wireless radio transceiver
B) Microcontroller
C) 15V power Supply
D) Pixel bottom layer interface
E) Relays
F) Pneumatic valves
G) 24V power supply
H) Compressed air supply
I) Soft robotic facade prototype

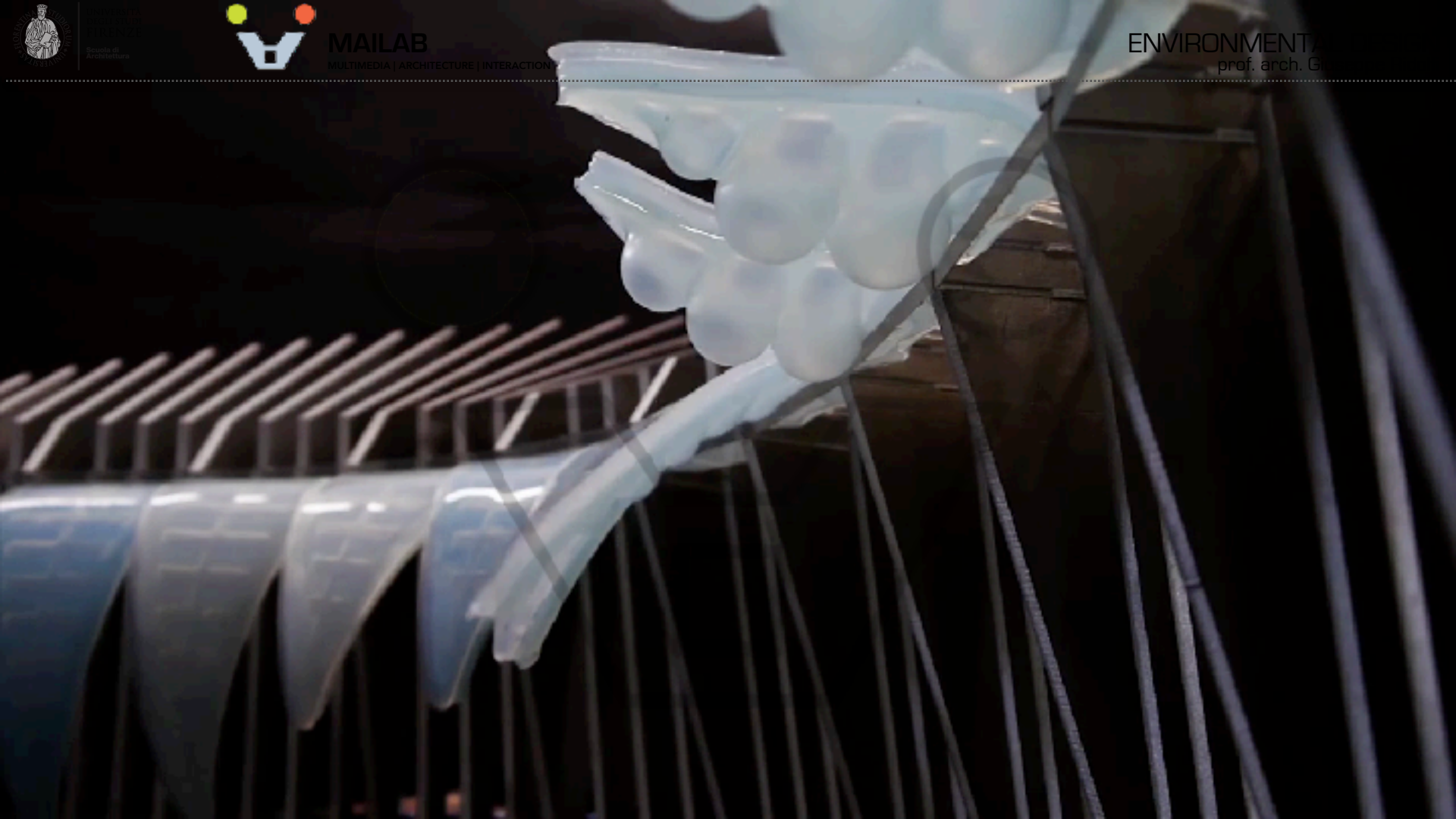




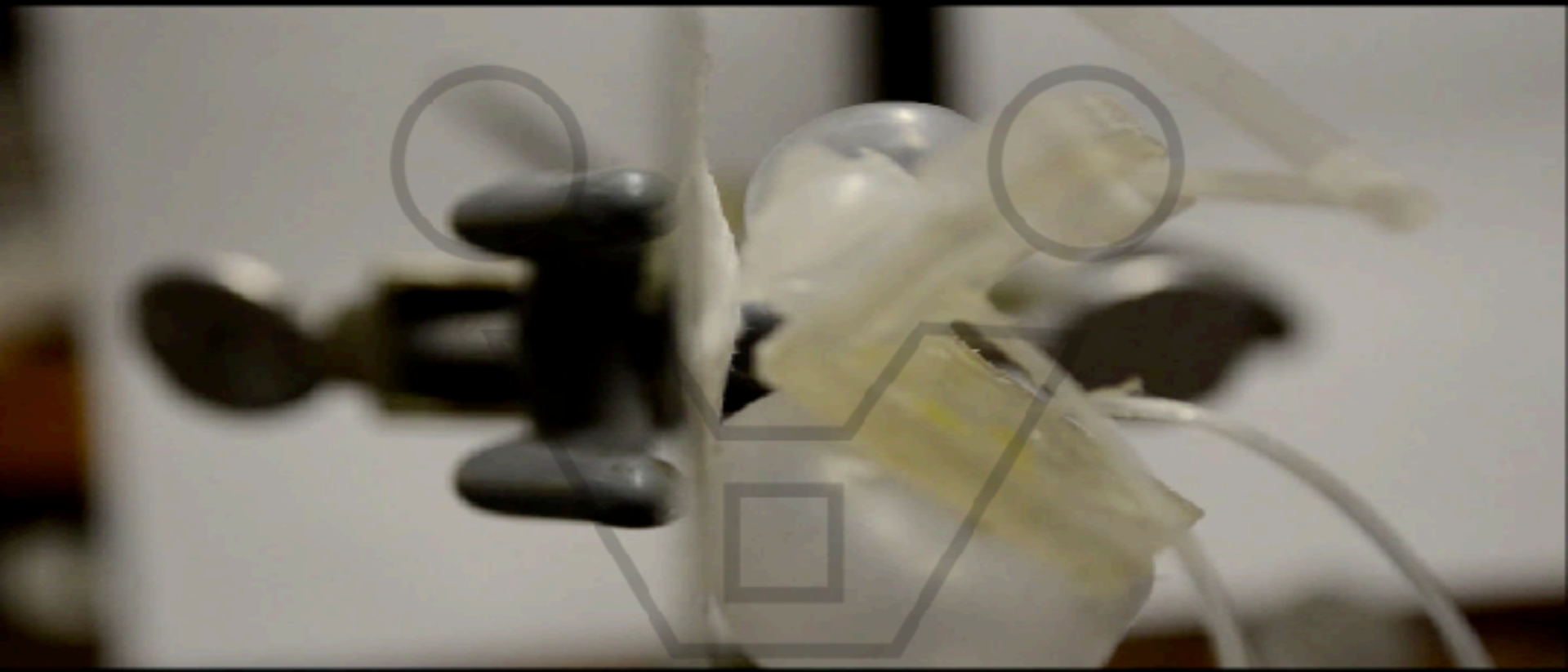
Ecoflex® 00-30 100X100 mm

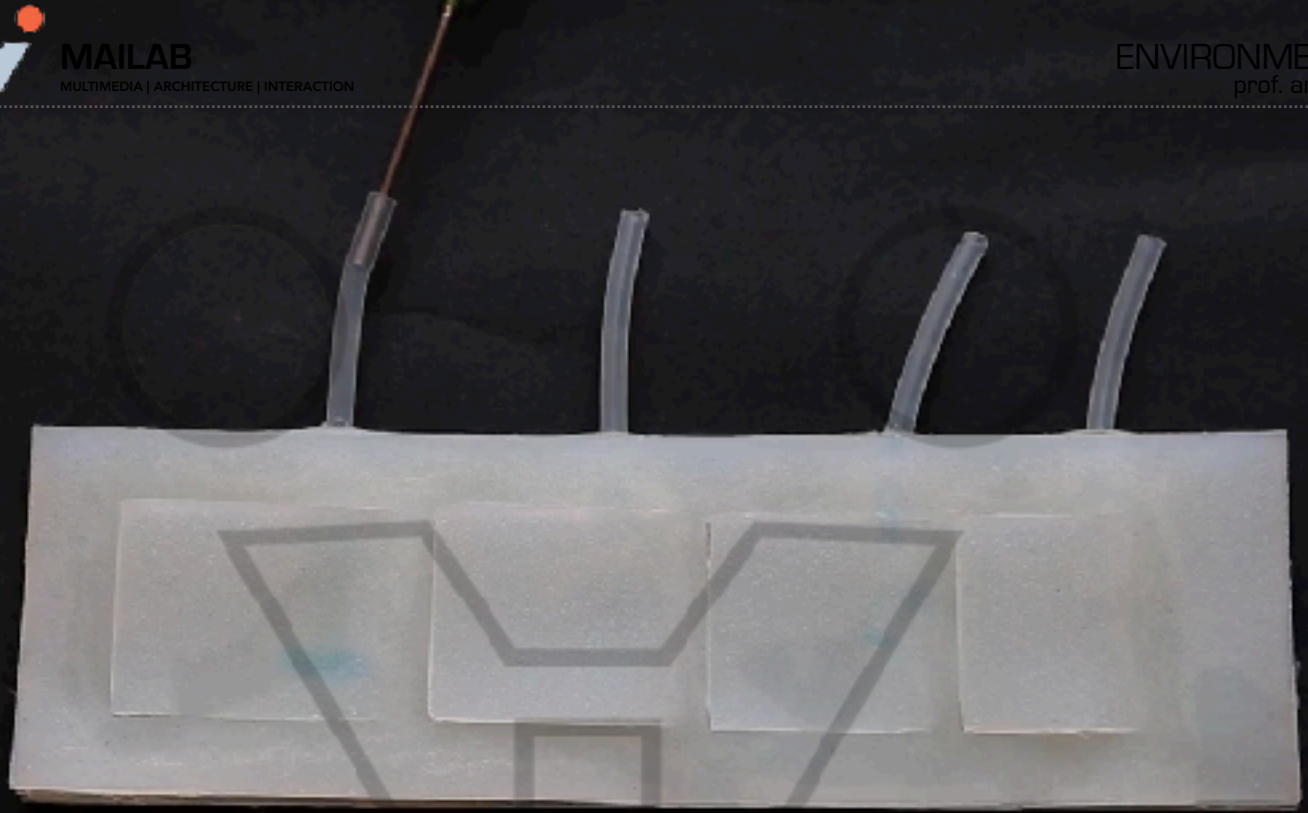

SOFT ROBOTS

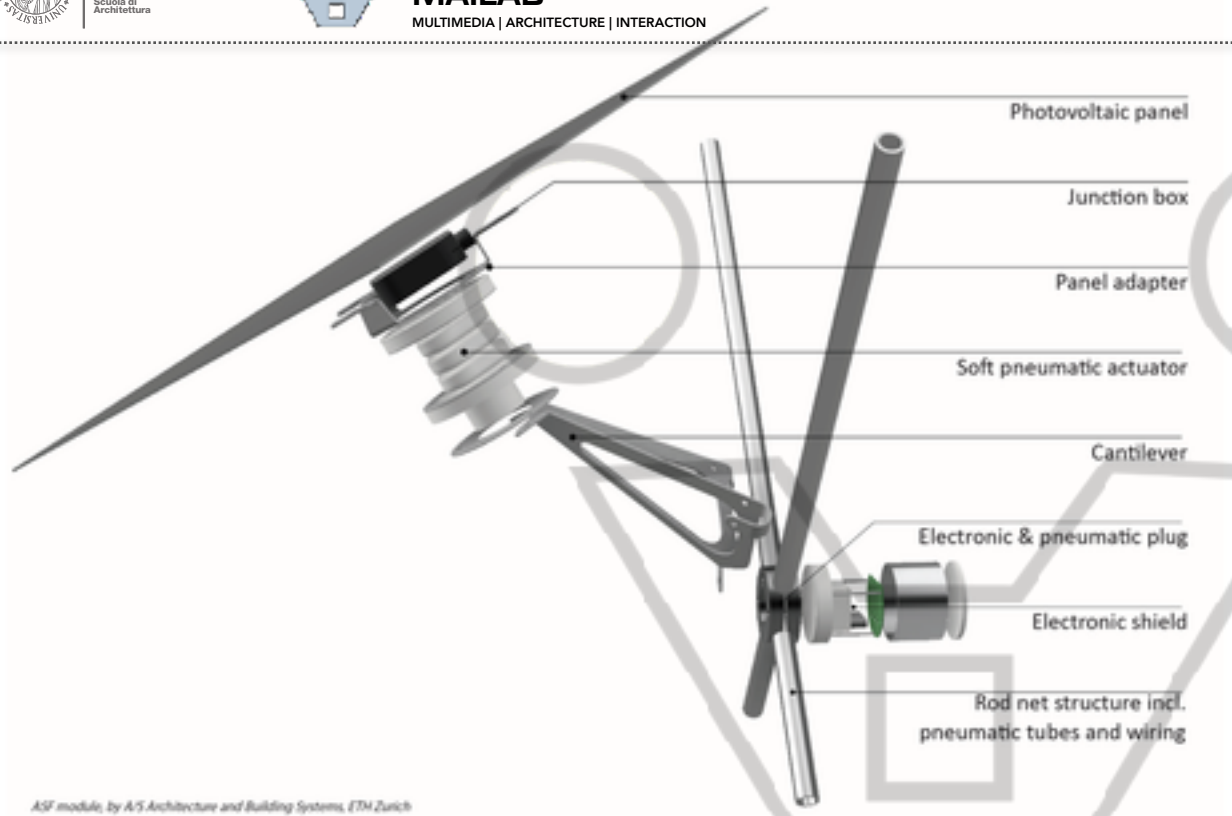
Artificial muscles
could make **soft robots**
safer and **stronger**



