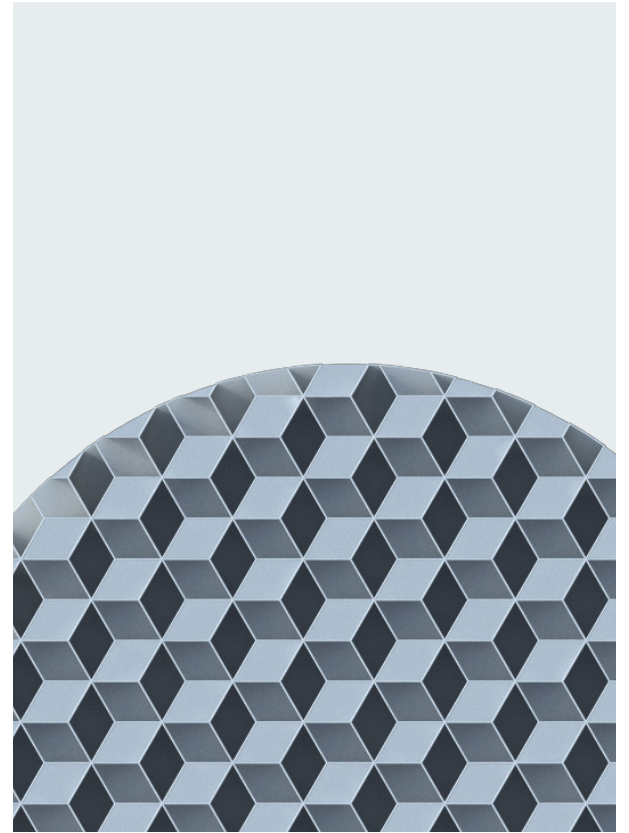
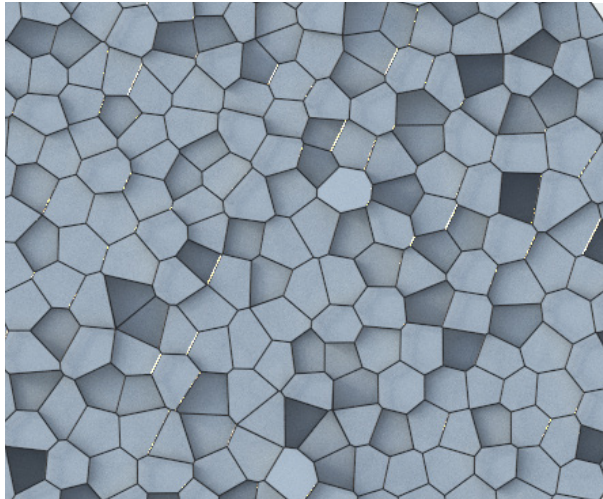
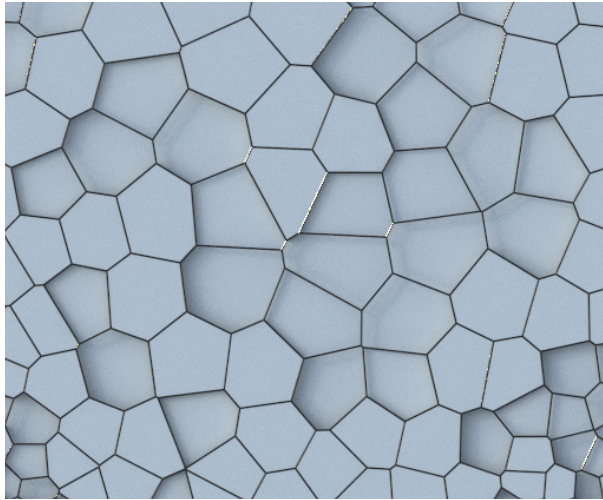
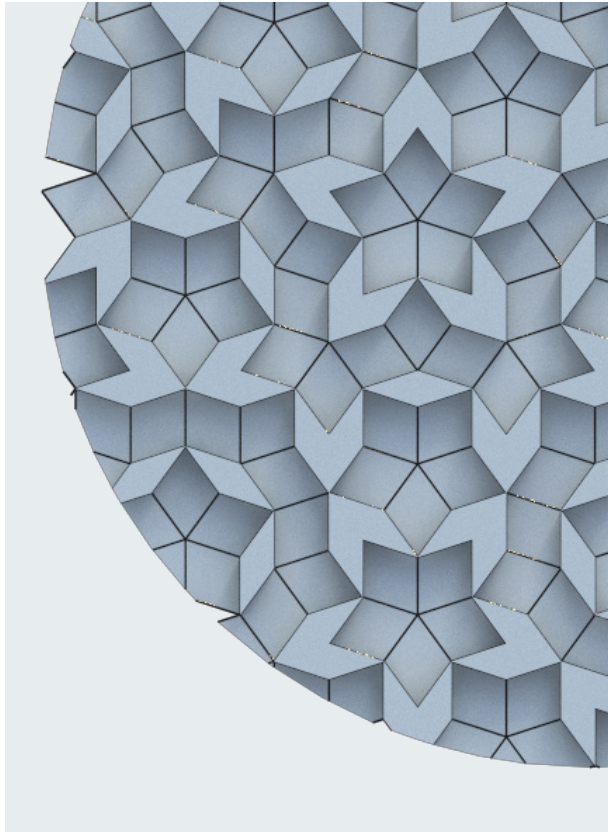


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LOCATION:
OPEN-PLAN PRESCHOOLS



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PROBLEM STATEMENT ▼

speech-in-noise perception

transdisciplinary approach

RESEARCH QUESTION ▼

How can different periodicity patterns applied on fibreless surfaces provide a toolbox for designers that aim for a balanced ratio of speech intelligibility and speech privacy in an ILE school by allowing low-frequency absorption and high-frequency diffusion?

RESEARCH OBJECTIVE ▼

convert traditional materials into sound controlling devices

- ▼ hybrid

absorption + diffusion

- ▼ periodicity

low-level rules

high-level of self-organization

WORKFLOW ▼

- ▼ macro-scale (where)

optimum proportions of absorption and diffusion

- ▼ micro-scale (how)

non-repetitive sequence for uniform dispersion

PARAMETERS ▼

- ▼ pattern

depth-to-length ratio

well width

period

- ▼ elements

finite set

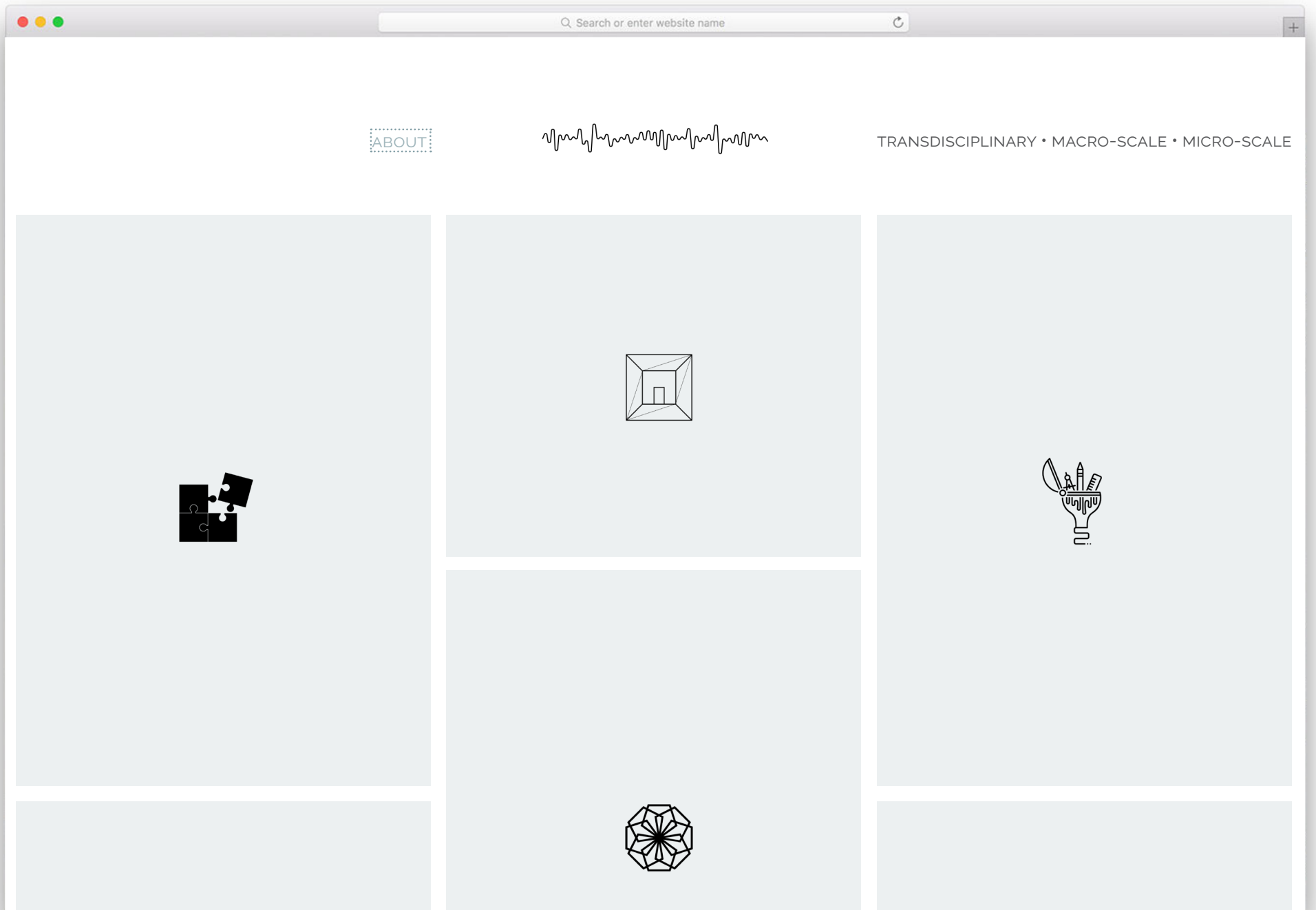
EVALUATION ▼

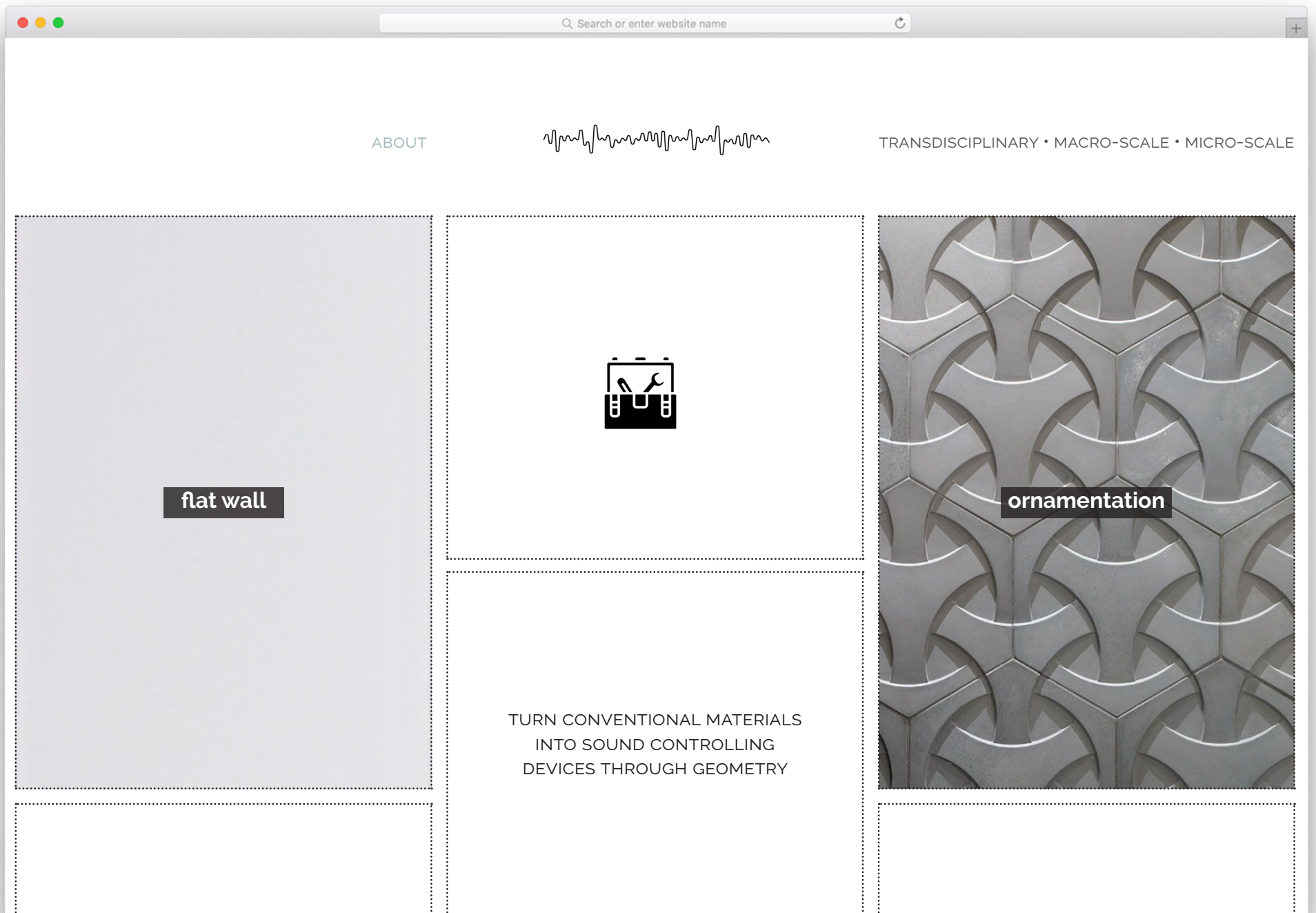
- ▼ selected pattern

increase complexity of the reflected sound field

- ▼ properties

overall simplicity (preserve the economy of the means for the end user)





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flat wall




ornamentation

TURN CONVENTIONAL MATERIALS
INTO SOUND CONTROLLING
DEVICES THROUGH GEOMETRY


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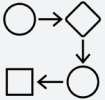
INTELLIGIBILITY: RECOGNIZING THE MESSAGE FROM THE DIN