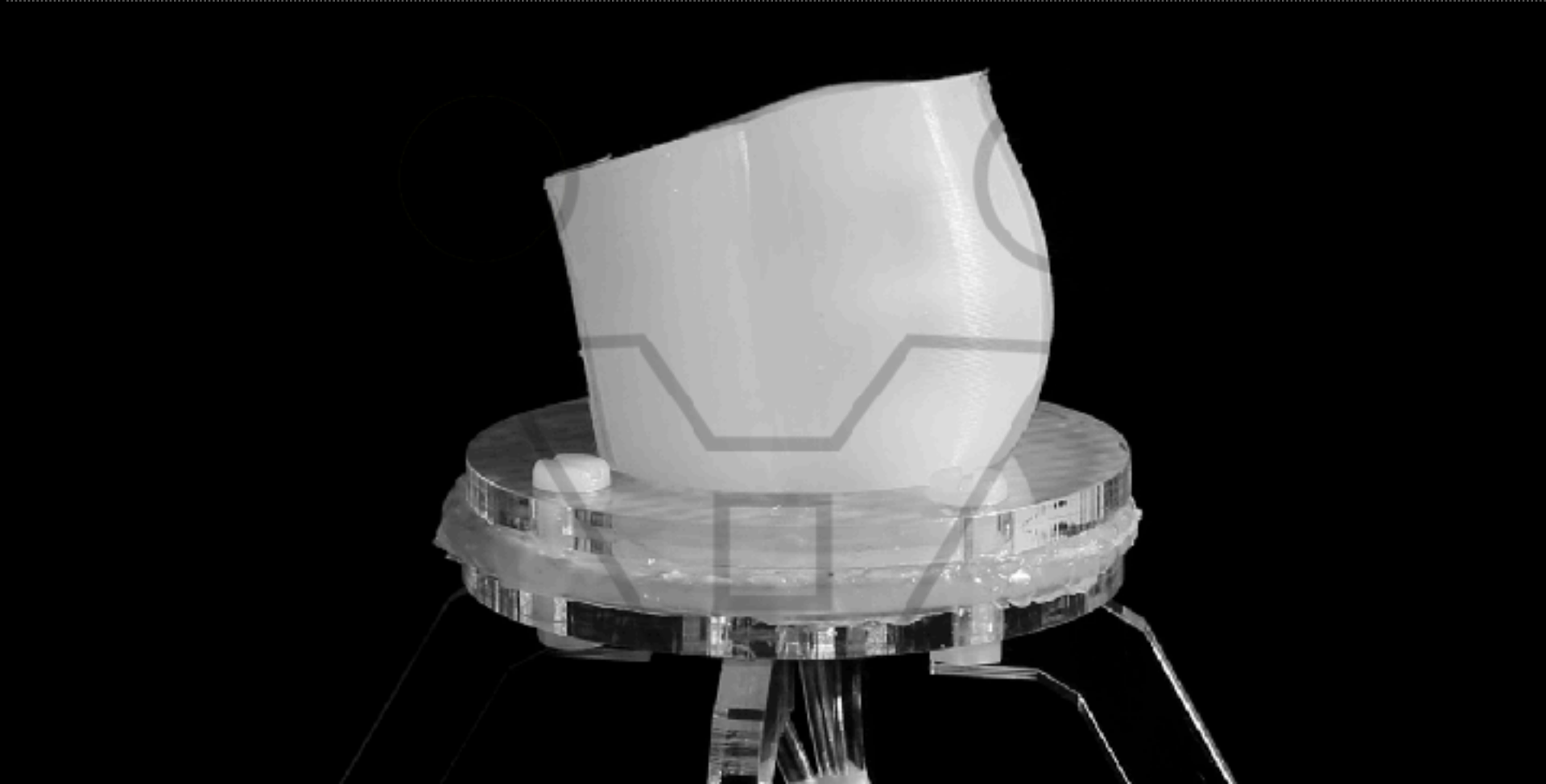

in order to support bi-directional communication between the modules.

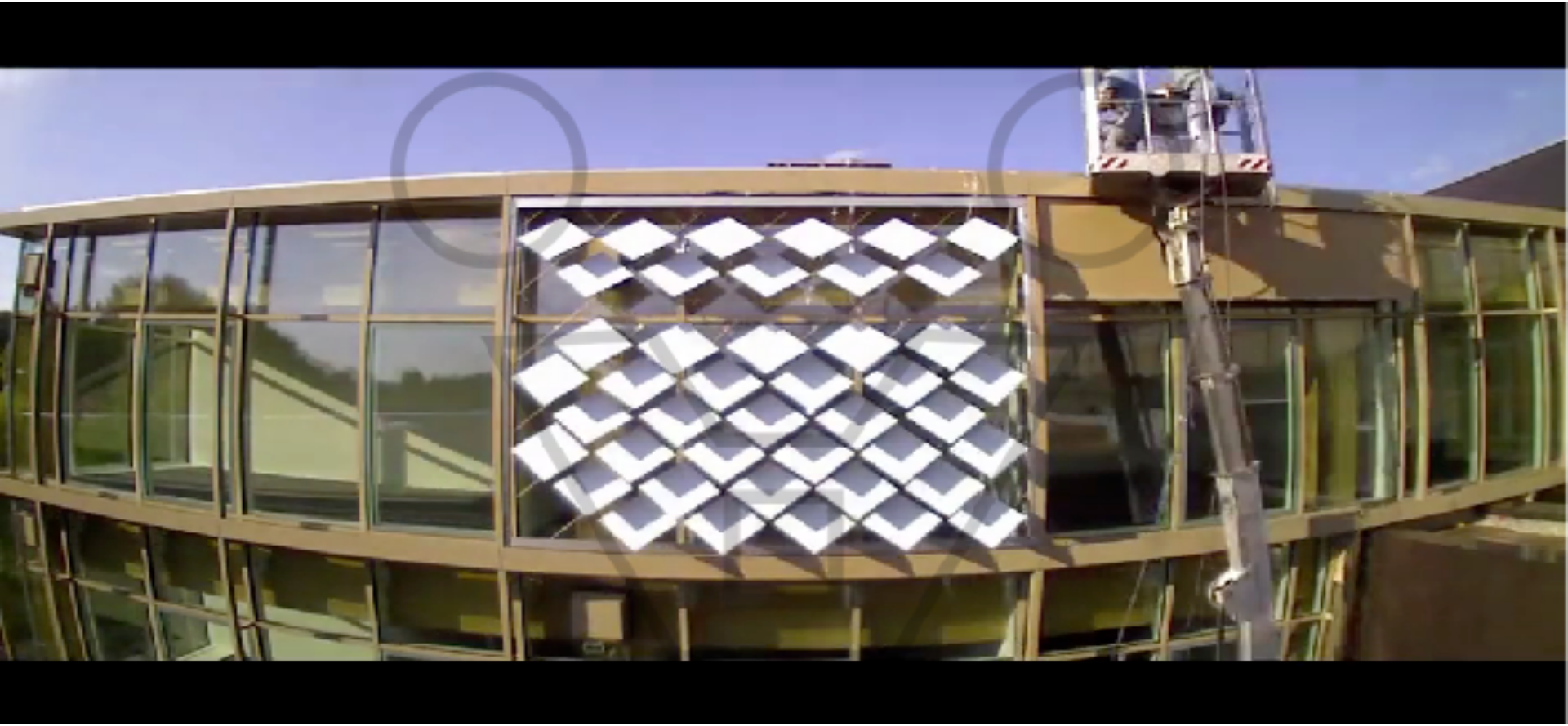


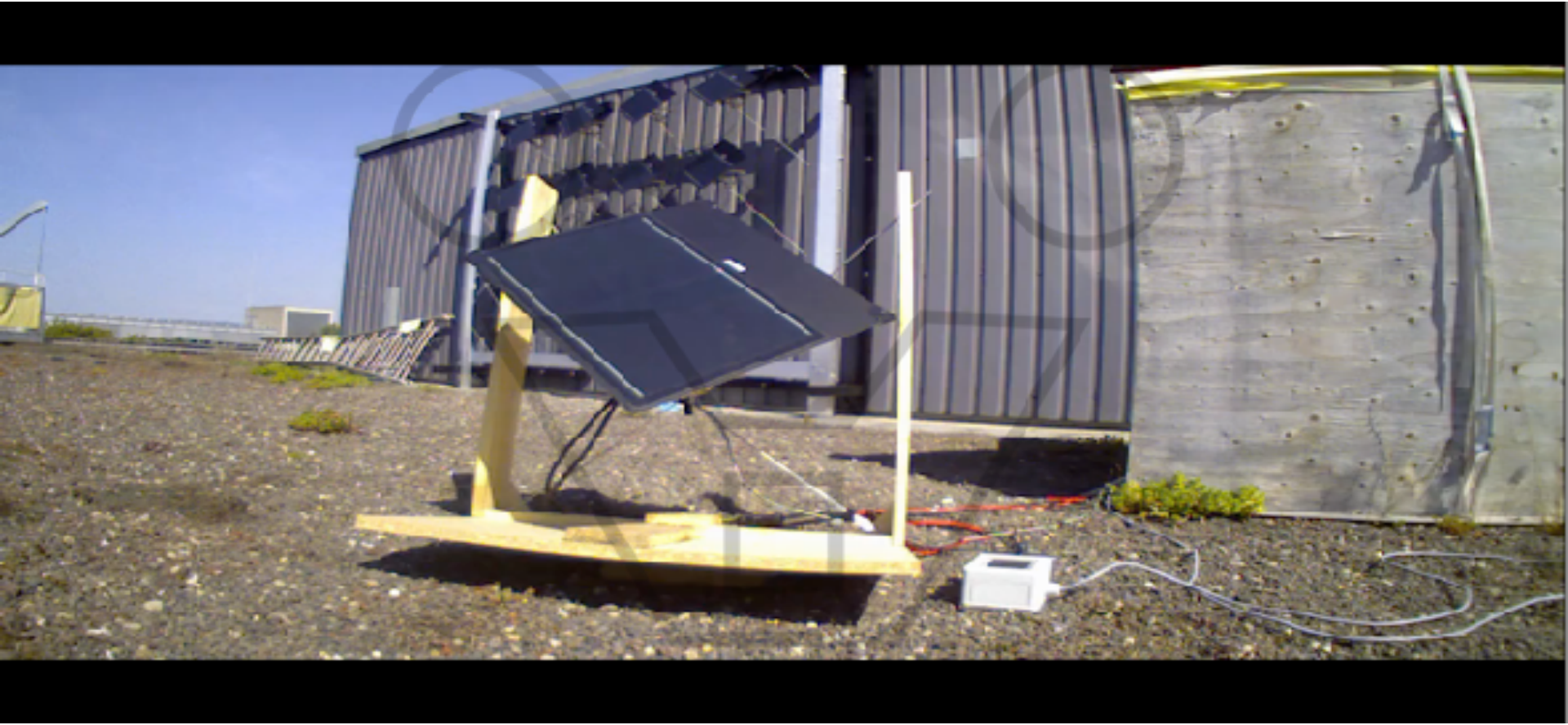




ASF module, by A/S Architecture and Building Systems, ETH Zurich

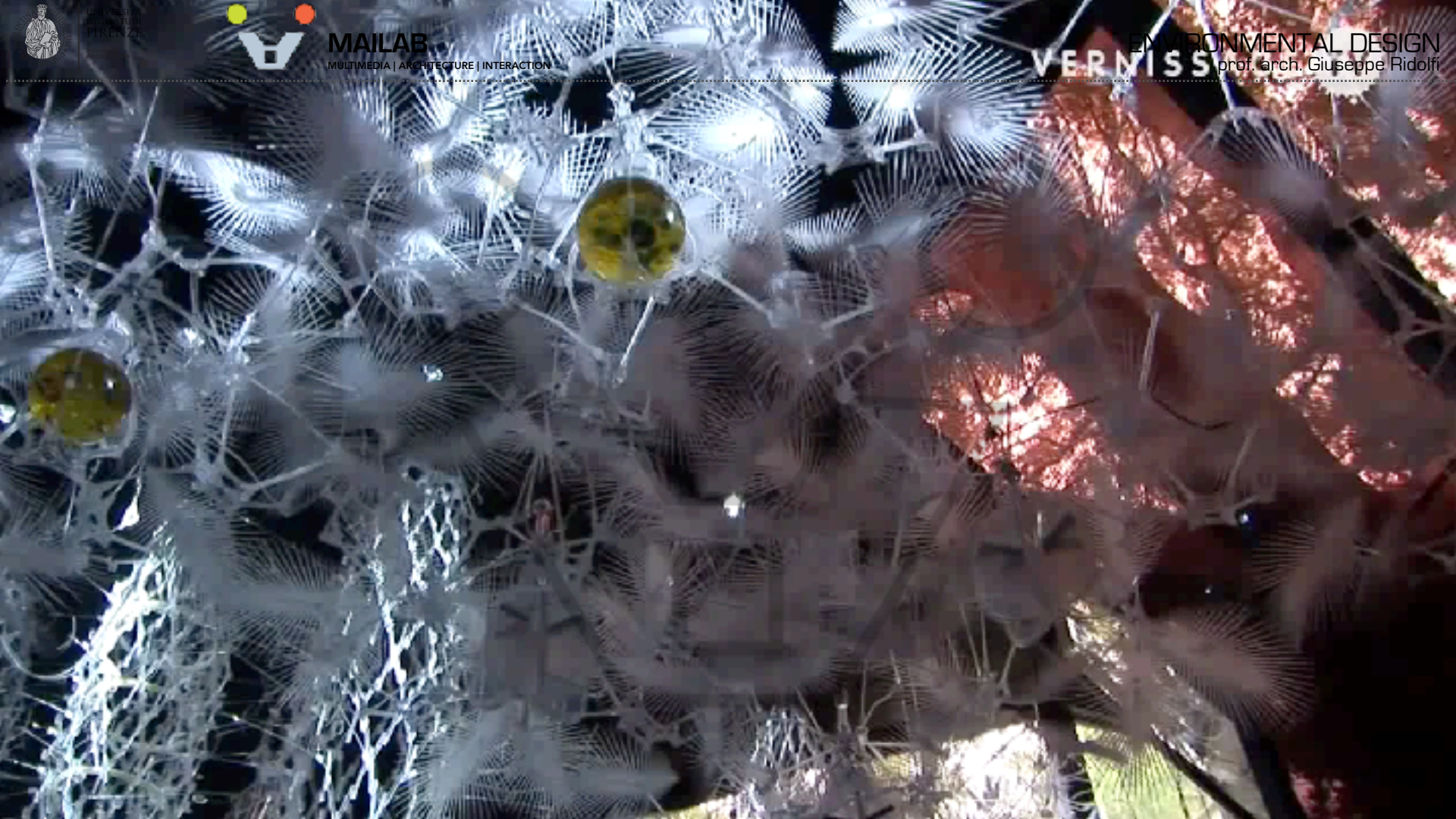






SMART METAL ALLOYS

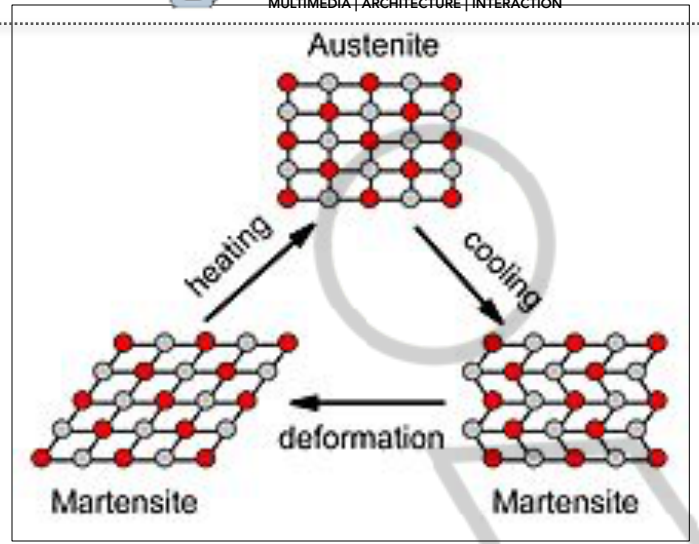
NITINOL E BIMETALS

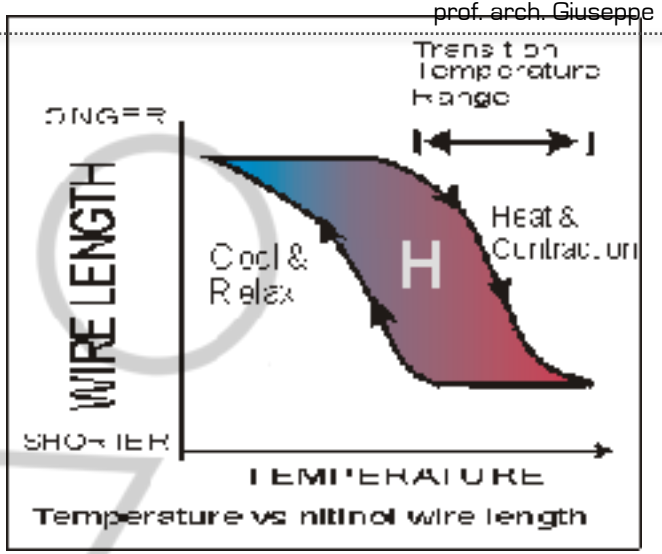

VERNISS

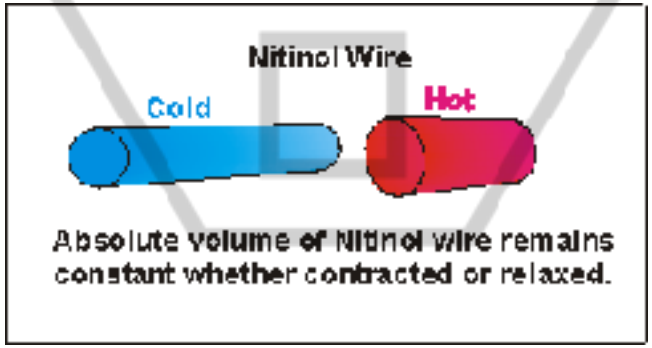
DYNAMIC +TENSEGRITY

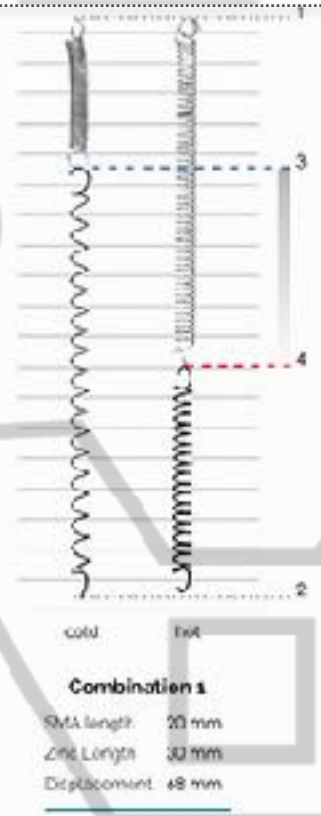