LONGITUDINAL RELATIONSHIP:
SPEECH-IN-NOISE PERCEPTION | COGNITIVE
| BIOLOGICAL DEVELOPMENT







CUSTOMIZATION VS MASS PRODUCTION



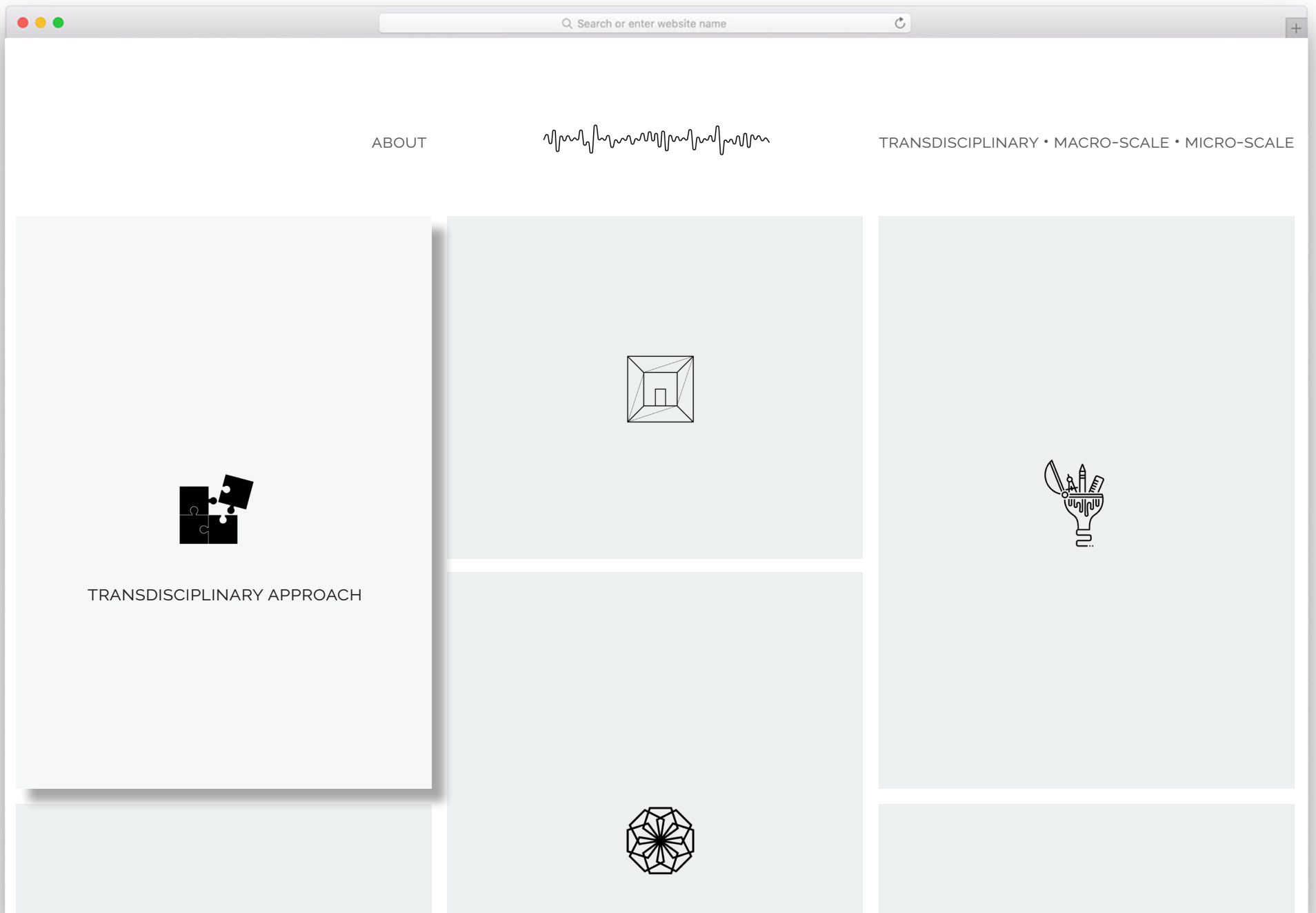
DESIGN-INCLUSIVE RESEARCH



SPATIAL CONTEXT



SURFACE PROPERTIES

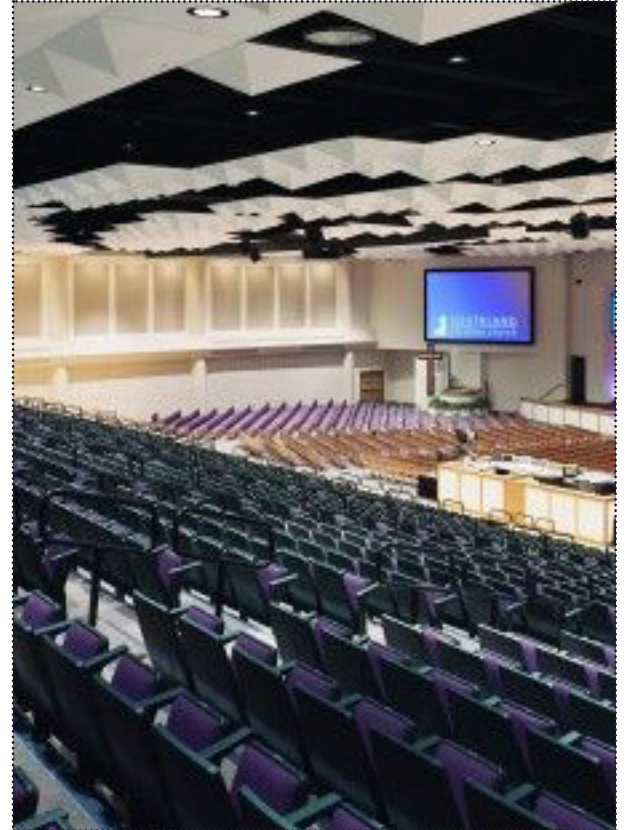


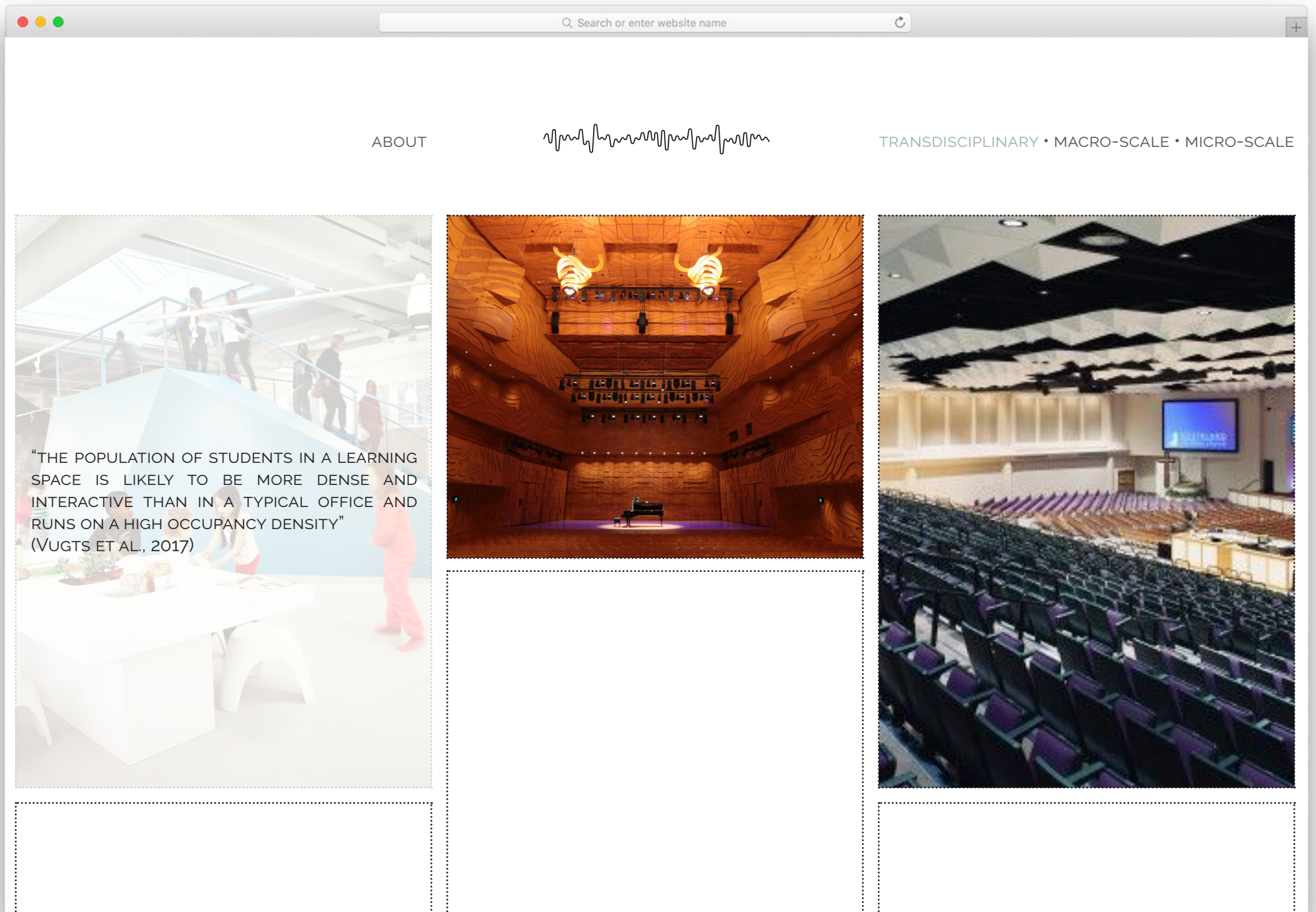


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"THE POPULATION OF STUDENTS IN A LEARNING SPACE IS LIKELY TO BE MORE DENSE AND INTERACTIVE THAN IN A TYPICAL OFFICE AND RUNS ON A HIGH OCCUPANCY DENSITY" (VUGTS ET AL., 2017)

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<div style="text-align: center; margin-bottom: 10px;">  </div> <p>STRONGLY AFFECTED BY NOISE: RAISING THEIR VOICES, LOSING CONCENTRATION OR WITHDRAWING</p> <div style="text-align: center; margin-bottom: 10px;">  </div> <p>ATTENTION, MEMORY, SENSORY PERCEPTION AND LINGUISTIC COGNITION ARE UNDERDEVELOPED</p> <div style="text-align: center; margin-bottom: 10px;">  </div> <p>LONG-LASTING IMPACT ON COGNITIVE PERFORMANCE, PRELITERACY AND AUDITORY PERCEPTION</p>	<p style="text-align: center; font-weight: bold; margin: 0;">PSYCHOLOGY NEUROSCIENCE</p>	<div style="text-align: center; margin-bottom: 10px;">  </div> <p>SPEECH-IN-NOISE PERCEPTION: MOSTLY HINDERED BY THE CHILDREN'S VOICES AND ACTIVITIES (1-4KH)</p> <div style="text-align: center; margin-bottom: 10px;">  </div> <p>EXPOSED TO INFORMATIONAL MASKING (CONFUSING THE SOURCE)</p> <div style="text-align: center; margin-bottom: 10px;">  </div> <p>LISTEN TO A BROADBAND OR TO ALL FREQUENCIES SIMULTANEOUSLY</p>
	<p style="text-align: center; font-weight: bold; margin: 0;">ACOUSTICS</p> <p style="text-align: center; font-weight: bold; margin: 0;">ACOUSTICS</p>	

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STRONGLY AFFECTED BY NOISE:
RAISING THEIR VOICES, LOSING
CONCENTRATION OR WITHDRAWING




ATTENTION, MEMORY, SENSORY
PERCEPTION AND LINGUISTIC
COGNITION ARE UNDERDEVELOPED




LONG-LASTING IMPACT ON COGNITIVE
PERFORMANCE, PRELITERACY AND
AUDITORY PERCEPTION

**PSYCHOLOGY
NEUROSCIENCE**


ACOUSTICS



SPEECH-IN-NOISE PERCEPTION:
MOSTLY HINDERED BY THE
CHILDREN'S VOICES AND ACTIVITIES
(1-4KH)



EXPOSED TO INFORMATIONAL
MASKING (CONFUSING THE SOURCE)



LISTEN TO A BROADBAND OR TO ALL
FREQUENCIES SIMULTANEOUSLY

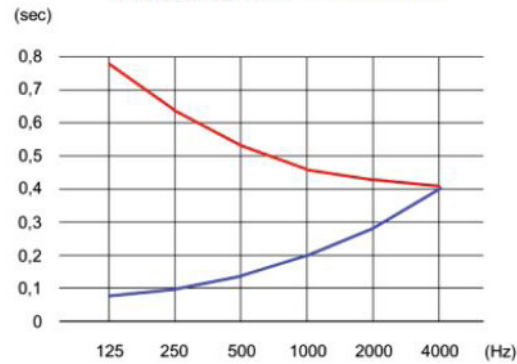
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Class Rooms vs Forests



SPEECH POWER: LOW FREQUENCY VOWELS (125-500Hz)

SPEECH INTELLIGIBILITY: HIGH FREQUENCY CONSONANTS (2000-6000Hz)

NOISE: PROBLEM WITH DYNAMIC QUES + SPEAKERS LOCALIZATION

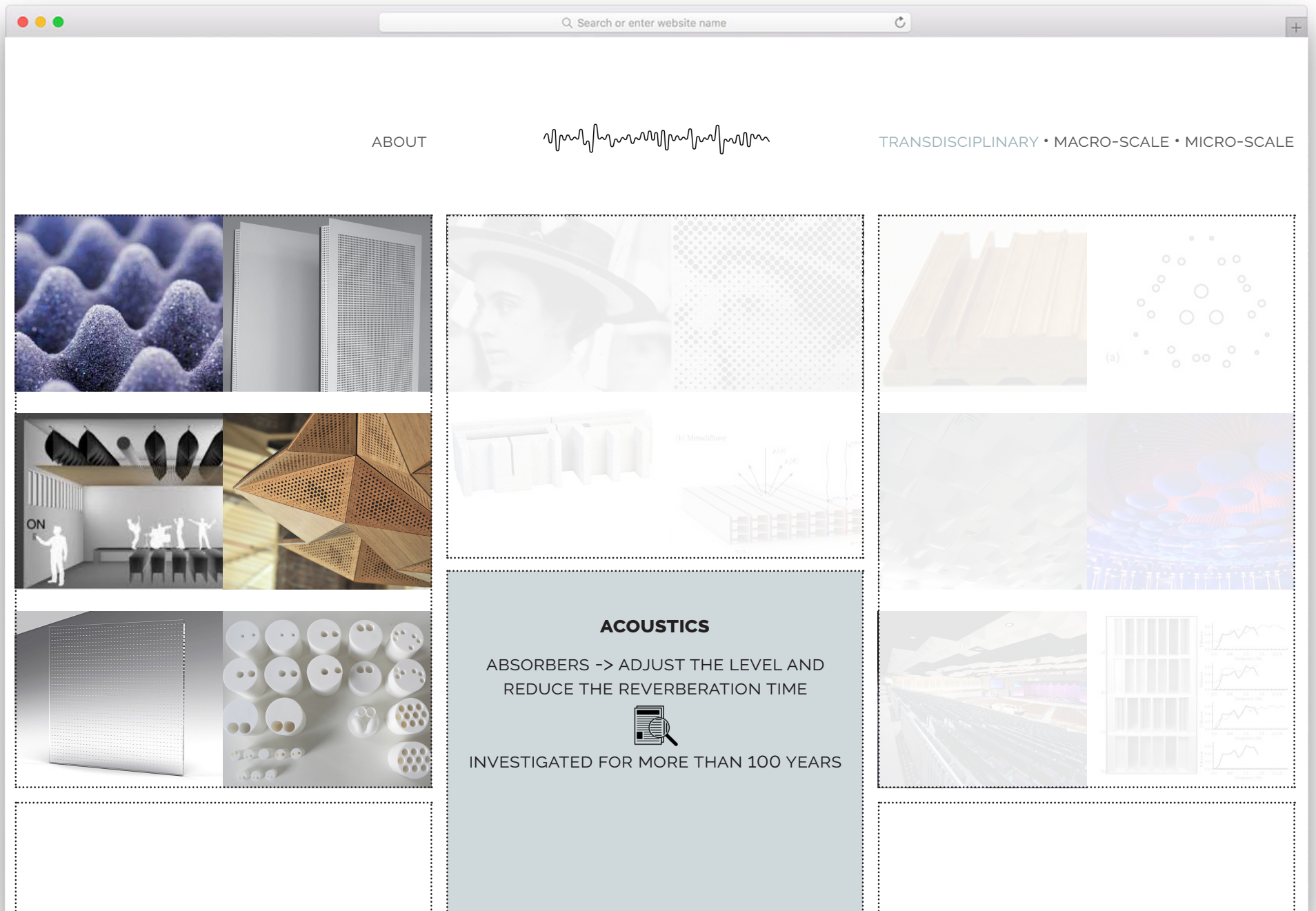
ACOUSTICS




FOREST: LOW REVERBERANCE FOR LOW FREQUENCIES, ESPECIALLY AT 125 HZ

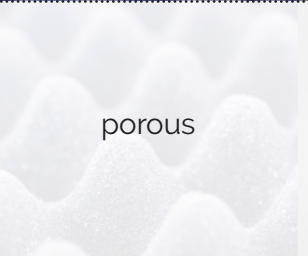


INDOORS: HIGH REVERBERANCE FOR LOW FREQUENCY - VOWELS ARE AMPLYFIED, MASKING THE CONSONANTS.




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porous




plate




membrane




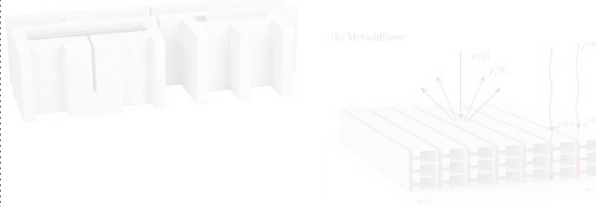
helmholtz




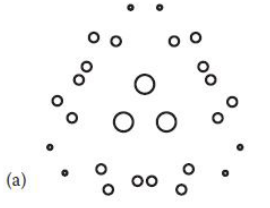
mf





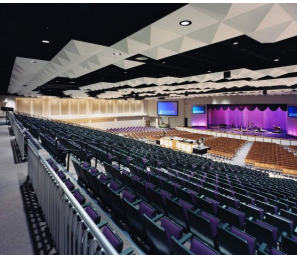
tube


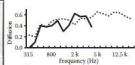




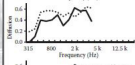



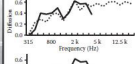


(a)





ACOUSTICS

DIFFUSERS -> DELAY AND TEMPORALLY
DIFFUSE EARLY REFLECTIONS, AVOID SOUND
FOCUSING + FLUTTER ECHOES, WHILE
PRESERVING SOUND ENERGY



INVESTIGATED IN RECENT DECADES

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porous
plate

membrane
helmholtz

mf
tube

schroeder
sonic crystals

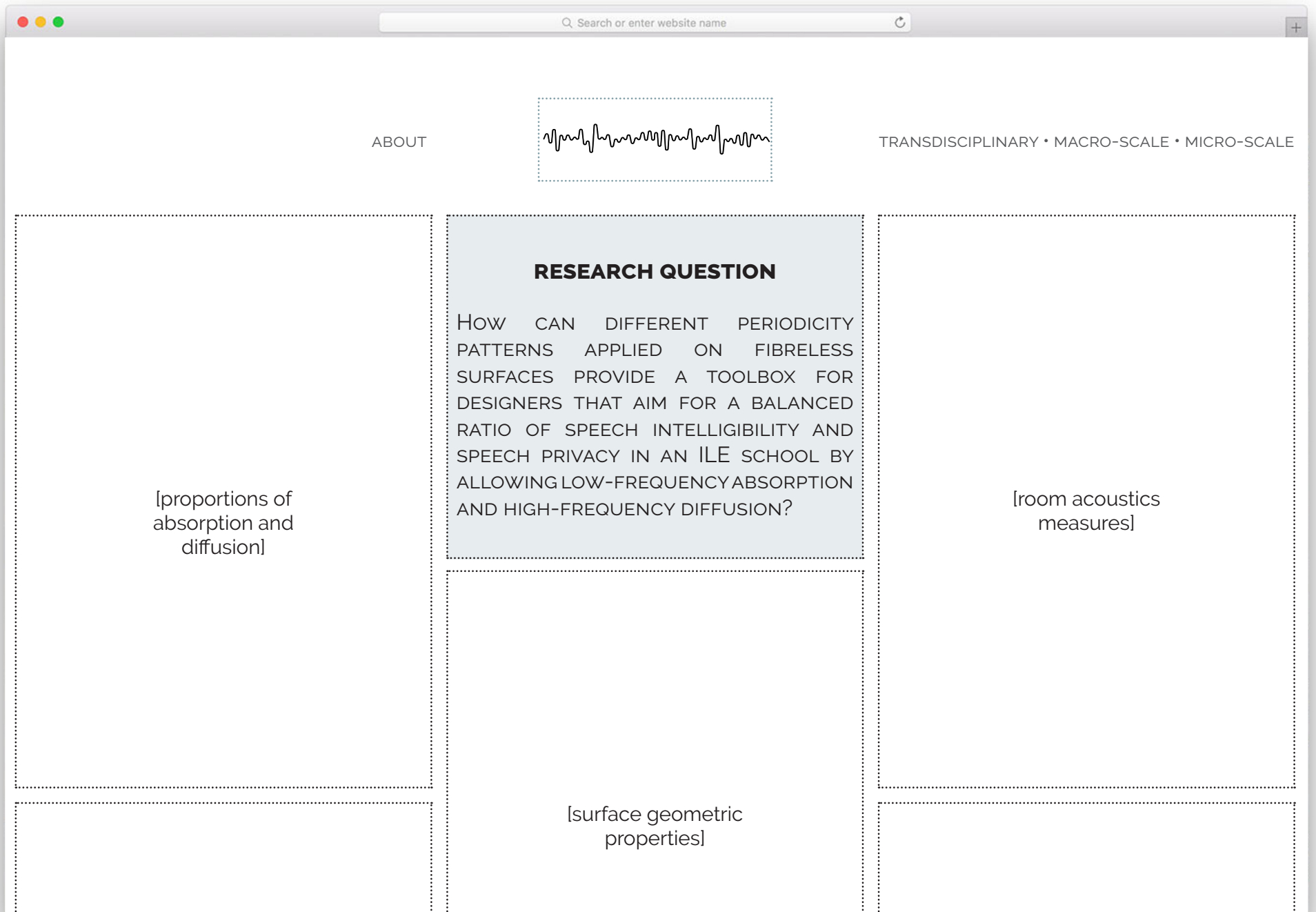
cylinders
concave

triangles
fractals

ACOUSTICS

HYBRID ->

INVESTIGATED CURRENTLY



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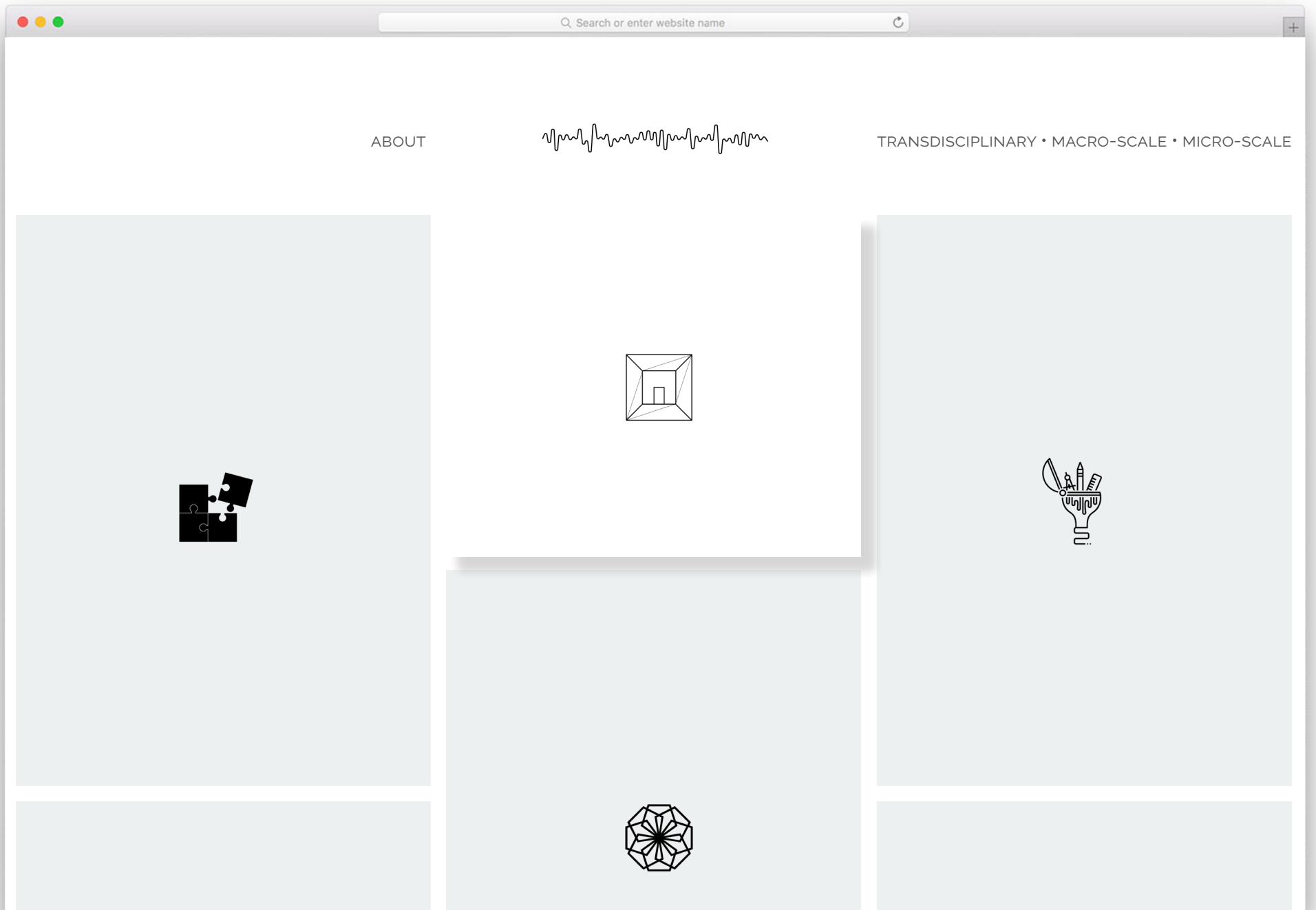
RESEARCH QUESTION

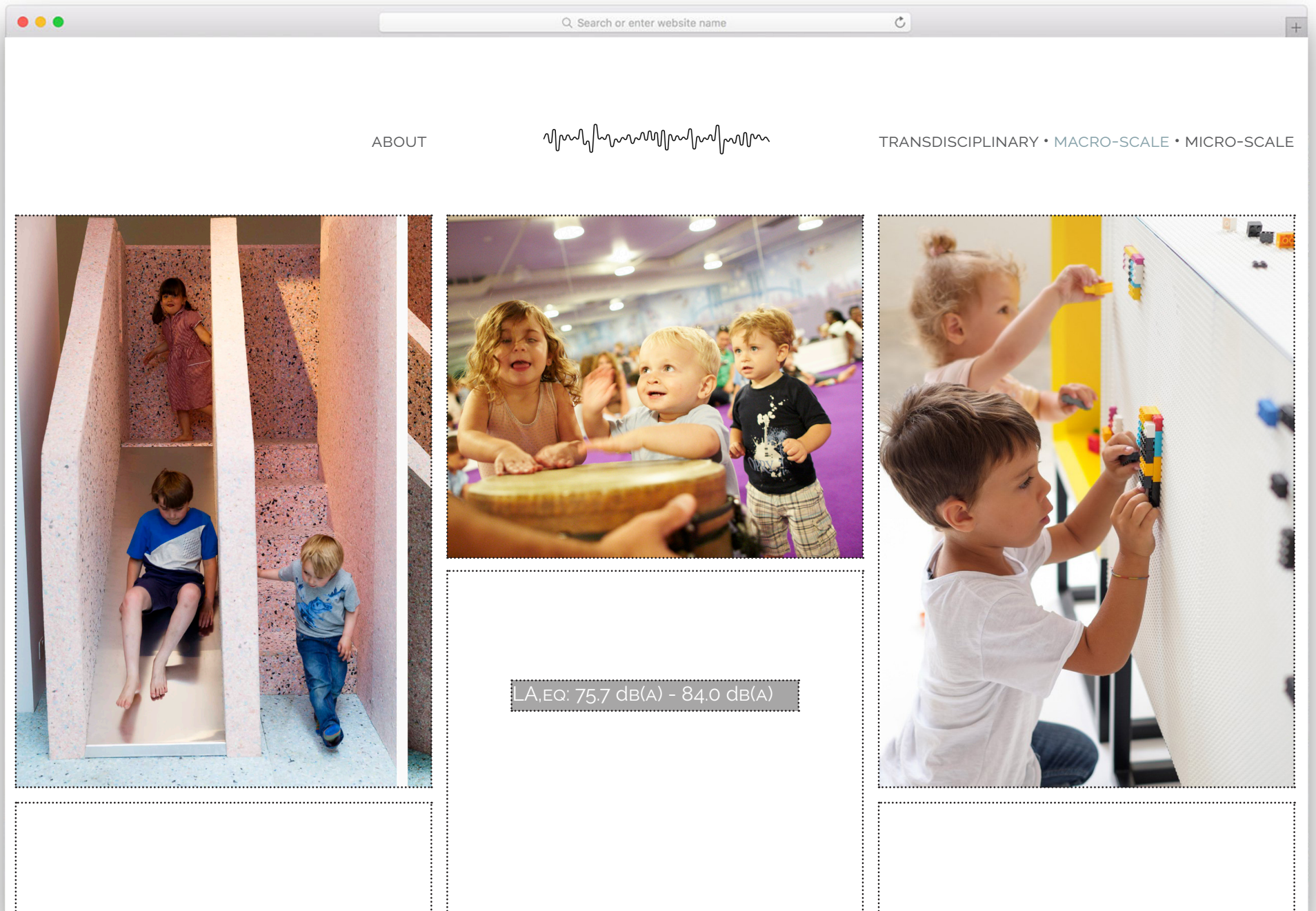
HOW CAN DIFFERENT PERIODICITY PATTERNS APPLIED ON FIBRELESS SURFACES PROVIDE A TOOLBOX FOR DESIGNERS THAT AIM FOR A BALANCED RATIO OF SPEECH INTELLIGIBILITY AND SPEECH PRIVACY IN AN ILE SCHOOL BY ALLOWING LOW-FREQUENCY ABSORPTION AND HIGH-FREQUENCY DIFFUSION?

[proportions of absorption and diffusion]

[room acoustics measures]

[surface geometric properties]





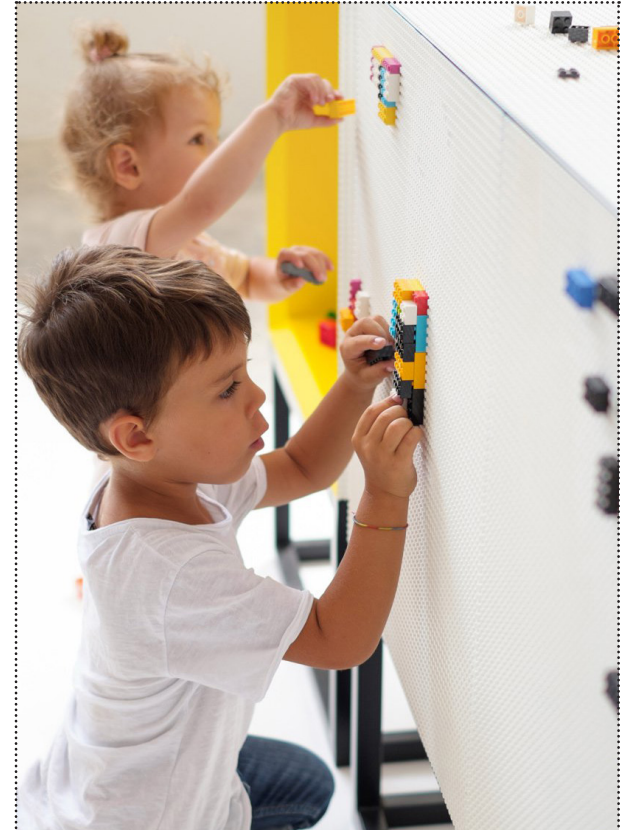
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LA,Eq: 75.7 dB(A) - 84.0 dB(A)



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60-75 CHILDREN: 1800M³
 PLAYROOM USERS: **7**, IMPACT ON NOISE LEVEL
 GROUP SIZE PER CLASSROOM: **15**
 ACTIVITY ZONES:
 PLAYROOM-CLASS-WITHDRAWAL


SPEECH INTELLIGIBILITY

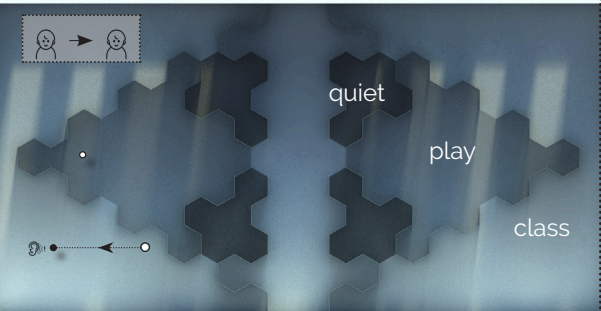

CHOOSE SCENARIO:

- 1. ABSORPTIVE**
- 2. NORMAL**

Measures	Parameters	Comments
noise levels		
1 play area	L_{A, EQ} DB(A)	>60
2 high task concentration		45-55
CURRENTLY UP TO 80dB(A)		
reverberation time		
1 open work-space	T₃₀ S	0.4-0.6
2 play room		0.4
THOUGH LOW, SPL CAN REMAIN HIGH		
Intelligibility		
1 speech intelligibility	STI	0.6-1
2 speech privacy		0.2<
REFLECTIONS TO RETAIN THE SOUND ENERGY INSIDE		
Early-Arriving Speech Energy		
1 inside zone	U₅₀	?
2 outside zone		?
REVISE WEIGHT FACTORS		

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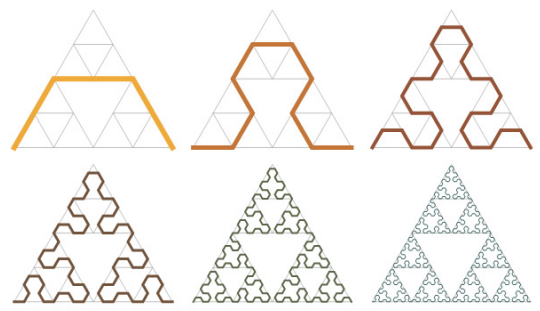
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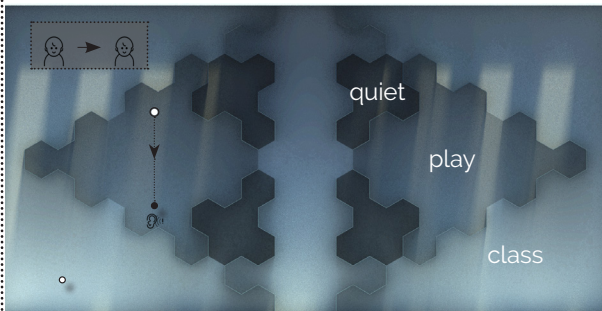

quiet

play

class



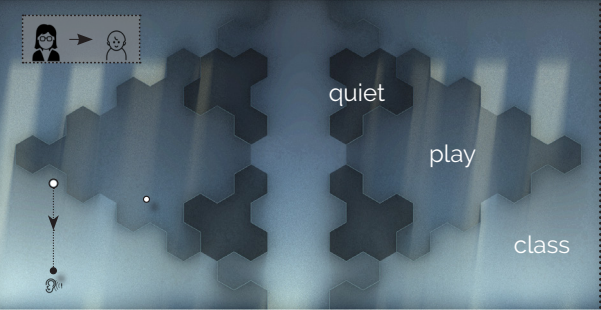

CASE STUDY: SERPIENSKY
SPACE FILLING CURVE/SURFACE:



quiet

play

class

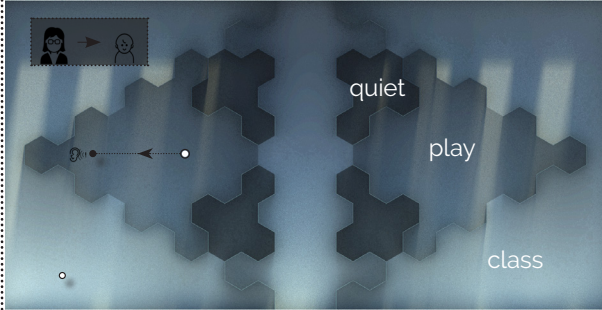



quiet

play

class

AVOID PARALLEL HARD SURFACES




quiet

play

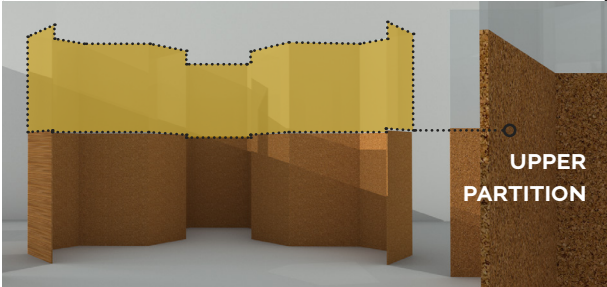
class

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%


PROHIBIT THE TEACHER'S DIRECT SPEECH FROM BEING TRANSMITTED TO THE IMMEDIATE SURROUNDINGS + TRANSPARENCY TO OBTAIN VISUAL CONTROL.



%

ABSORPTION COEFFICIENTS (A)							
upper partition (0.8m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
1	6	28	70	68	74	53	53
2	10	45	85	30	10	5	5
3	50	90	90	25	25	25	25

lower partition (1m)							
4	50	90	90	25	25	25	25



GA "VIRTUAL" MEASUREMENT:
APPROXIMATIONS OF SOUND PROPAGATION
(ENERGY-BASED RATHER THAN SOLVING THE
WAVE EQUATION),

SCATTERING COEFFICIENTS (S)							
upper partition (0.8m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
1	10	10	10	10	10	10	10
2	10	10	10	10	10	10	10
3	25	25	25	50	50	50	50

lower partition (1m)							
4	25	25	25	50	50	50	50

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T₃₀

1. MPP FOIL "MICROSORBER"
2. MPP GLASS, 5 MM CAVITY
3. BALANCED

STI

ABSORPTION COEFFICIENTS (A)

upper partition (0.8m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
1	6	28	70	68	74	53	53
2	10	45	85	30	10	5	5
3	50	90	90	25	25	25	25

REVISE CERTAIN ACOUSTIC MEASURES
 TAILOR-MADE FOR VARIOUS USERS
(WEIGHT FACTORS+HYPOTHESIS)

SCATTERING COEFFICIENTS (S)

upper partition (0.8m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
1	10	10	10	10	10	10	10
2	10	10	10	10	10	10	10
3	25	25	25	50	50	50	50

lower partition (1m)

4	50	90	90	25	25	25	25
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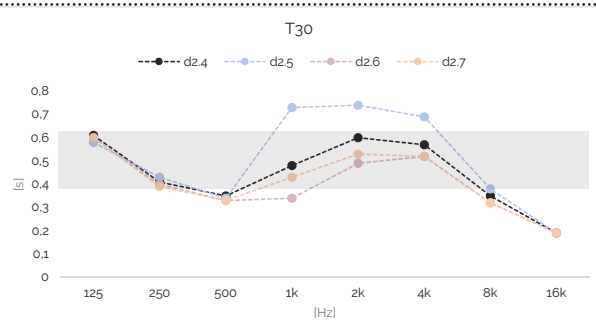
lower partition (1m)

4	25	25	25	50	50	50	50
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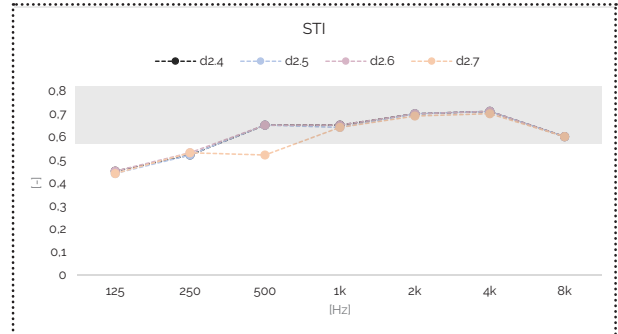
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- 4. BALANCED
- 5. UNIFORM SCATTERING
- 6. BROADBAND SCATTERING
- 7. BROADBAND ABSORPTION



ABSORPTION COEFFICIENTS (A)

lower partition (1m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
4	50	90	90	25	25	25	25
5	50	90	90	25	25	25	25
6	50	90	90	25	25	25	25
7	50	90	90	90	90	90	25

upper partition (0.8m)