Tristan d'Estree Sterk+Orambra,


MASTER IN ADVANCED ARCHITECTURE
Digital Matter - Intelligent Constructions
2014 - 15
SELF - ADAPTIVE
MEMBRANE
KINETIC PASSIVE SYSTEM


Austenite
heating
cooling
deformation
Martensite
Martensite

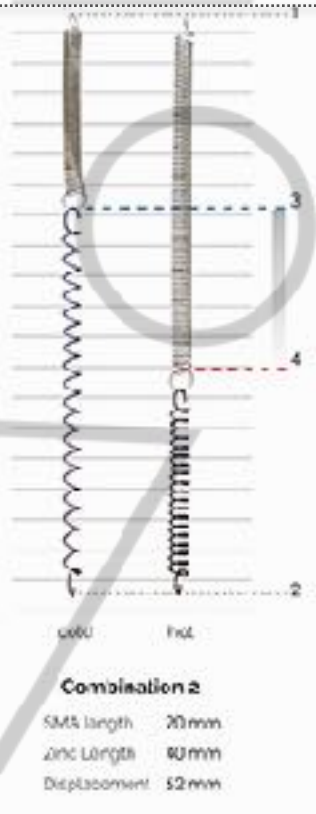

WIRE LENGTH
Cool &
Relax
H
Heat &
SHORTER
TEMPERATURE
Temperature vs nitinol wire length


Nitinol Wire
Cold
Hot
Absolute volume of Nitinol wire remains
constant whether contracted or relaxed.