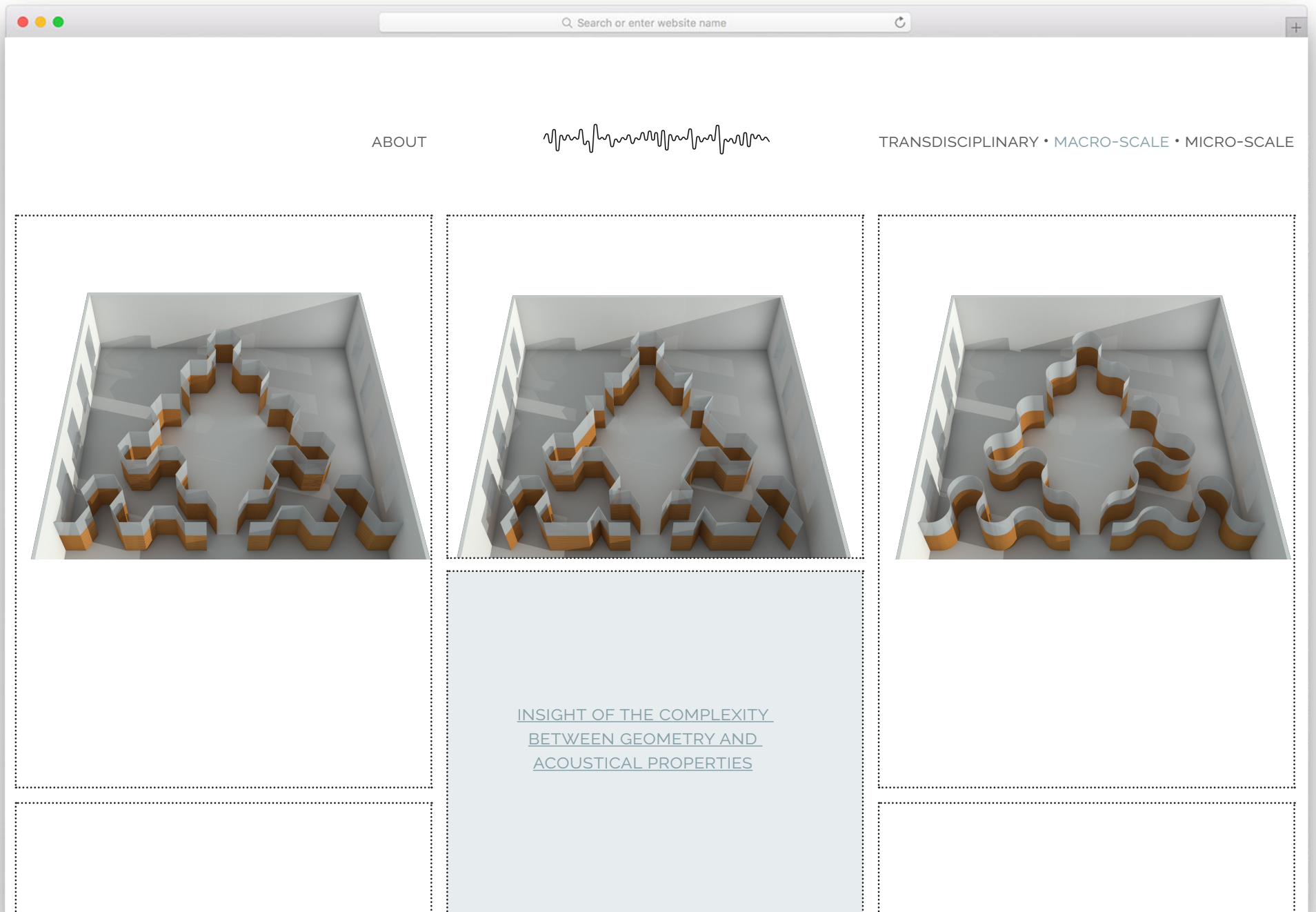
2	10	45	85	30	10	5	5
---	----	----	----	----	----	---	---

SCATTERING COEFFICIENTS (s)

lower partition (1m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
4	25	25	25	50	50	50	50
5	25	25	25	10	10	10	10
6	25	25	25	90	90	90	50
7	25	25	25	50	50	50	50

upper partition (0.8m)

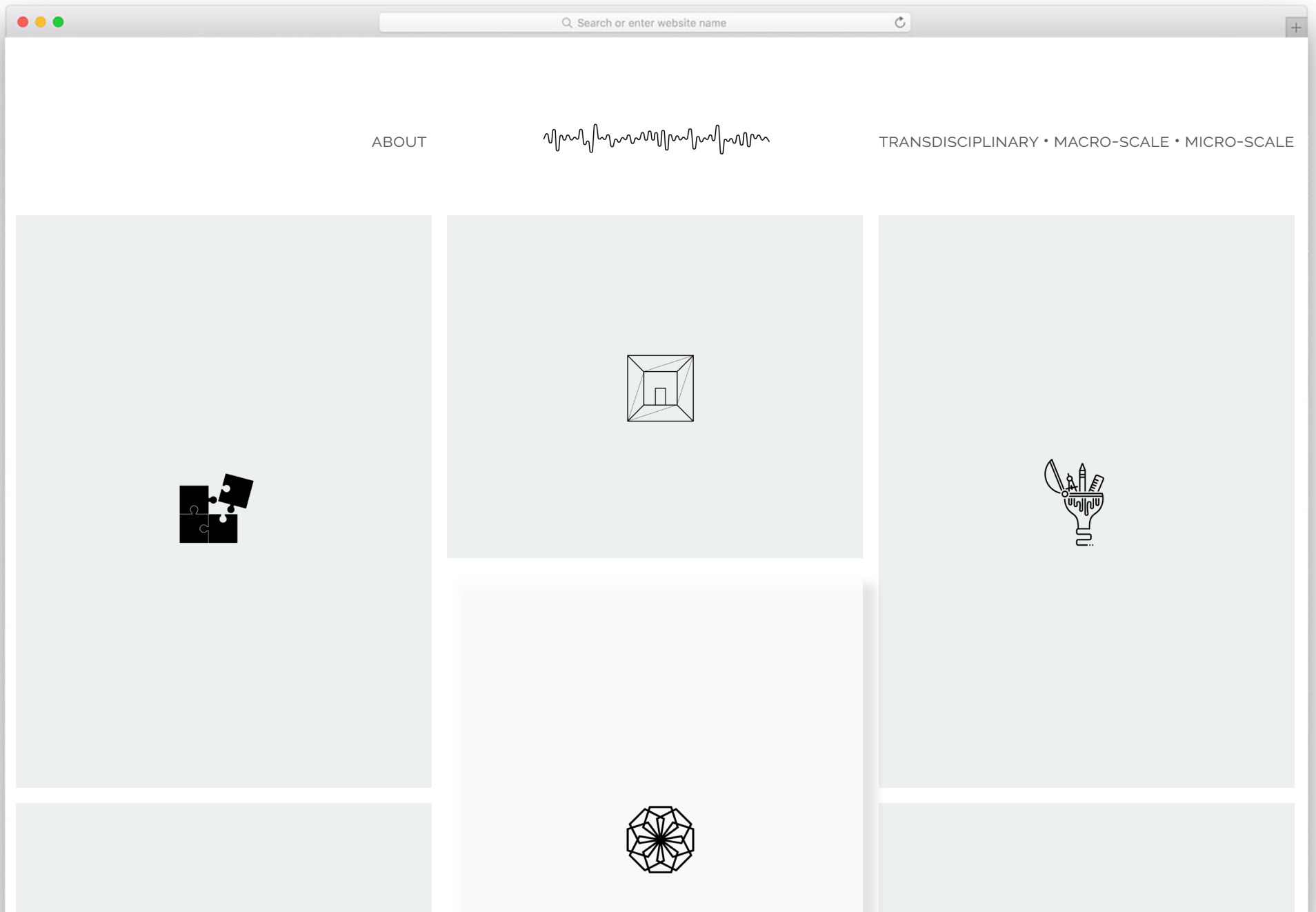
2	10	10	10	10	10	10	10
---	----	----	----	----	----	----	----



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upper partition (0.8m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
2	10	45	85	30	10	5	5
lower partition (1m)							
4	50	90	90	25	25	25	25

upper partition (0.8m)	Octave band centre frequency (Hz)						
	125	250	500	1k	2k	4k	8k
2	10	10	10	10	10	10	10
lower partition (1m)							
4	25	25	25	50	50	50	50



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» COMPLEX SURFACES
-> GREATER SCATTERING

» PERIODIC SURFACES: REDUCE THE COMPLEXITY OF THE REFLECTED SOUND FIELD
NON-PERIODIC SURFACES: POTENTIAL FOR UNIFORM DIRECTIVITY

» LONG NUMBER SEQUENCE WITH GOOD APERIODIC AUTOCORRELATION

» NON-REPETITIVE SEQUENCE VIA THE GEOMETRY ARTICULATION

	periodicity	parameters	profile	con- strains
steps	<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • side legth • well • period 	<ul style="list-style-type: none"> • extruded • tapered 	amount of cells production

well	depth-to-length ratio			
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]	
various depths	d=20% l [m] : 3			d=200% l [m] : 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]	

WIDTH + DEPTH CONSTRAINTS FOR SPATIAL AND TEMPORAL DISPERSION

»

VISUAL FREEDOM OF THE SHAPE

»

COMPLEXITY: LOW LEVEL RULES / HIGH LEVEL OF SELF-ORGANIZATION

»

SIMPLICITY + ARCHITECTURAL SMARTNESS: PRESERVING THE ECONOMY OF MEANS FOR THE END USERS

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

» **COMPLEX SURFACES**
-> GREATER SCATTERING

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» **NON-REPETITIVE SEQUENCE** VIA THE GEOMETRY ARTICULATION

	periodicity	parameters	profile	con- strains
steps	• aperiodic	• side legth • well • period	• extruded • tapered	amount of cells
	• periodic • non- periodic			produc- tion

well	depth-to-length ratio			
two depths	d=20% l l (m)	d=50% l (m)	d=150% l (m)	
various depths	d=20% l l (m) : 3			d=200% l (m) : 3
narrow width	d=20% l l (m)	d=50% l (m)	d=150% l (m)	

WIDTH + DEPTH CONSTRAINTS FOR SPATIAL AND TEMPORAL DISPERSION

⇓

VISUAL FREEDOM OF THE SHAPE

⇓

COMPLEXITY: LOW LEVEL RULES / HIGH LEVEL OF SELF-ORGANIZATION

⇓

SIMPLICITY + ARCHITECTURAL SMARTNESS: PRESERVING THE ECONOMY OF MEANS FOR THE END USERS

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COMPLEX SURFACES
-> GREATER SCATTERING

» PERIODIC SURFACES: REDUCE THE COMPLEXITY OF THE REFLECTED SOUND FIELD
NON-PERIODIC SURFACES: POTENTIAL FOR UNIFORM DIRECTIVITY

» LONG NUMBER SEQUENCE WITH GOOD APERIODIC AUTOCORRELATION

» NON-REPETITIVE SEQUENCE VIA THE GEOMETRY ARTICULATION

	periodicity	parameters	profile	con- strains
steps	<ul style="list-style-type: none"> aperiodic periodic non-periodic 	<ul style="list-style-type: none"> cells period well 	<ul style="list-style-type: none"> extruded tapered 	amount finite set

well	depth-to-length ratio			
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]	
various depths	d=20% l [m]: 3			d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]	

WIDTH + DEPTH CONSTRAINTS FOR SPATIAL AND TEMPORAL DISPERSION

»

VISUAL FREEDOM OF THE SHAPE

»

COMPLEXITY: LOW LEVEL RULES / HIGH LEVEL OF SELF-ORGANIZATION

»

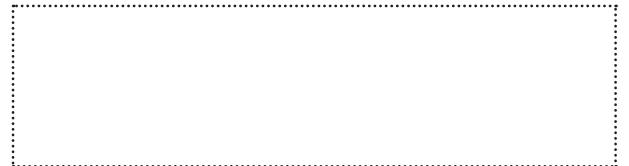
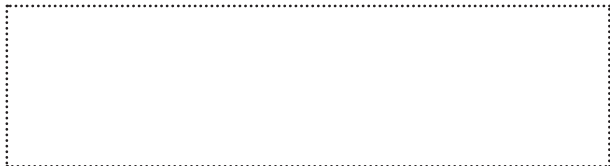
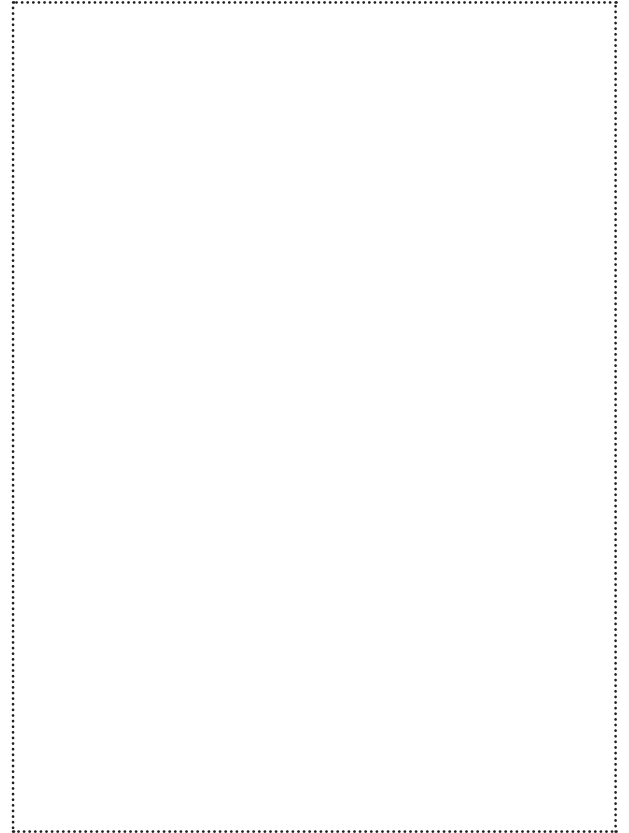
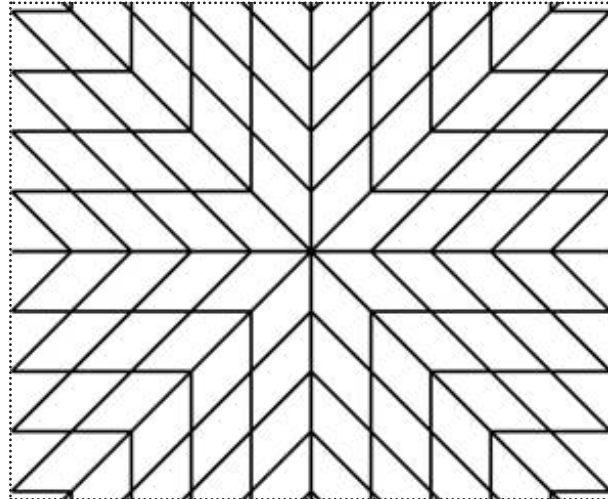
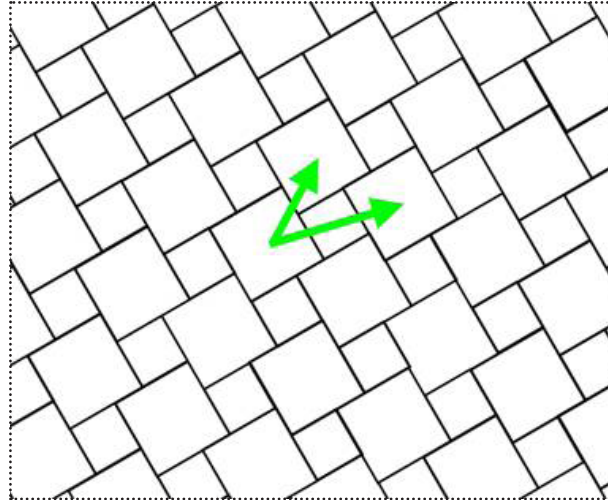
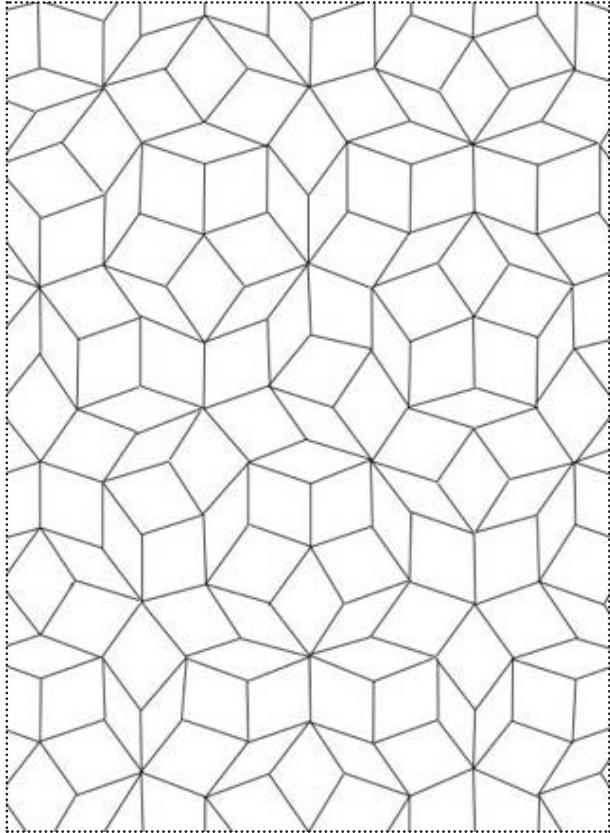
SIMPLICITY + ARCHITECTURAL SMARTNESS: PRESERVING THE ECONOMY OF MEANS FOR THE END USERS

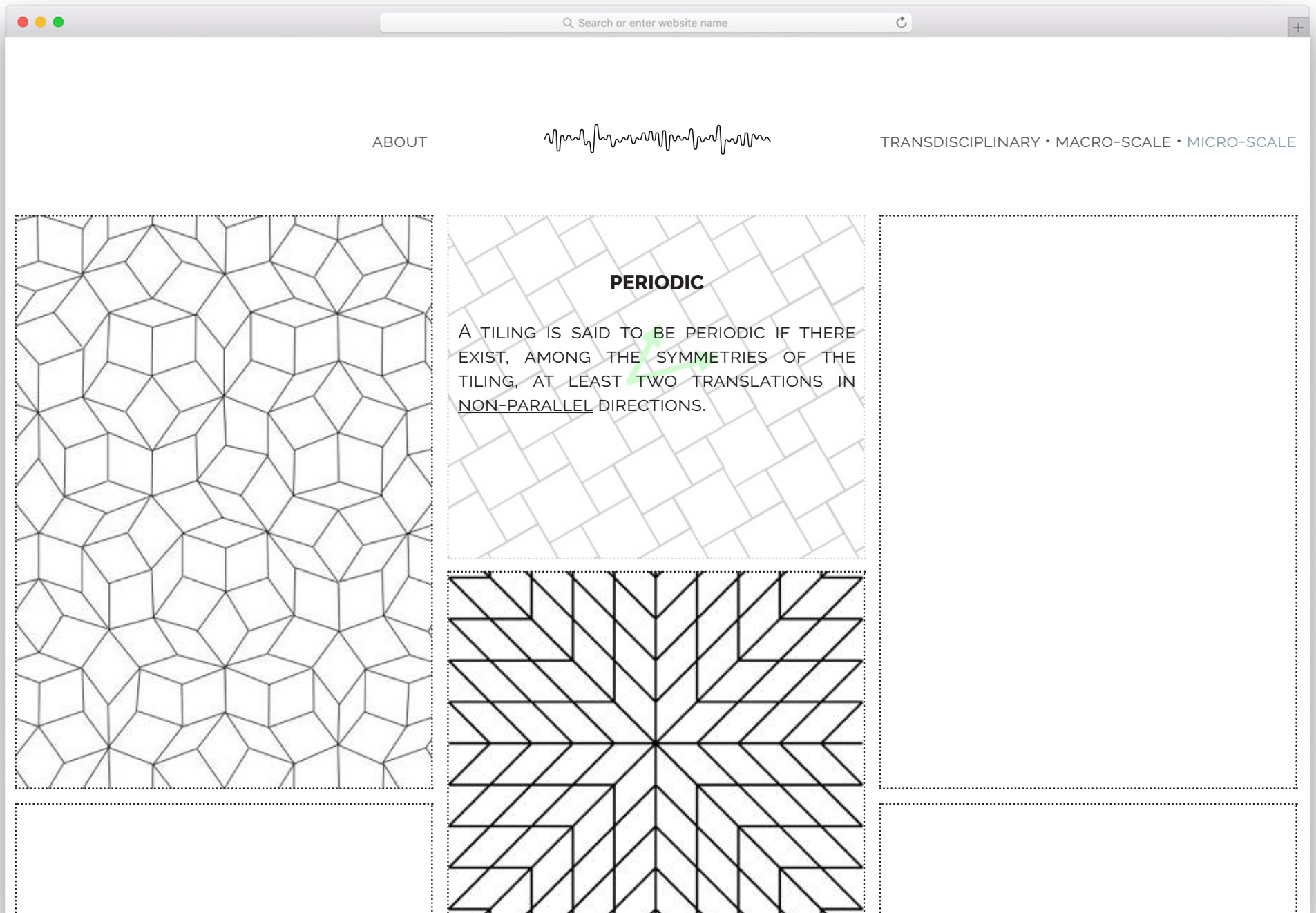


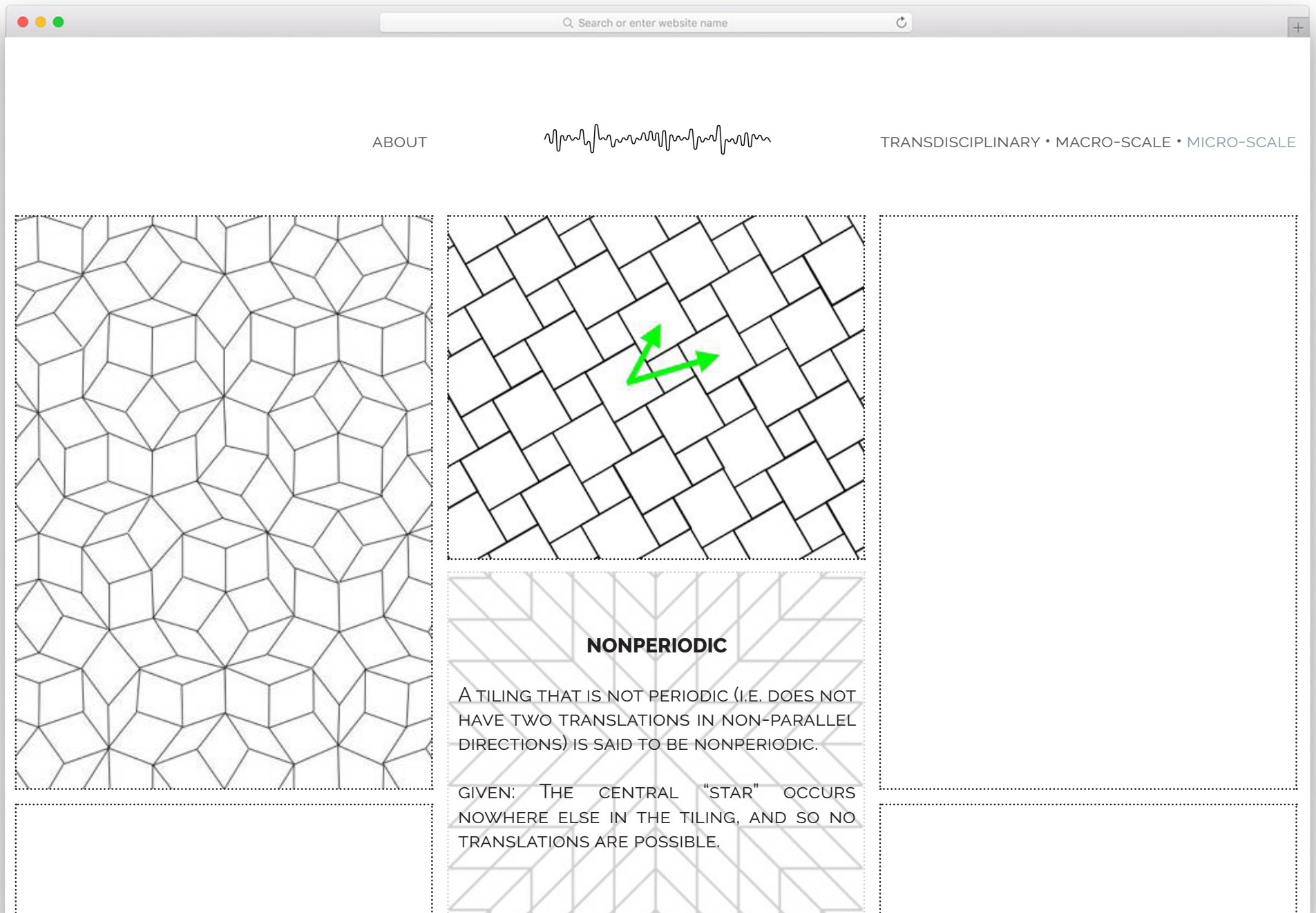
ABOUT



TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



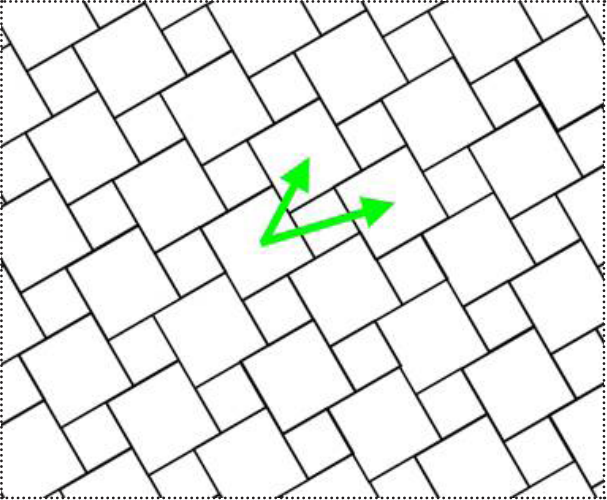
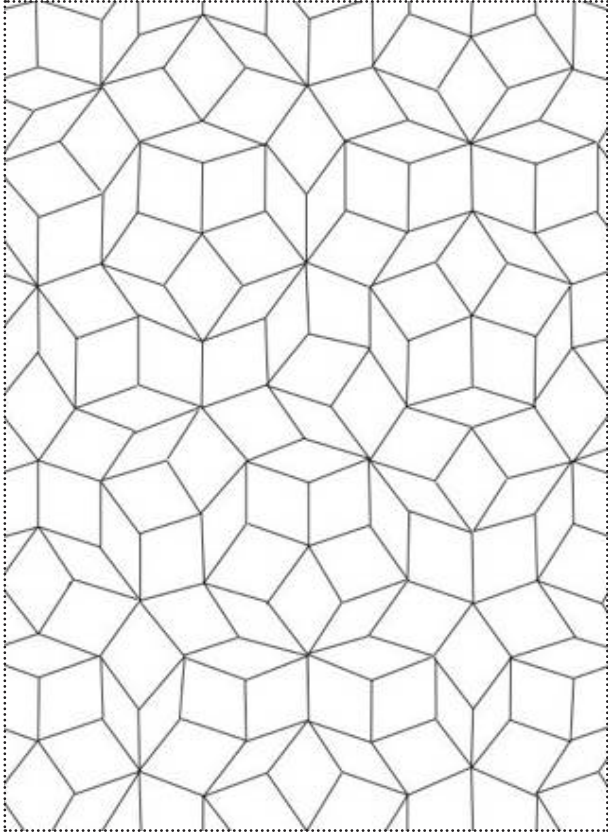




The screenshot shows a web browser window with a search bar at the top containing the text "Search or enter website name". Below the search bar, there are navigation links: "ABOUT", a decorative waveform icon, and "TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE". The main content area is divided into several sections by dotted lines. On the left, there is a large image of a complex, non-periodic tiling pattern. To its right, there is another image of a similar tiling pattern with a green double-headed arrow indicating a non-parallel translation. Below these images, there is a section titled "NONPERIODIC" with a definition: "A TILING THAT IS NOT PERIODIC (I.E. DOES NOT HAVE TWO TRANSLATIONS IN NON-PARALLEL DIRECTIONS) IS SAID TO BE NONPERIODIC." Below the definition, there is a note: "GIVEN: THE CENTRAL 'STAR' OCCURS NOWHERE ELSE IN THE TILING, AND SO NO TRANSLATIONS ARE POSSIBLE." The background of this text section features a faint, repeating pattern of the same tiling.

ABOUT

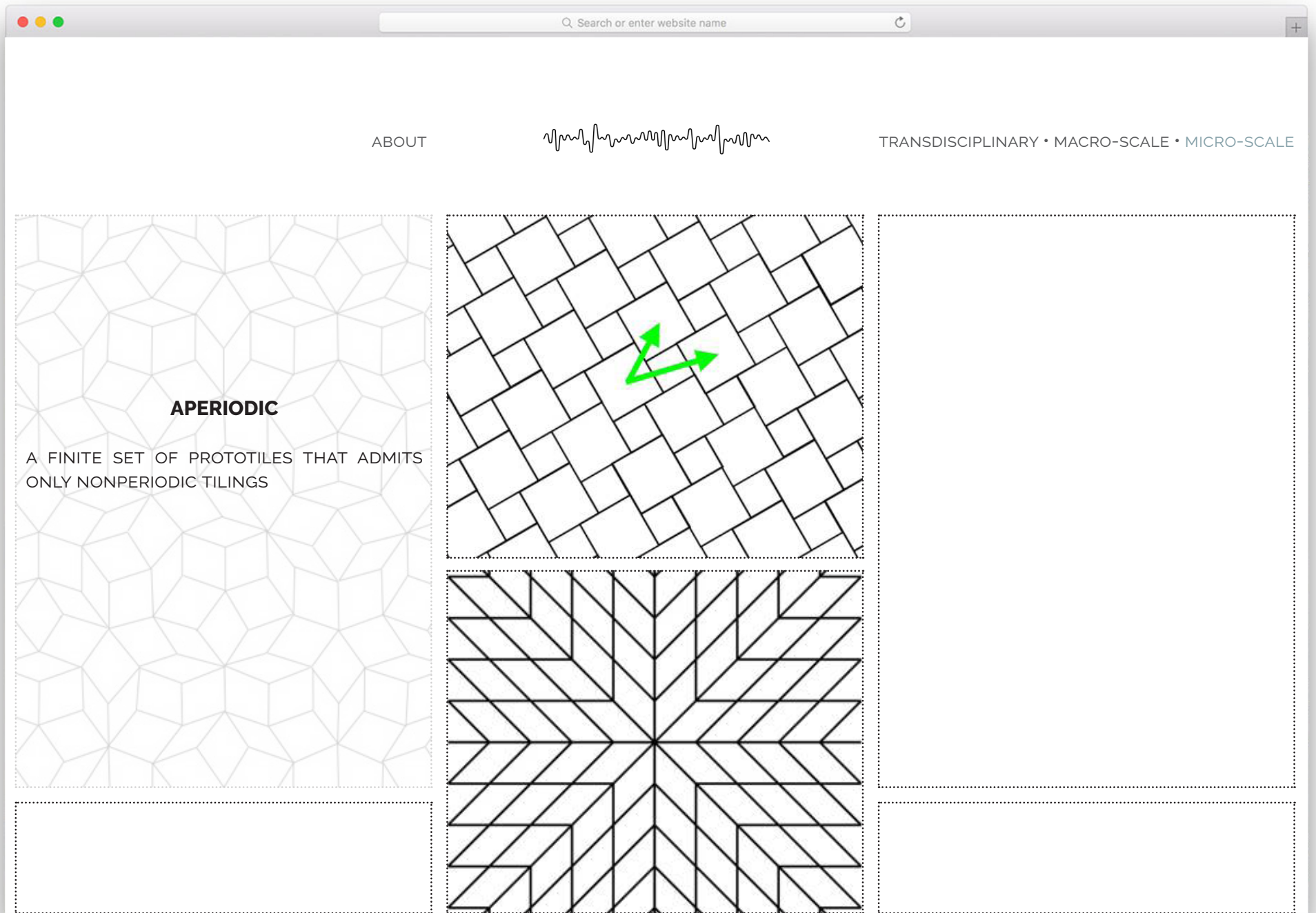
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