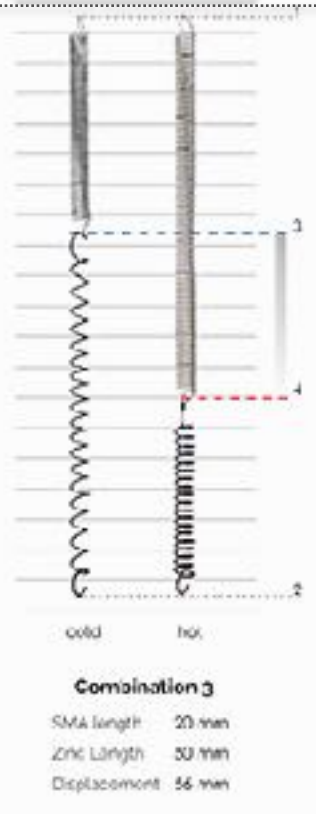
Combination 1

SMA length	20 mm
Zinc Length	30 mm
Displacement	48 mm



Combination 2

SMA length	20 mm
Zinc Length	40 mm
Displacement	52 mm



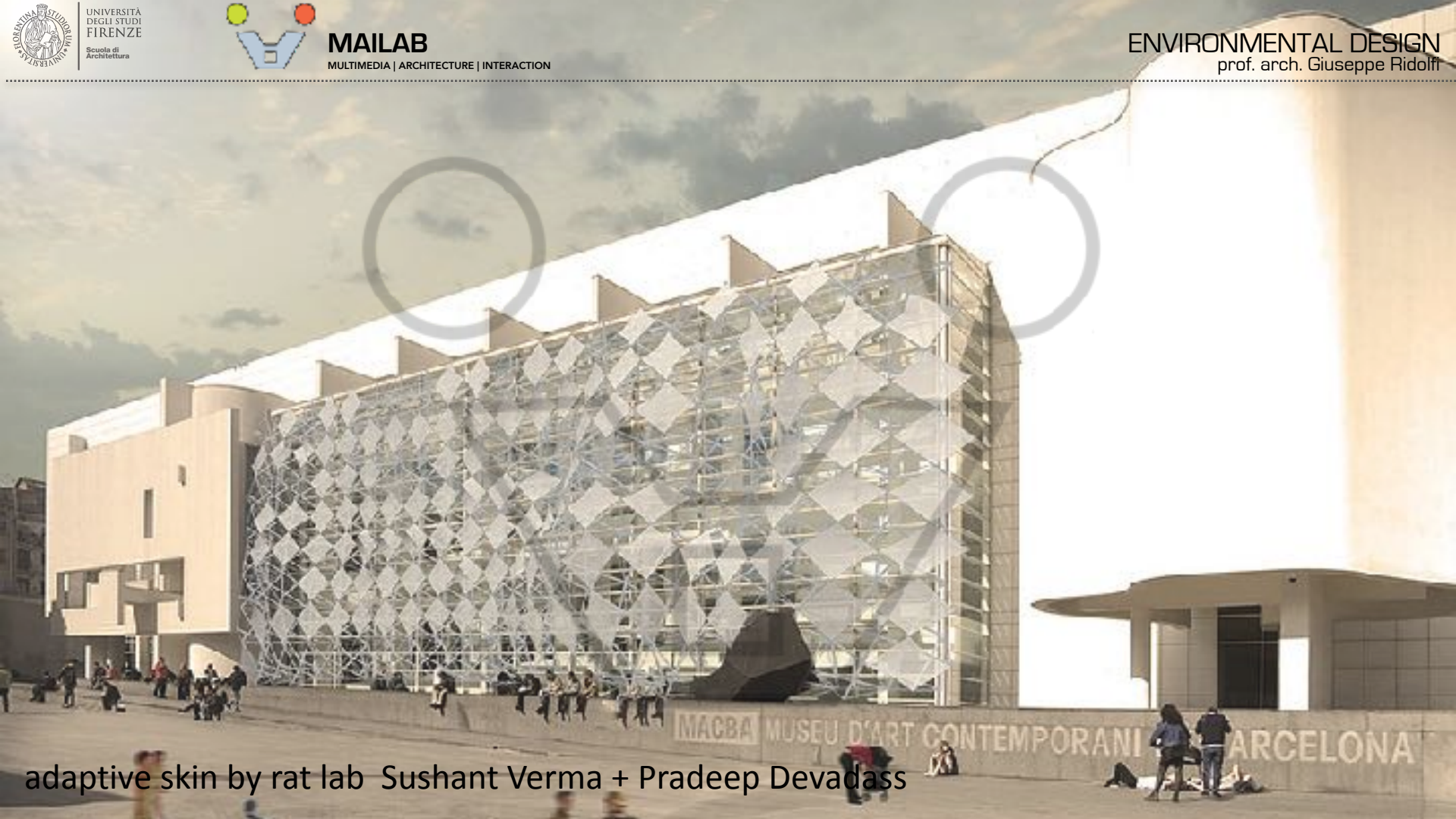
Combination 3

SMA length	20 mm
Zinc Length	50 mm
Displacement	56 mm