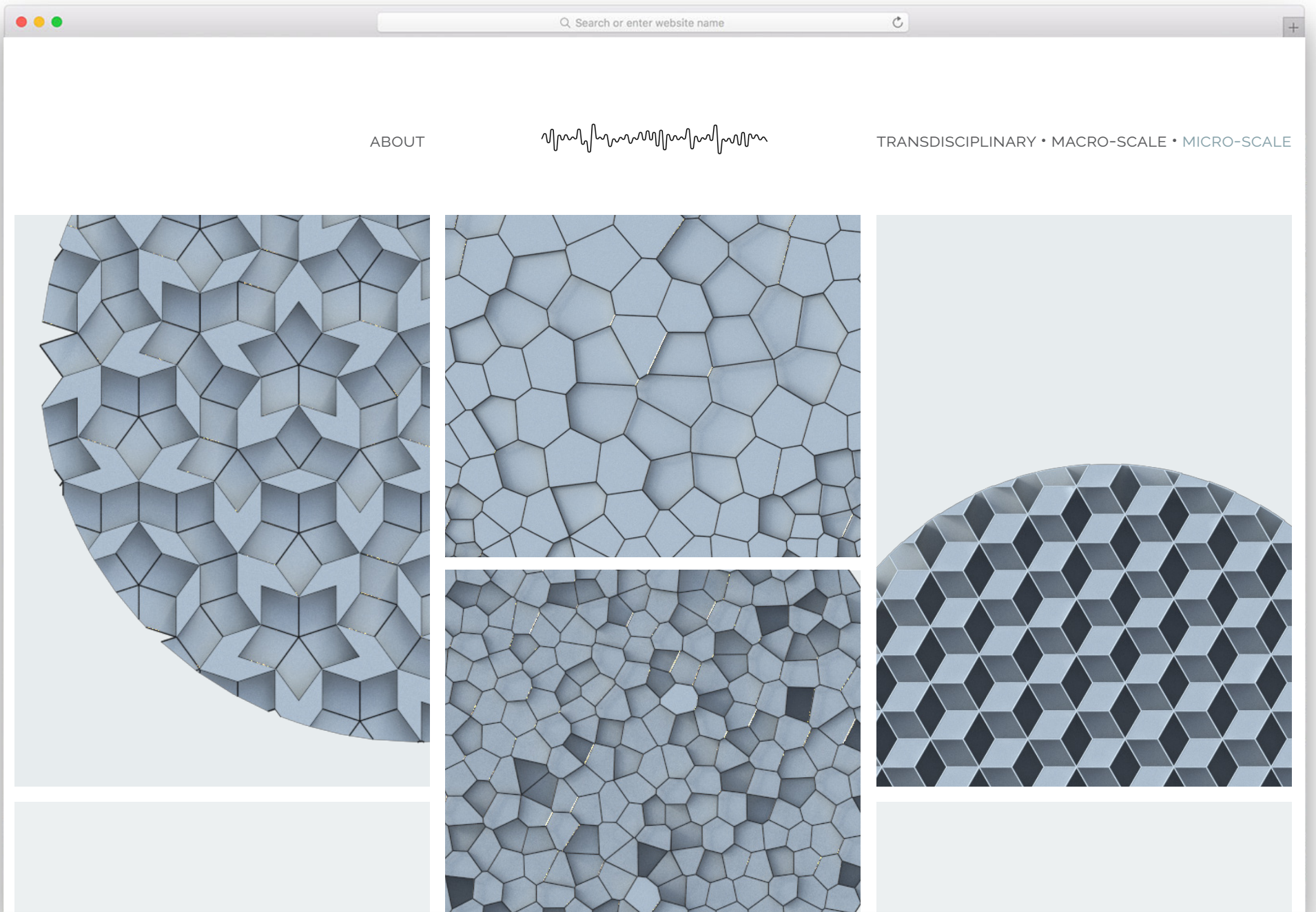


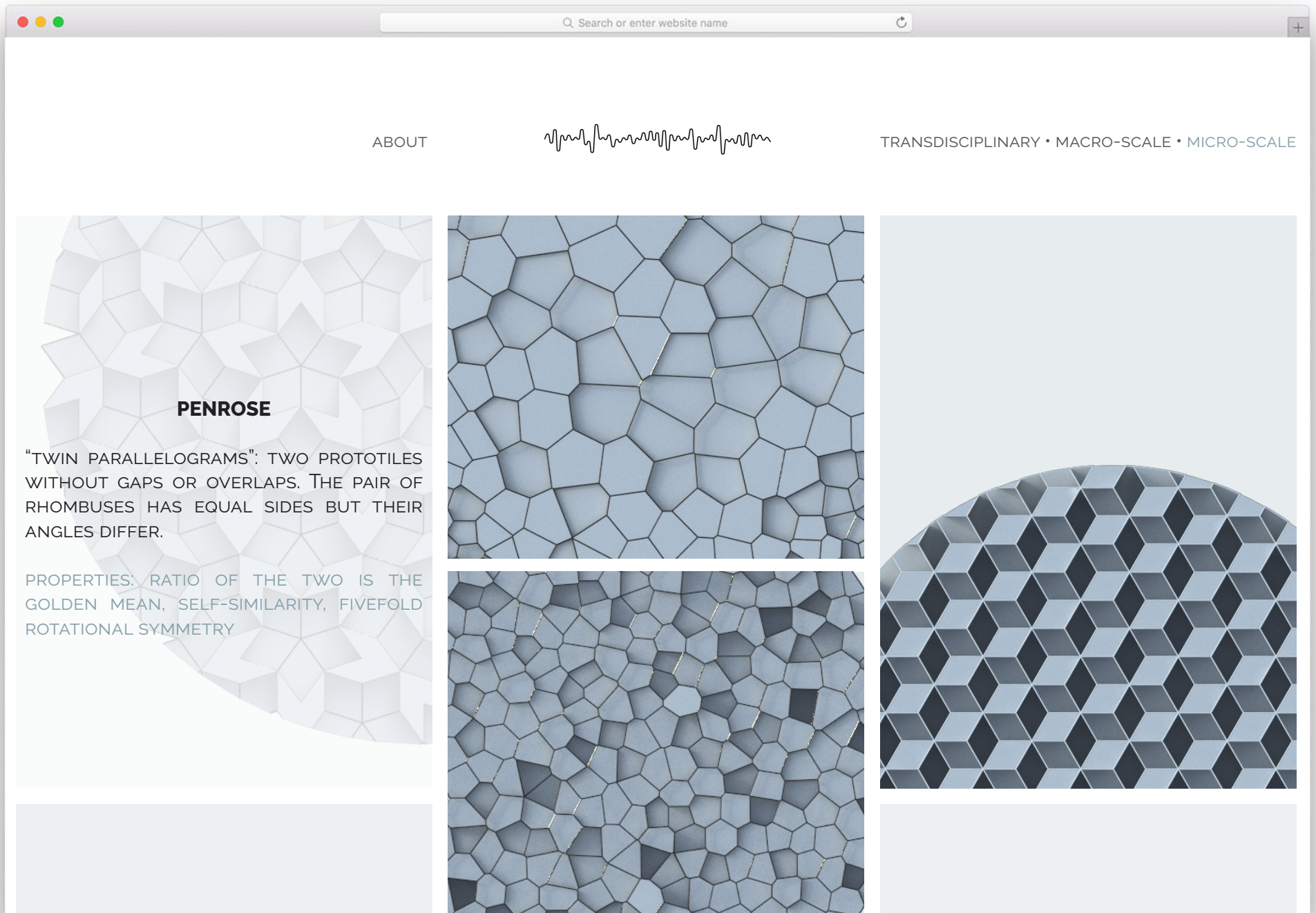
NONPERIODIC

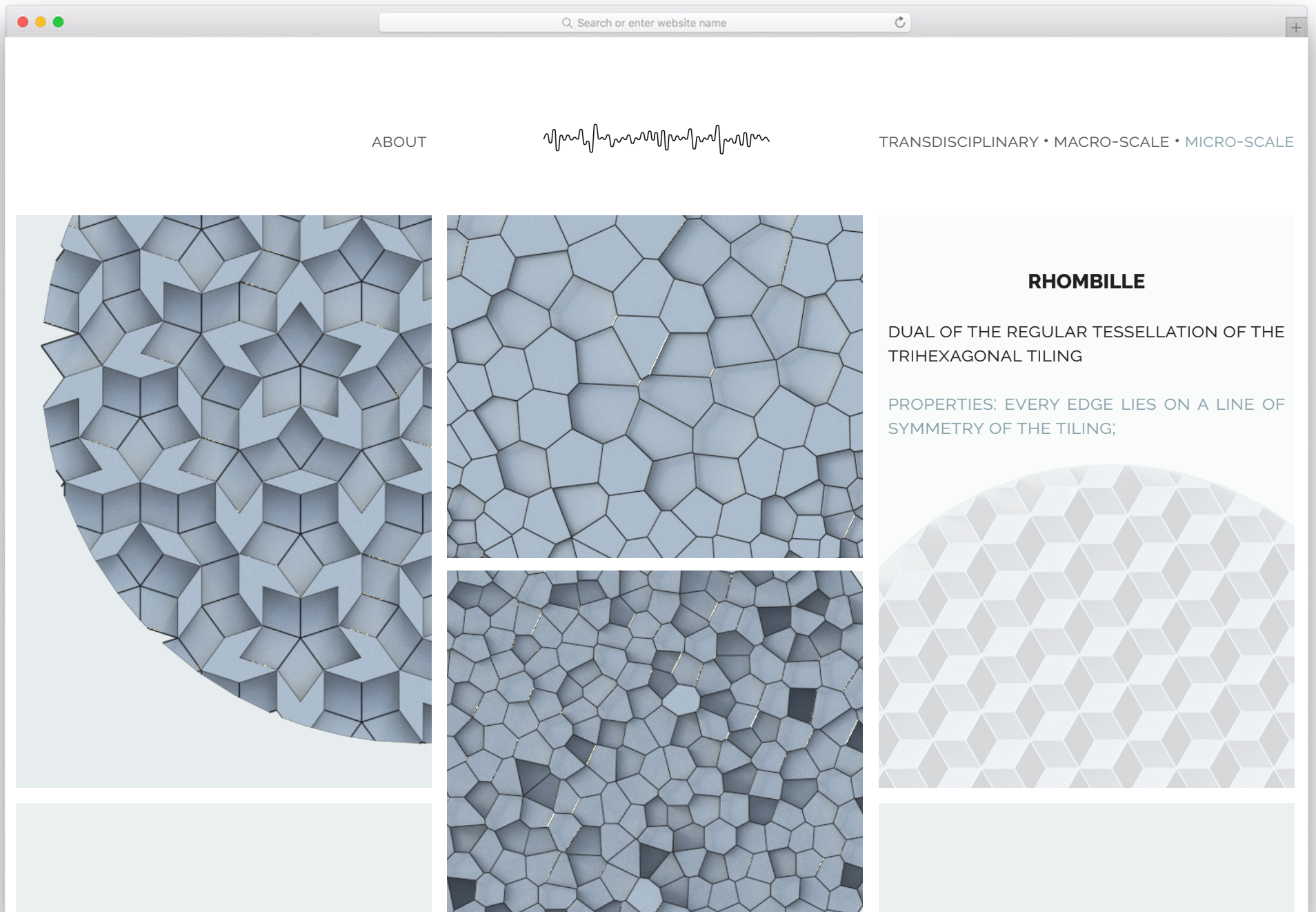
A TILING THAT IS NOT PERIODIC (I.E. DOES NOT HAVE TWO TRANSLATIONS IN NON-PARALLEL DIRECTIONS) IS SAID TO BE NONPERIODIC.

GIVEN: THE CENTRAL "STAR" OCCURS NOWHERE ELSE IN THE TILING, AND SO NO TRANSLATIONS ARE POSSIBLE.





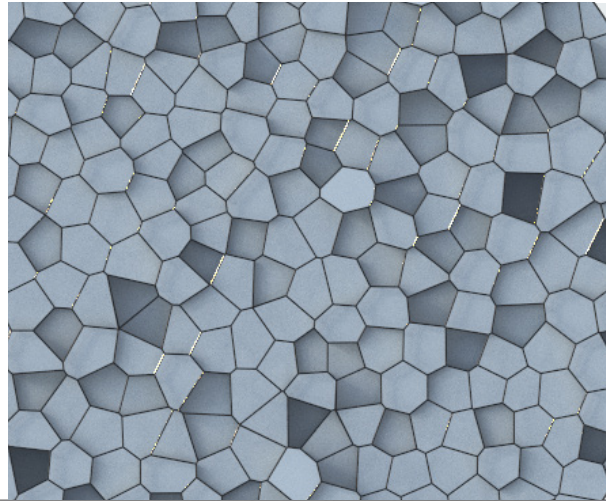
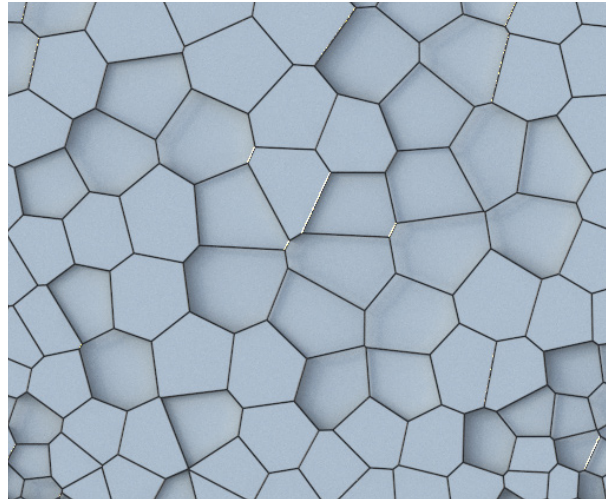
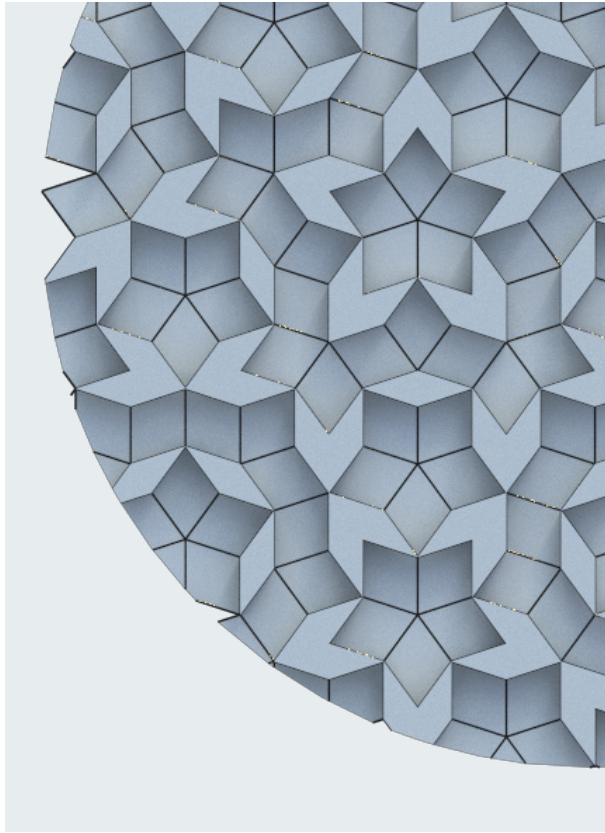




ABOUT



TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

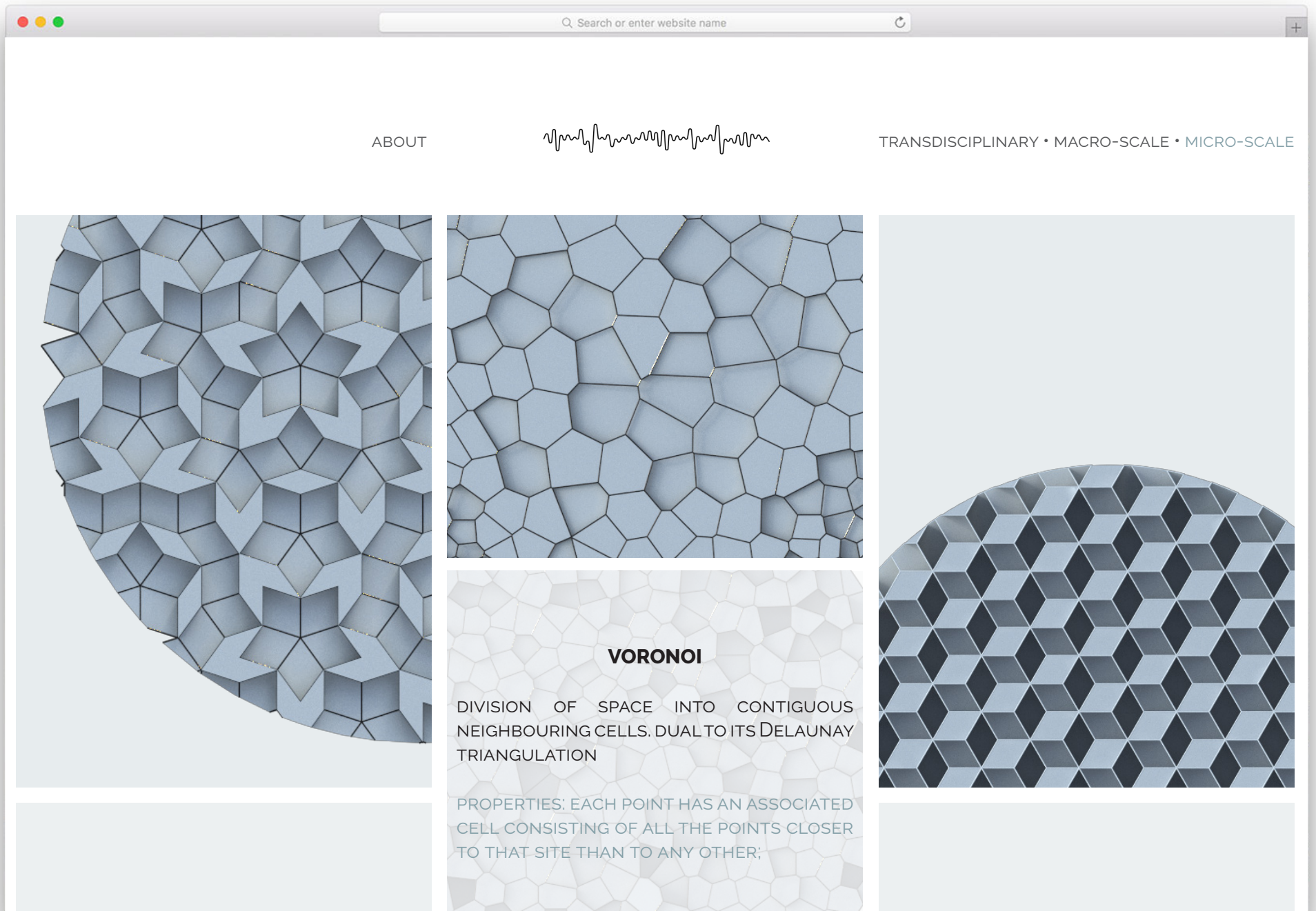


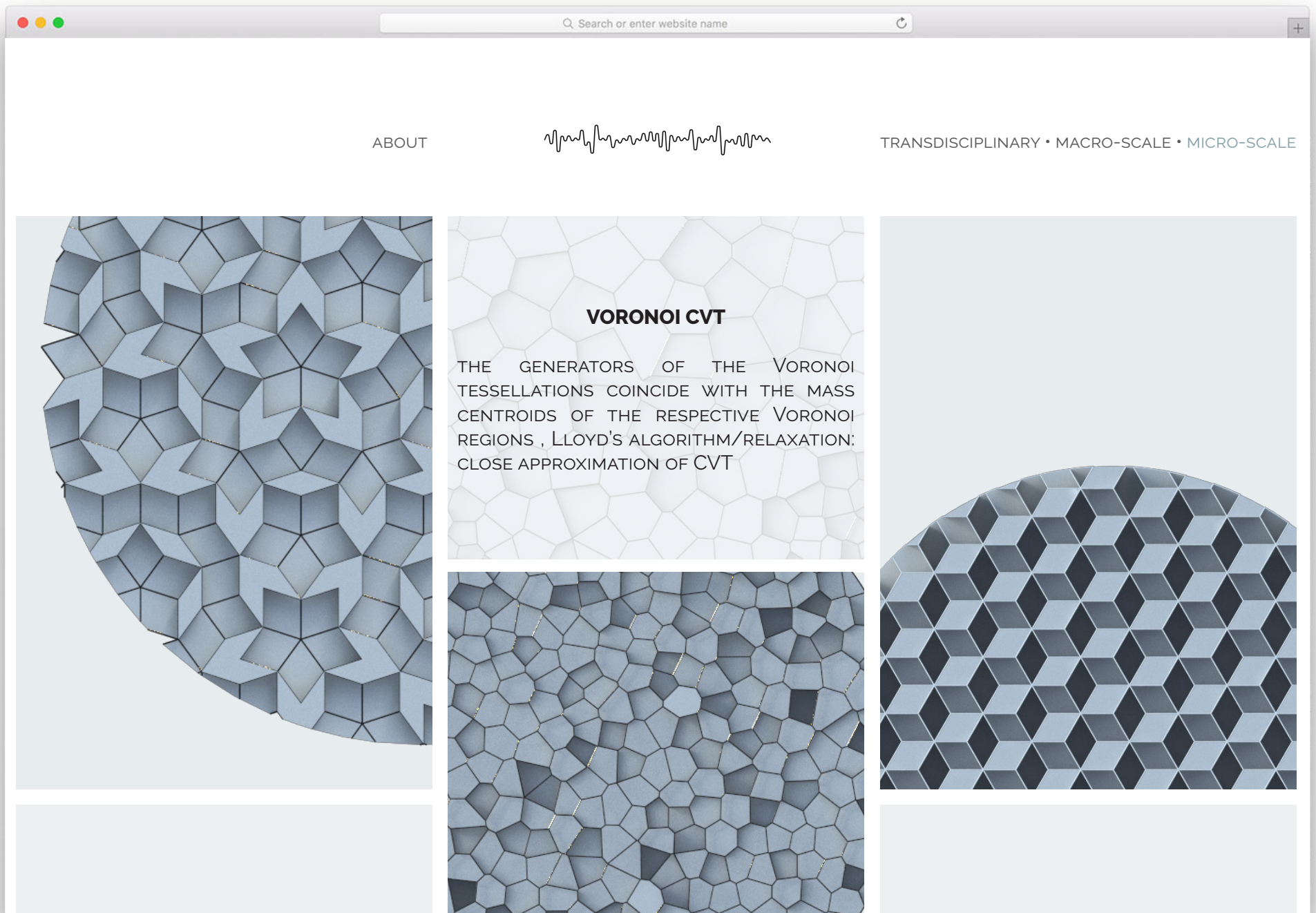
RHOMBILLE


DUAL OF THE REGULAR TESSELLATION OF THE TRIHEXAGONAL TILING

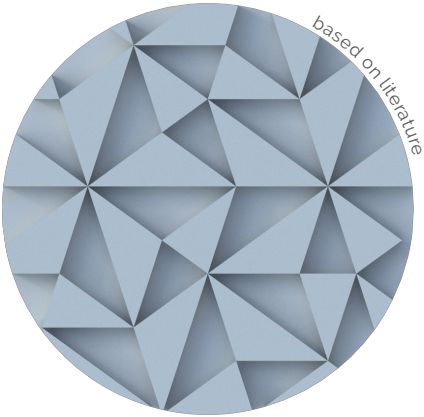
PROPERTIES: EVERY EDGE LIES ON A LINE OF SYMMETRY OF THE TILING;







ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE




based on literature

ISO SCATTERING

AMOUNT OF ENERGY REFLECTED IN THE SPECULAR DIRECTION

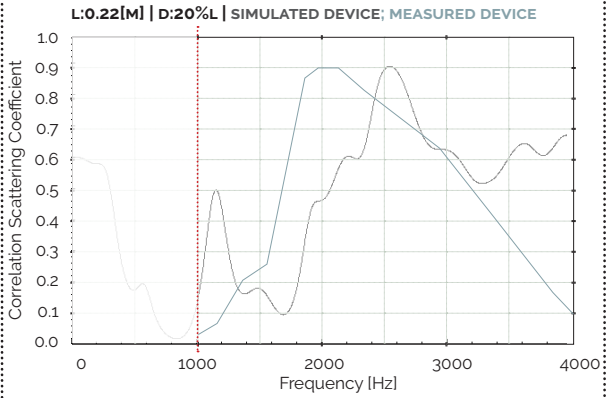
CORRELATION SCATTERING

DISSIMILARITY BETWEEN THE TEST AND FLAT SURFACE




QUALITY OF THE PRODUCED DISPERSION

MORE RESEARCH FOR COMPARISON PURPOSES



L:0.22[M] | D:20%L | SIMULATED DEVICE; MEASURED DEVICE



PACHYDERM ACOUSTICS PLUG-IN FOR GRASSHOPPER

! normal incidence: periodicity is highly dependent on the incidence angle

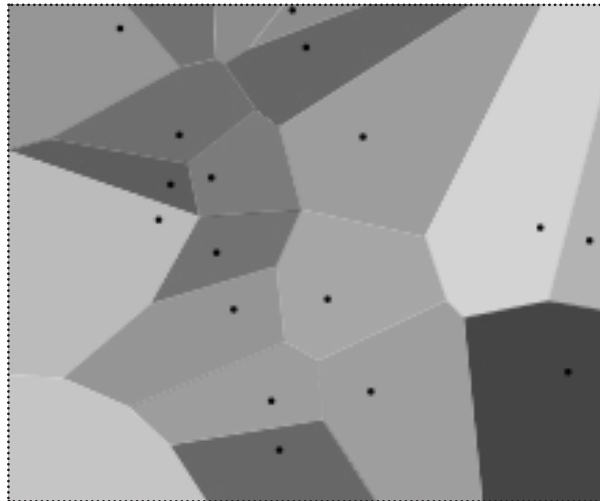
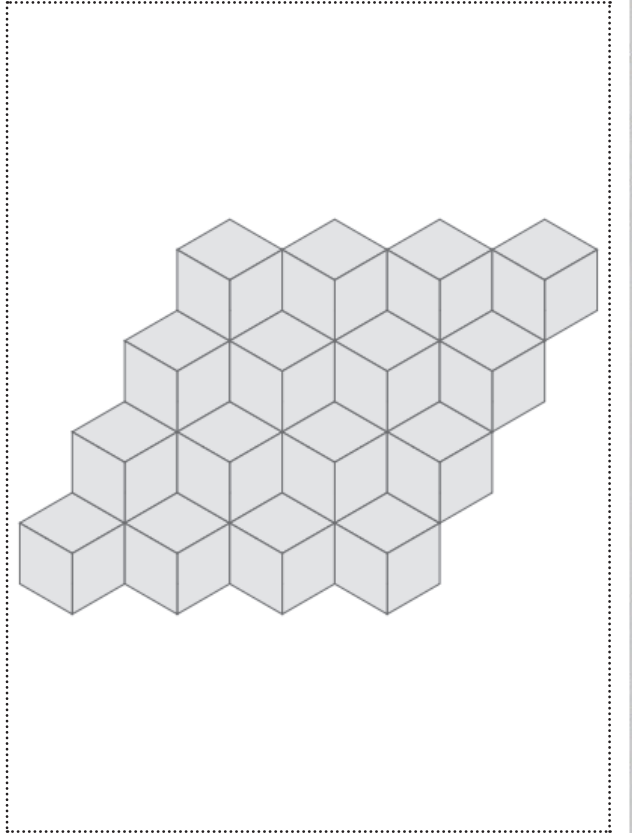
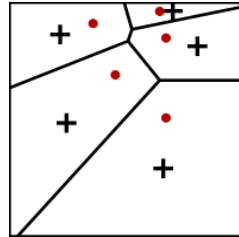
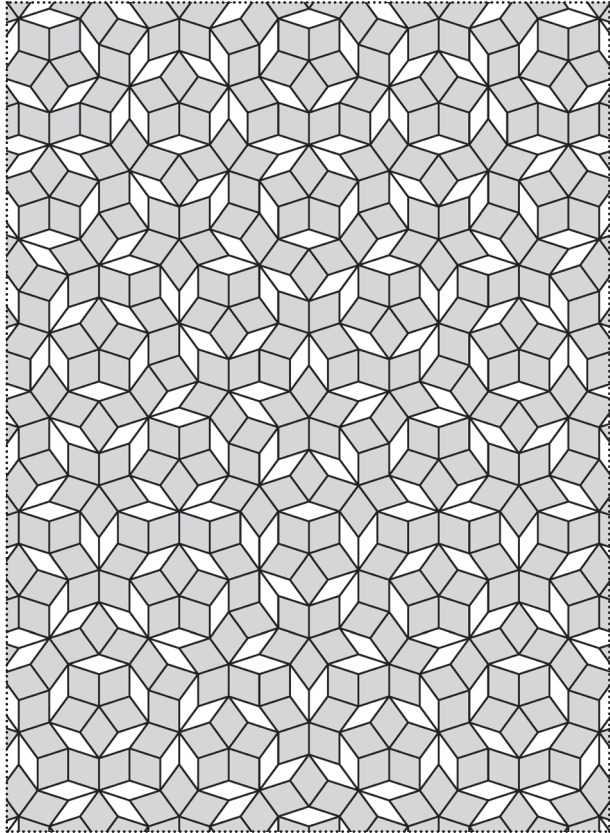
SCATTERING COEFFICIENT

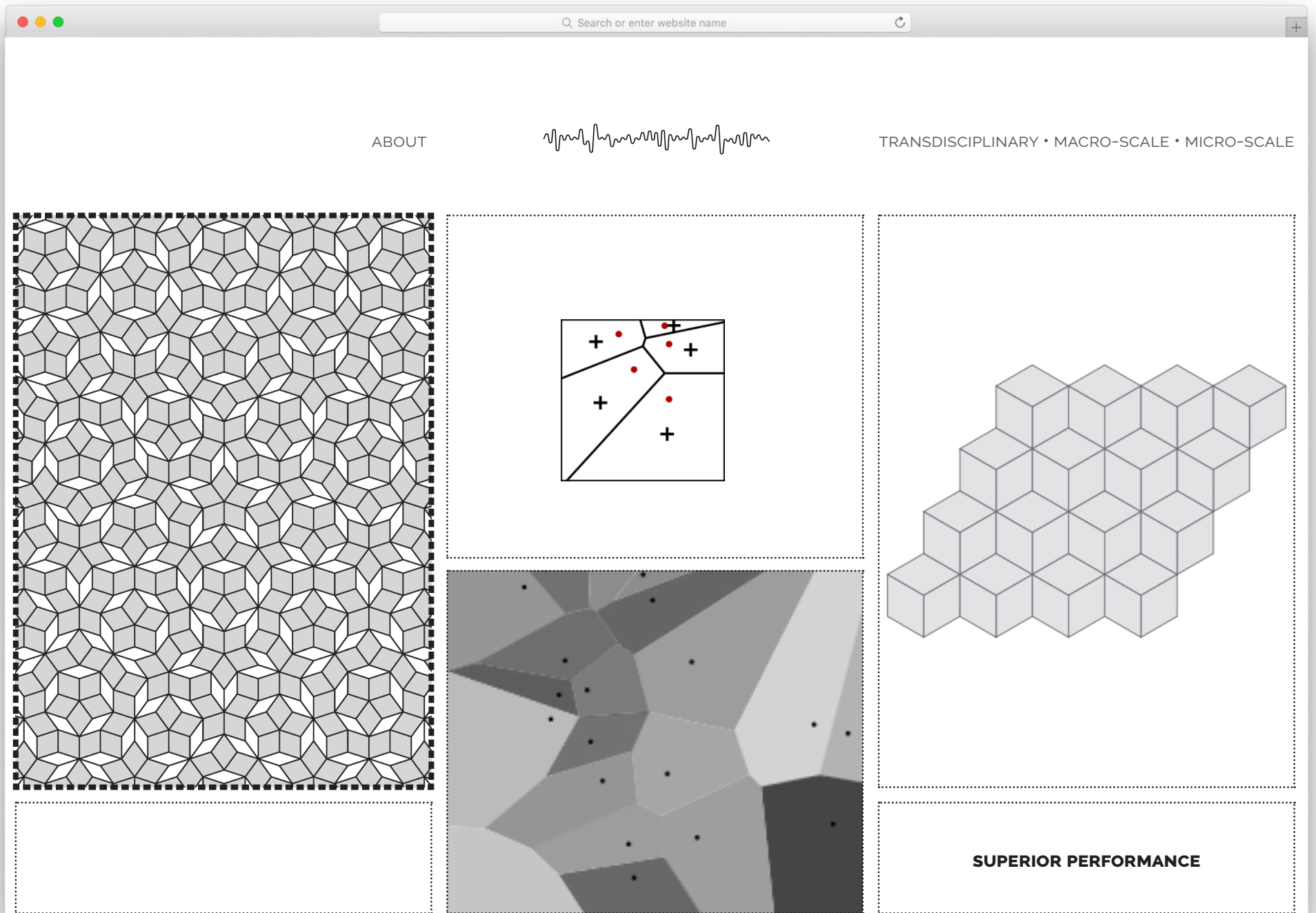



ABOUT

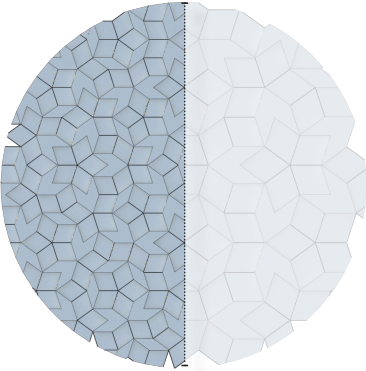


TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

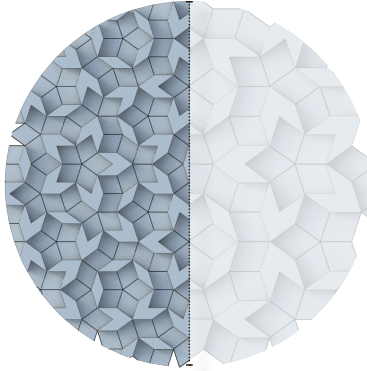




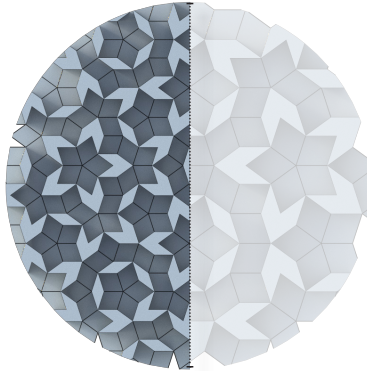
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [m] | D:20%L




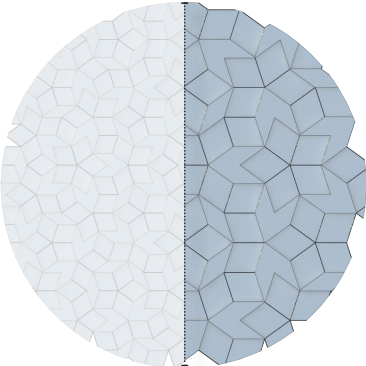
L:0.05 [m] | D:50%L



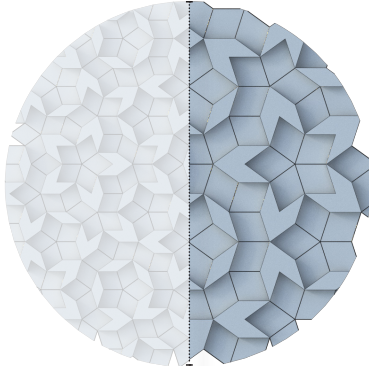
L:0.05 [m] | D:150%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

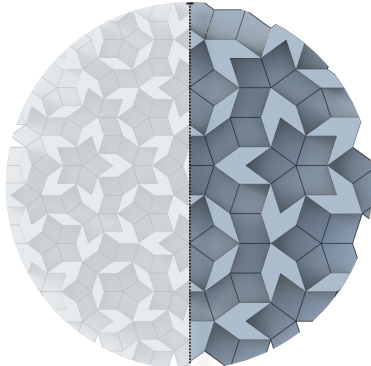
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.085 [M] | D:20%L



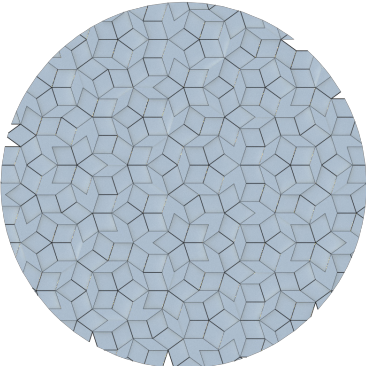
L:0.085 [M] | D:50%L



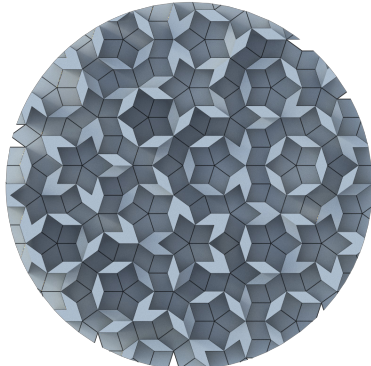
L:0.085 [M] | D:150%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE




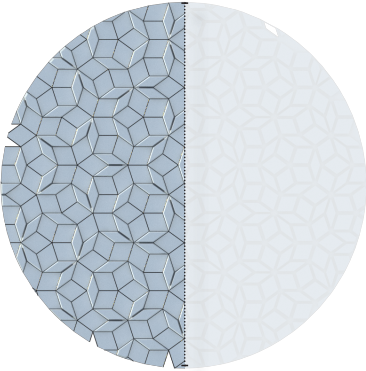
L:0.05 [m] | D:20%L



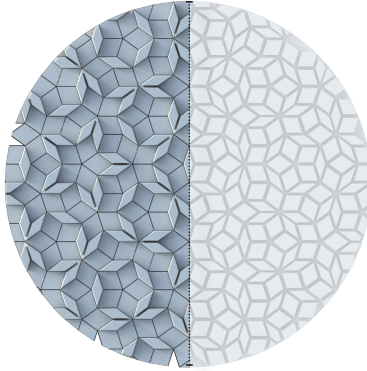
L:0.05 [m] | D:200%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
<u>various depths</u>	d=20% l [m] : 3		d=200% l [m] : 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

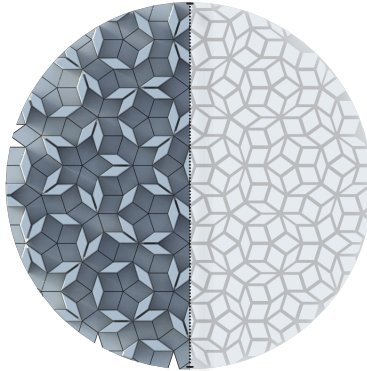
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L




L:0.05 [M] | D:50%L



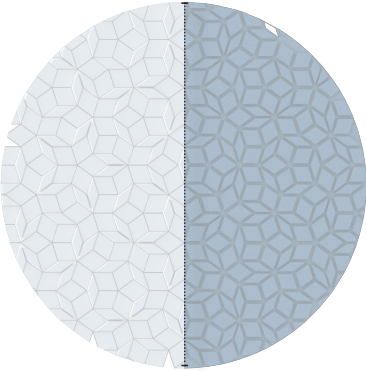
L:0.05 [M] | D:150%L

periodicity	parameters	profile	constrains	
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production 	
well	depth-to-length ratio			
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]	
various depths	d=20% l [m]: 3			d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]	

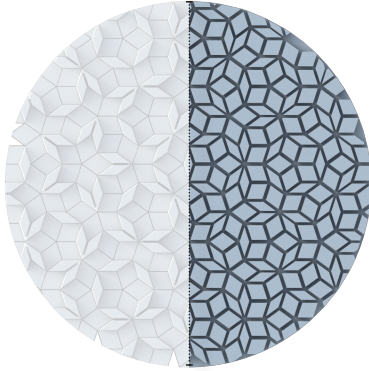
ABOUT



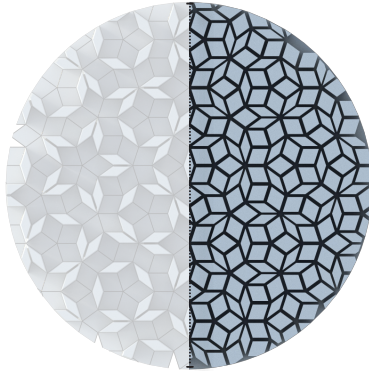
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L



L:0.05 [M] | D:50%L



L:0.05 [M] | D:150%L

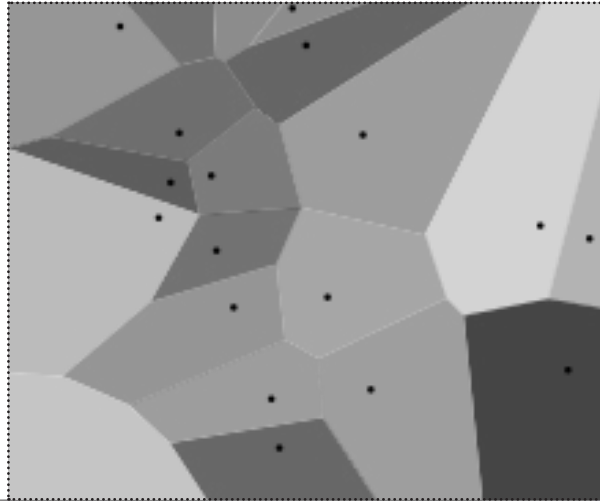
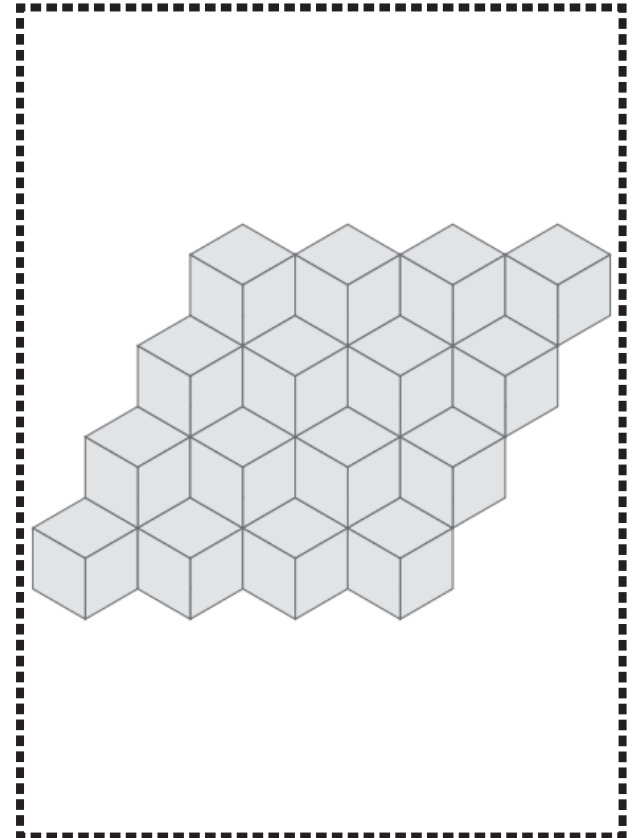
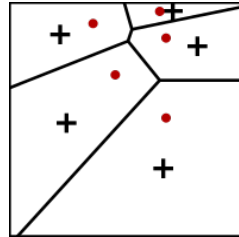
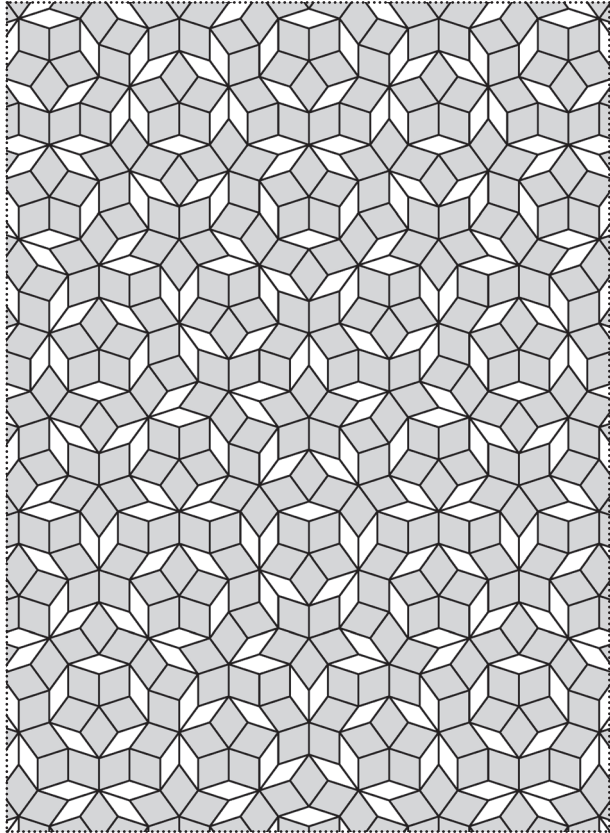
periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
<u>narrow width</u>	d=20% l [m]	d=50% l [m]	d=150% l [m]