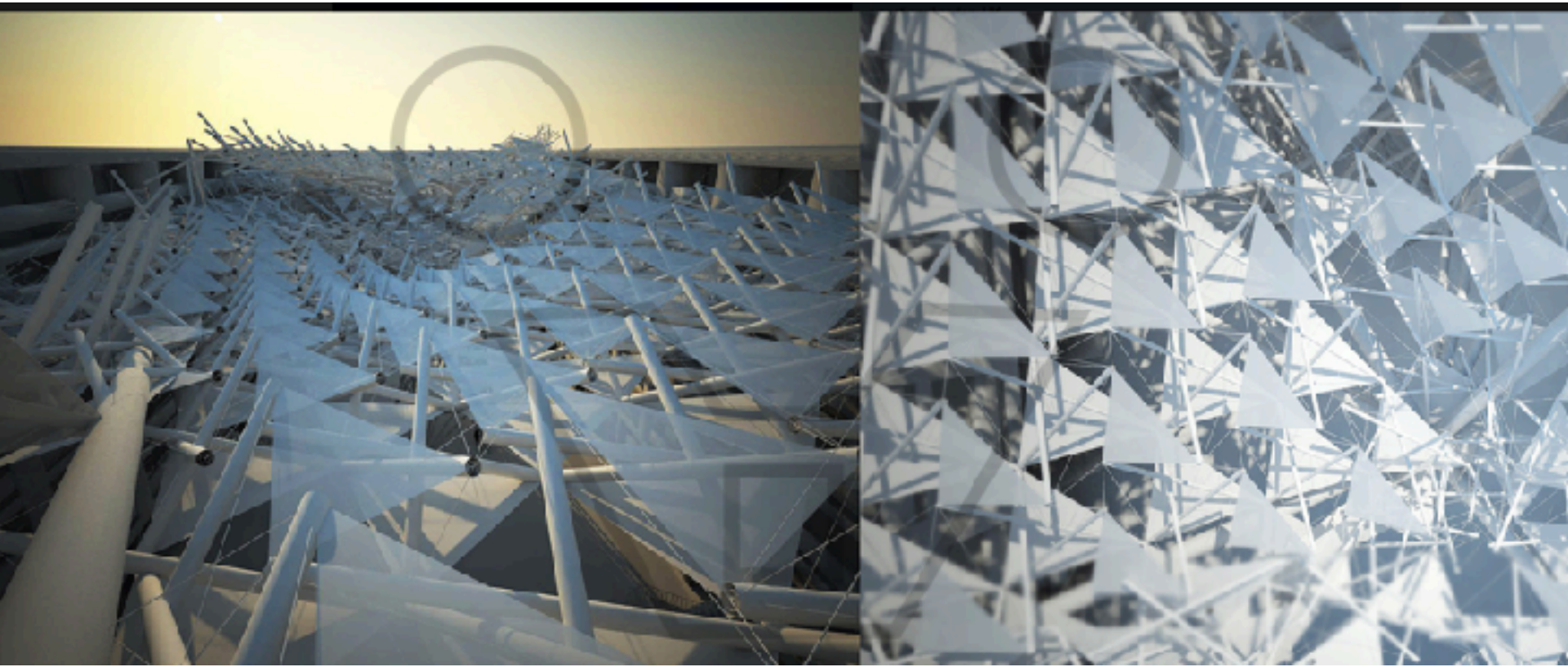
Reef

Rob Ley - *Urbana*
ley@urbanaarch.com

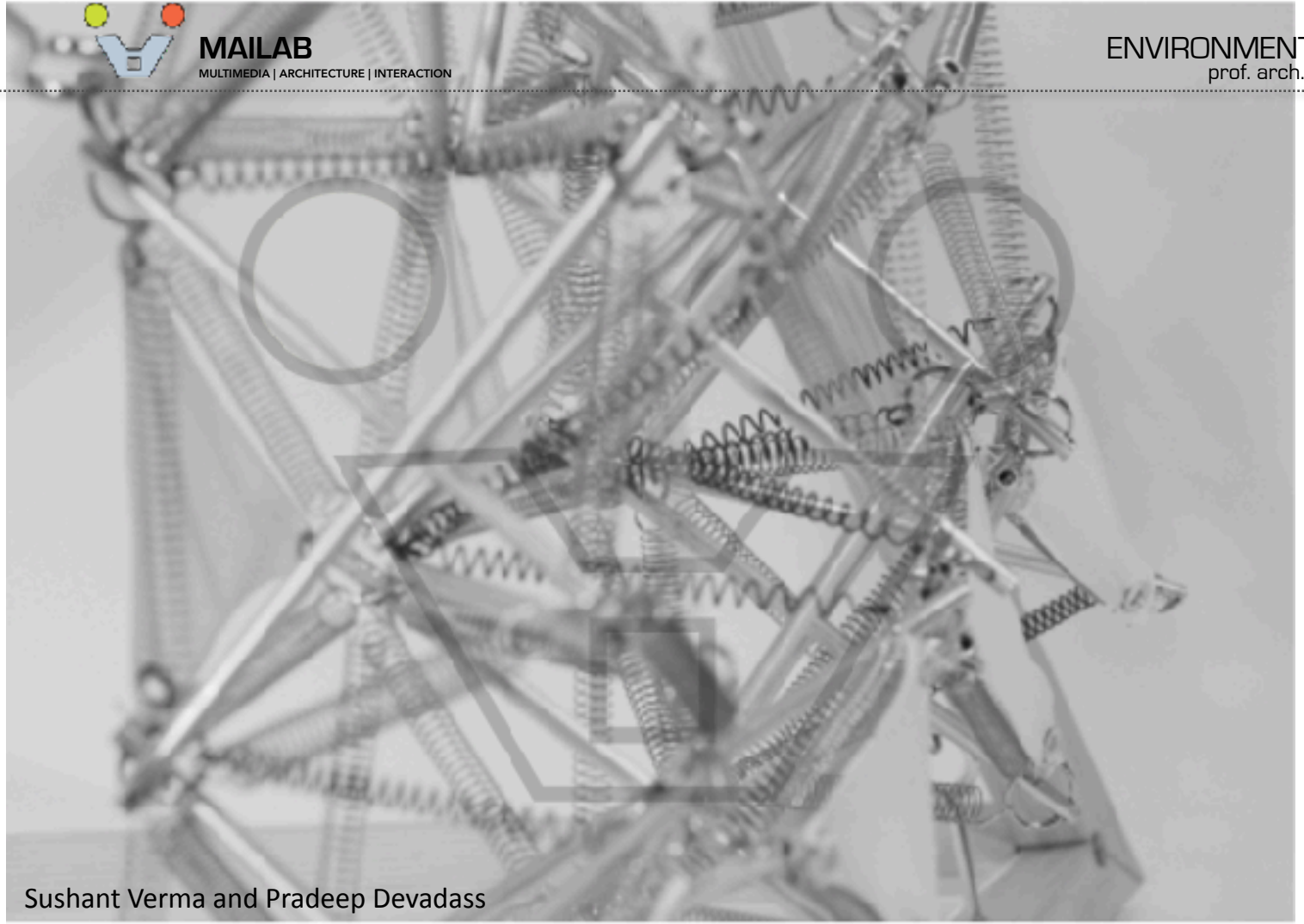
Joshua Stein - *Radical Craft*
jgstein@radical-craft.com



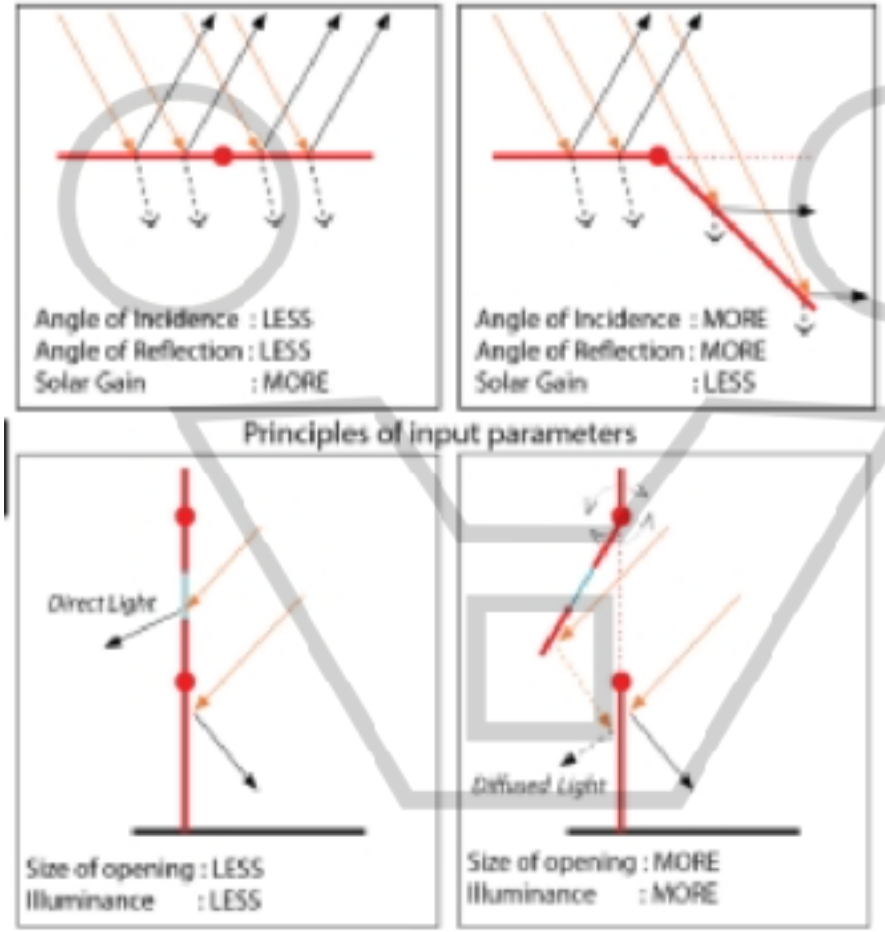
adaptive skin by rat lab Sushant Verma + Pradeep Devadass



Sushant Verma and Pradeep Devadass



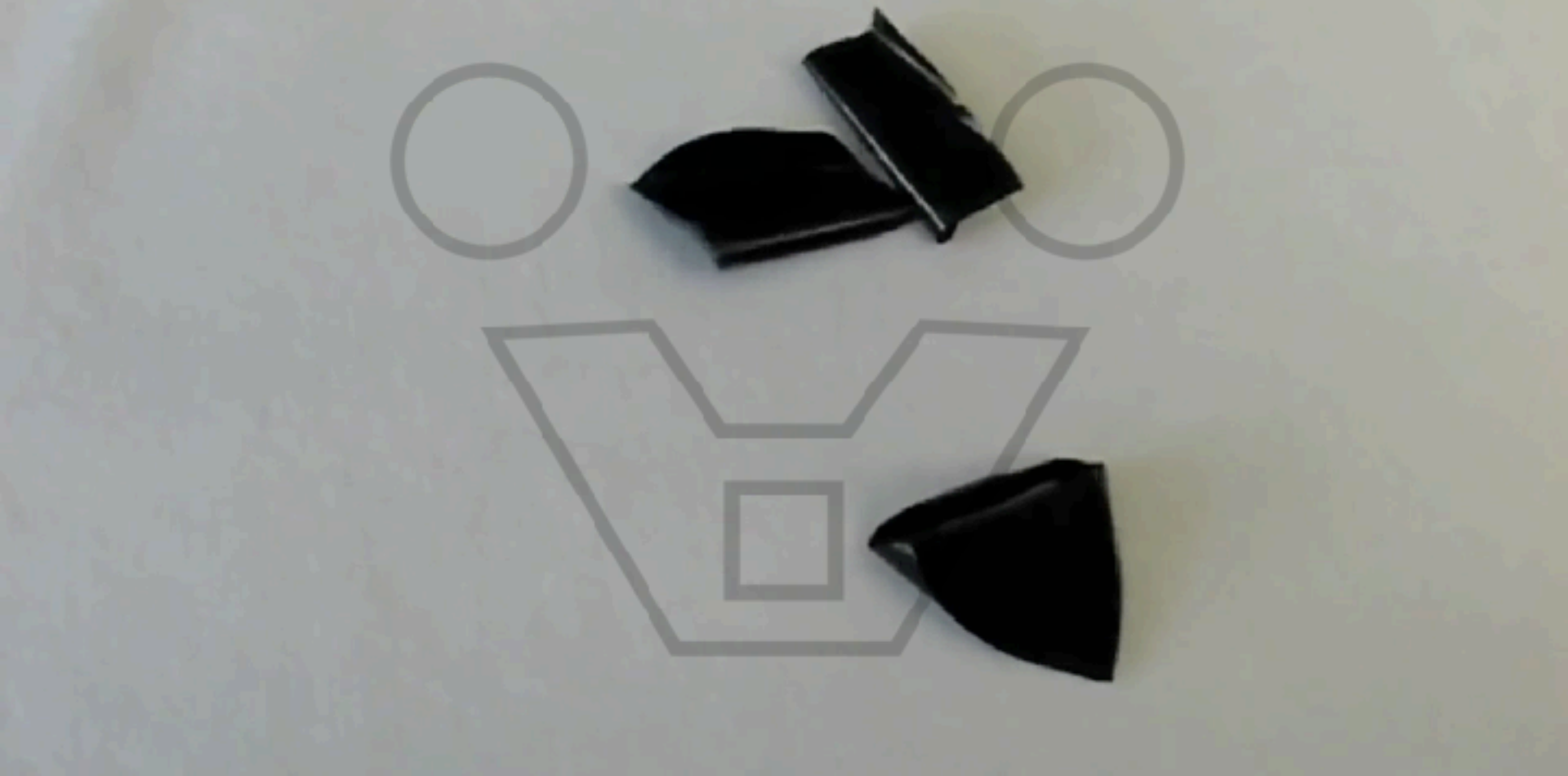
Sushant Verma and Pradeep Devadass


Angle of Incidence : LESS
Angle of Reflection : LESS
Solar Gain : MORE
Angle of Incidence : MORE
Angle of Reflection : MORE
Solar Gain : LESS
Principles of input parameters
Direct Light
Diffused Light
Size of opening : LESS
Illuminance : LESS
Size of opening : MORE
Illuminance : MORE

NANOTCHNOLOGIES

ELECTRO POLYMER


SOFT
MACHINES

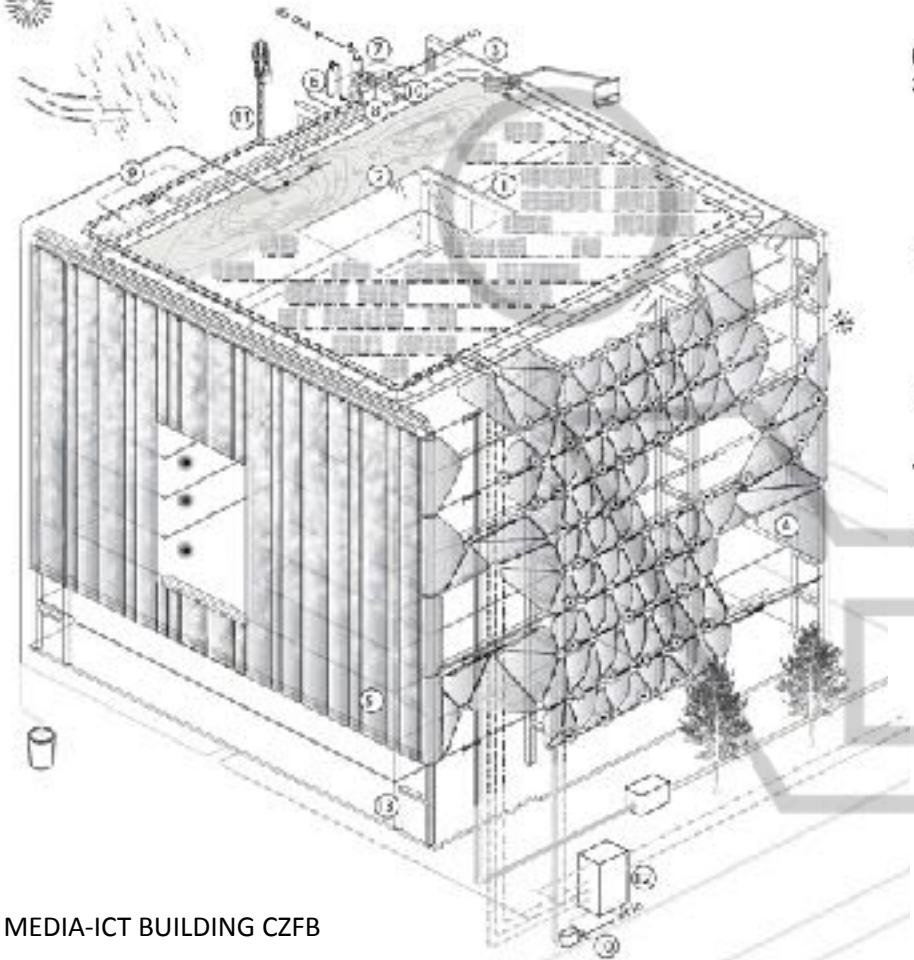



HygroSkin-Meteorosensitive Pavilion / Achim Menges Architect+Oliver David Krieg + Steffen Reichert _icd.uni-stuttgart.de

MEDIA-ICT BUILDING CZFB

22@, BARCELONA | Enric Ruiz-Geli

MEDIA-ICT BUILDING CZFB, 22@, BARCELONA | Enric Ruiz-Geli



DISTRICT HEATING AND COOLING

The Districlima project is the first district heating and cooling system in Spain. It derives its energy from a heating and cooling power plant utilizing renewable energy such as cooling sourced steam and a waste-to-energy heating source (steam).

FOTOVOLTAIC MODULES

(1) BP SOLAR mod. BP 3165S
Polikristallin (SI) 165 Wp
140 Units of 1,38m2
Peak potential of total installation: 23,02 kWp

GREEN ROOF

(2) Green roof built-up as an inverted roof
Sedum plants

Rainwater collection
Containers are installed underneath the ramp of the car park. Rain water is used for watering the green roof.

(3) Suspended working platform for maintenance and cleaning

SENSORS

Luxometer
Operating sun shading

(11) Directional luxmeter
Operating fog system

(8) Light sensor
Operating interior lighting

Data cable

Supply of electricity to the grid

Consumption of electricity from the grid

(12) Central Computer of Building Management System

(13) Bioluminescent paint applied to primary structure

ETFE FACADES

(4) Air supply Sancho d'Avila facade
Sancho d'Avila façade (south-east facing):

-Type A cushions: 3 layer cushions with pneumatic sun shading, allowing to adjust solar transmittance to either 65% or 45%. Each cushion is individually operated by a light sensor. The programming of each cushion can be manipulated via an IP address.

Type B: 2 layer cushions. Exterior layer print of silver circles. Interior layer green tinted ETFE foil. Solar transmittance approx. 55 %.

Type C: 2 layer cushions. Exterior layer transparent, interior layer green tinted ETFE foil. Solar transmittance approx. 65%.

-Type D: 2 layer cushions. Exterior layer transparent, interior layer print of negative silver circles. Solar transmittance approx. 50%

CAC façade (south-west facing):

(5) -Solar sun shading is achieved via a system which injects fog into the cushions. This system provides a variable shading which reduces solar heat gain up to 90%.

Air supply CAC facade

Return fog CAC facade

Nitrogen Supply

(6) Nitrogen cylinder

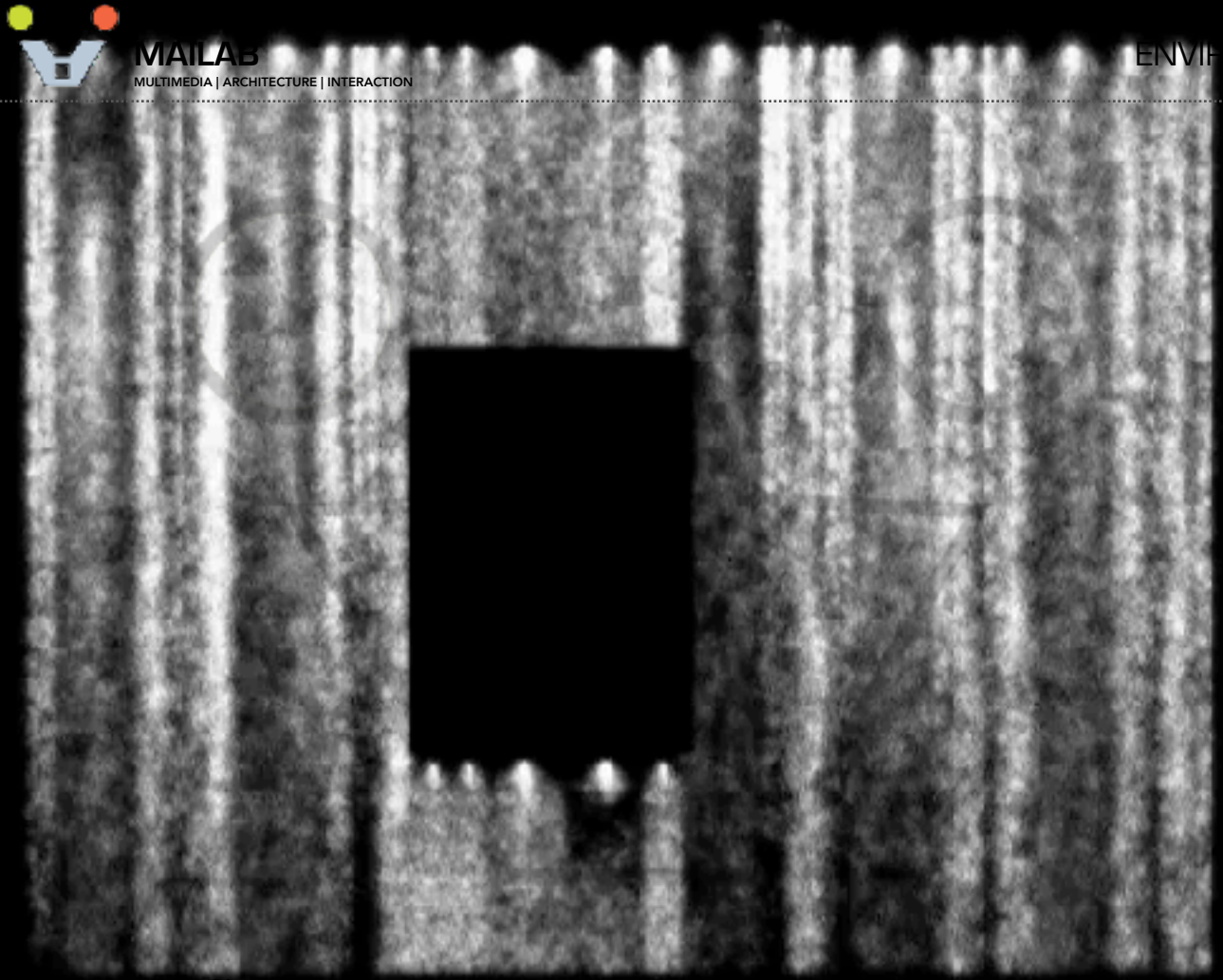
(7) Oil mist separator

(8) Fog generating system
Concept VICount 180 Smoke System

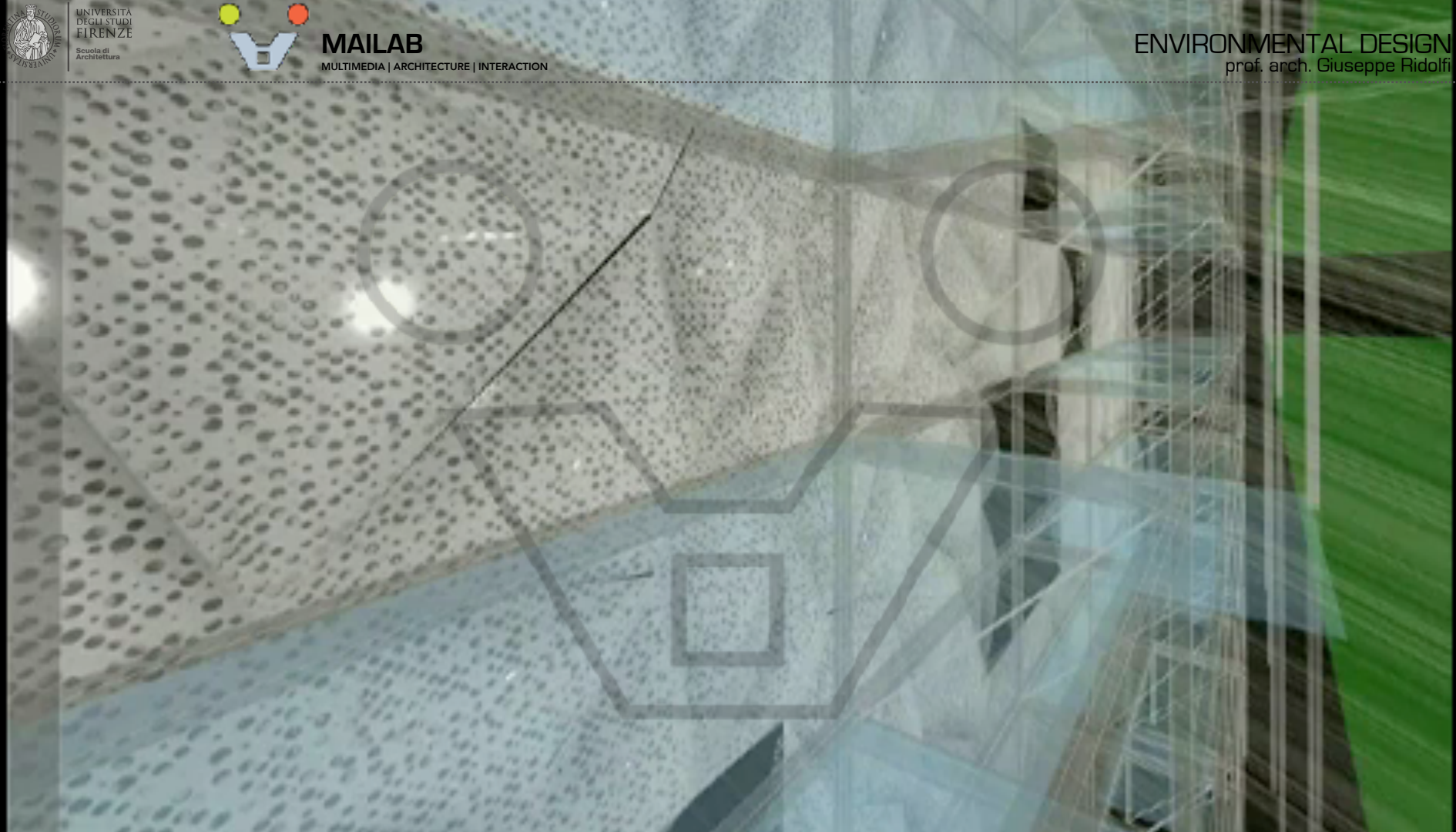
(9) Circular cased axial fan

(10) Inflation unit

MEDIA-ICT BUILDING CZFB



Section of ETFE cushions at South-East facade



the END