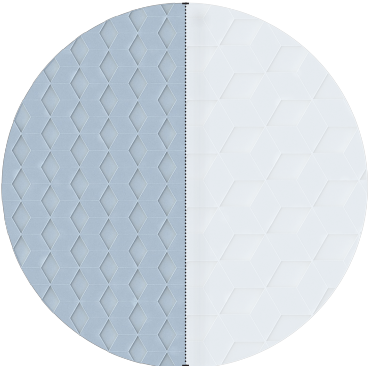
ABOUT



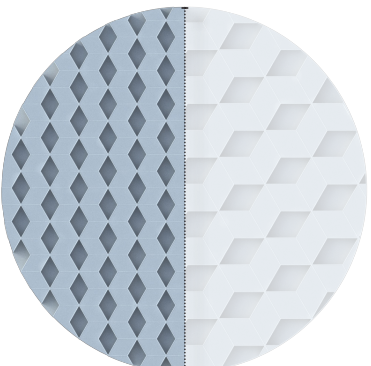
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



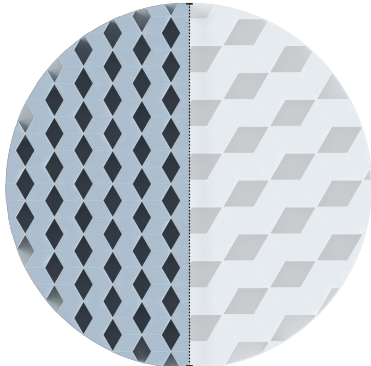
ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L | EXTRUDED




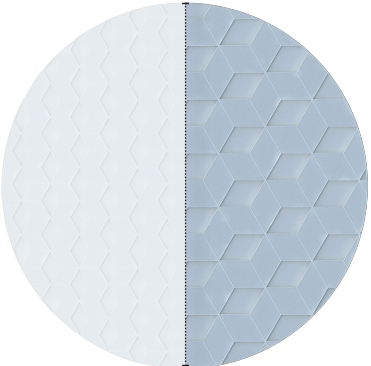
L:0.05 [M] | D:50%L | EXTRUDED



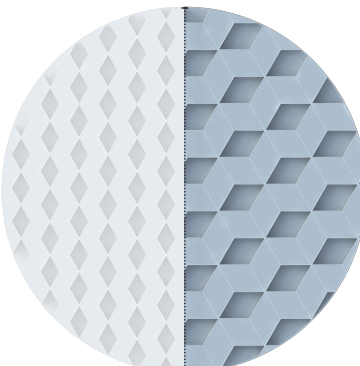
L:0.05 [M] | D:150%L | EXTRUDED

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

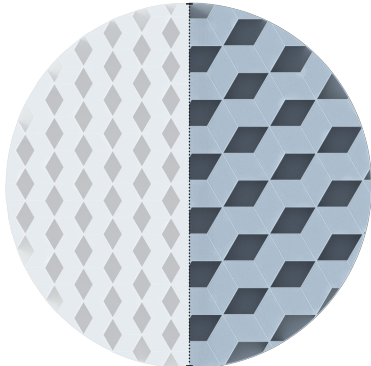
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.085 [M] | D:20%L | EXTRUDED




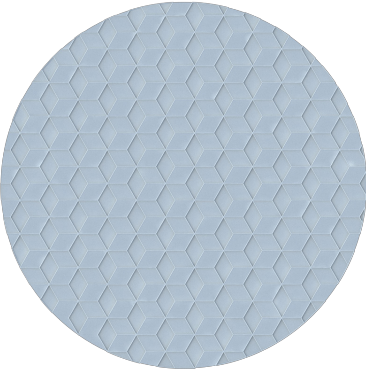
L:0.085 [M] | D:50%L | EXTRUDED



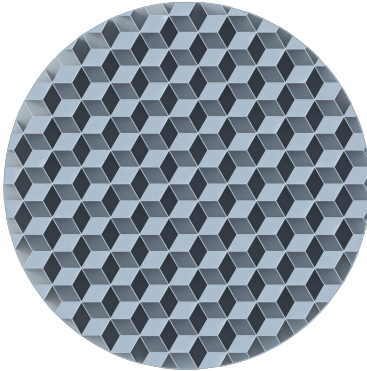
L:0.085 [M] | D:150%L | EXTRUDED

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE




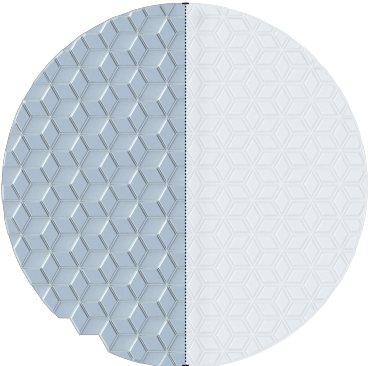
L:0.05 [m] | D:20%L



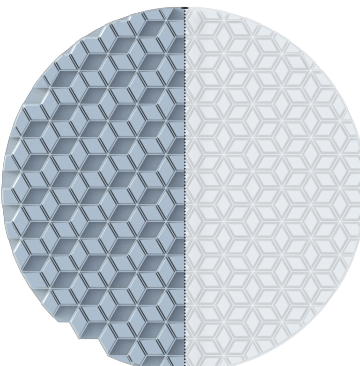
L:0.05 [m] | D:200%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
<u>various depths</u>	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

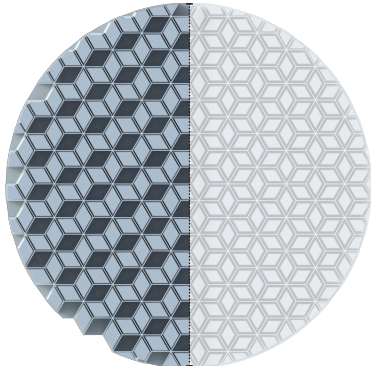
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L




L:0.05 [M] | D:50%L

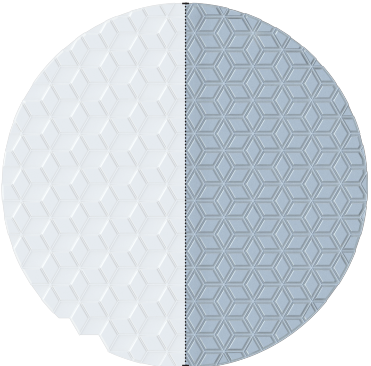


L:0.05 [M] | D:150%L

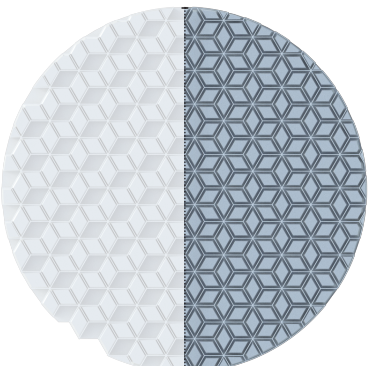
periodicity	parameters	profile	constrains	
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production 	
well	depth-to-length ratio			
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]	
various depths	d=20% l [m]: 3			d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]	

Search or enter website name
+

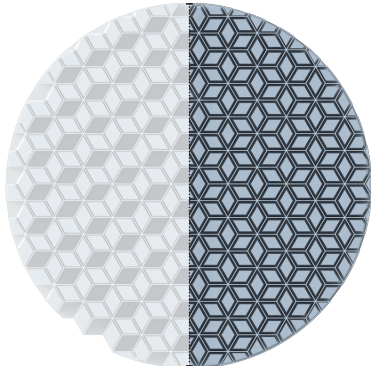
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L

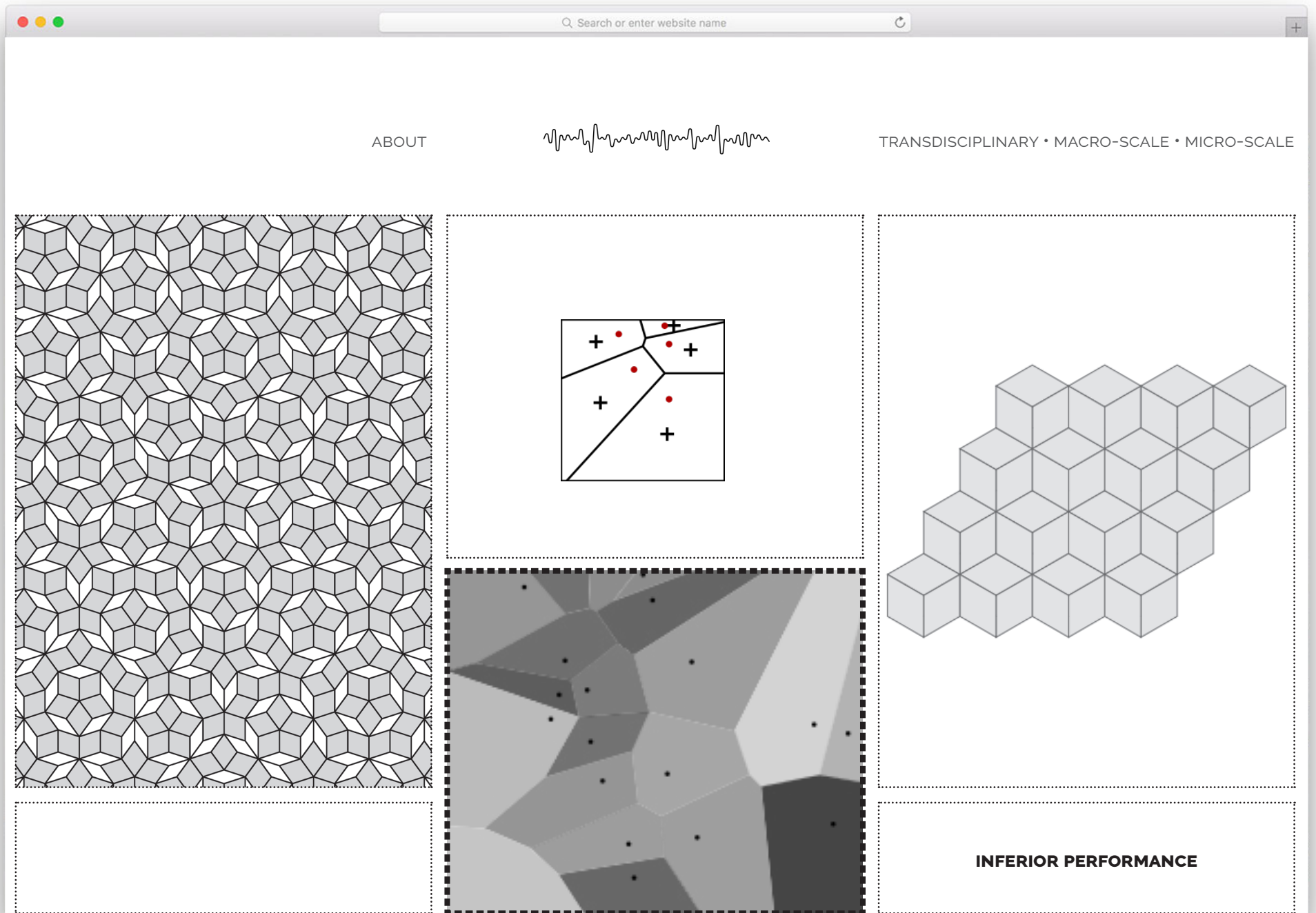



L:0.05 [M] | D:50%L

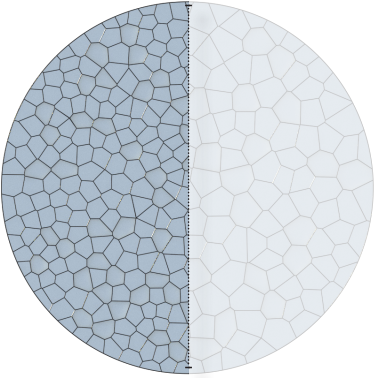


L:0.05 [M] | D:150%L

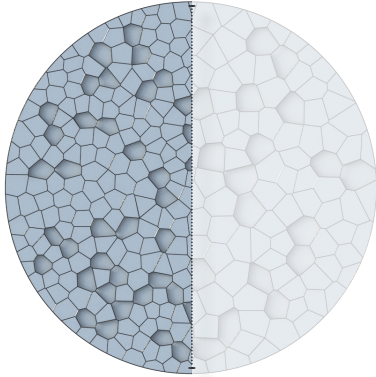
periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
<u>narrow width</u>	d=20% l [m]	d=50% l [m]	d=150% l [m]



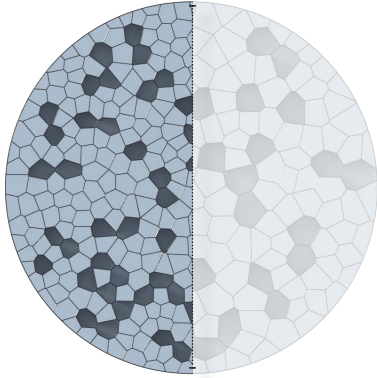
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L | EXTRUDED




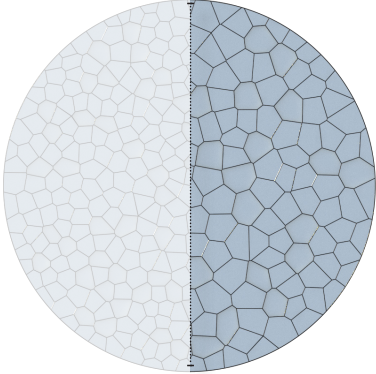
L:0.05 [M] | D:50%L | EXTRUDED



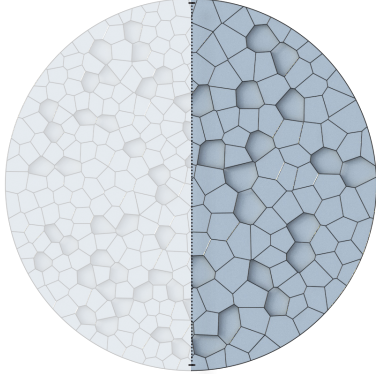
L:0.05 [M] | D:150%L | EXTRUDED

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

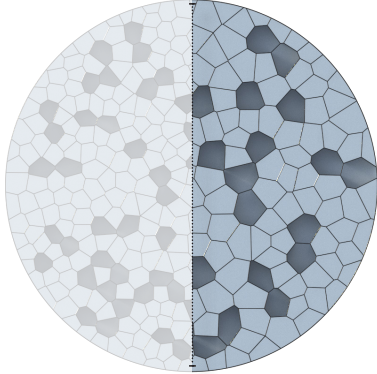
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.085 [M] | D:20%L | EXTRUDED



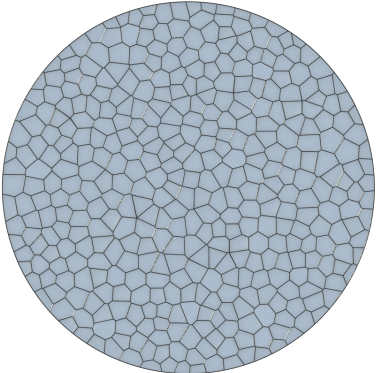
L:0.085 [M] | D:50%L | EXTRUDED



L:0.085 [M] | D:150%L | EXTRUDED

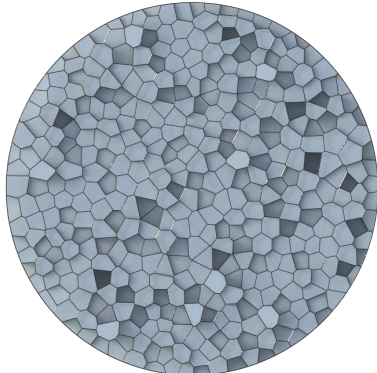
periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE




L:0.05 [m] | D:20%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
<u>various depths</u>	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

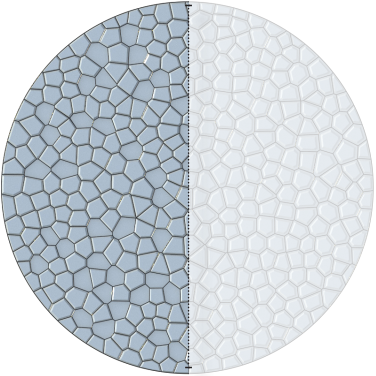


L:0.05 [m] | D:200%L

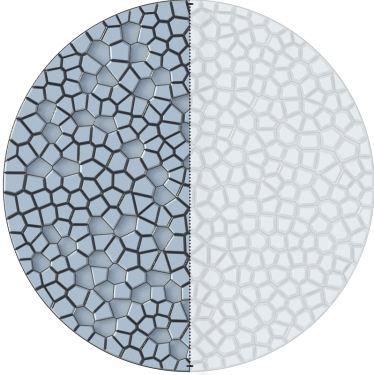
ABOUT



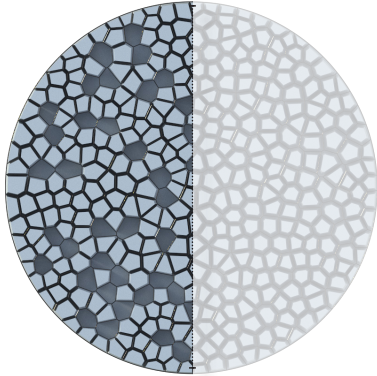
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L



L:0.05 [M] | D:50%L



L:0.05 [M] | D:150%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

Search or enter website name
+

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

L:0.05 [M] | D:20%L

L:0.05 [M] | D:50%L

L:0.05 [M] | D:150%L

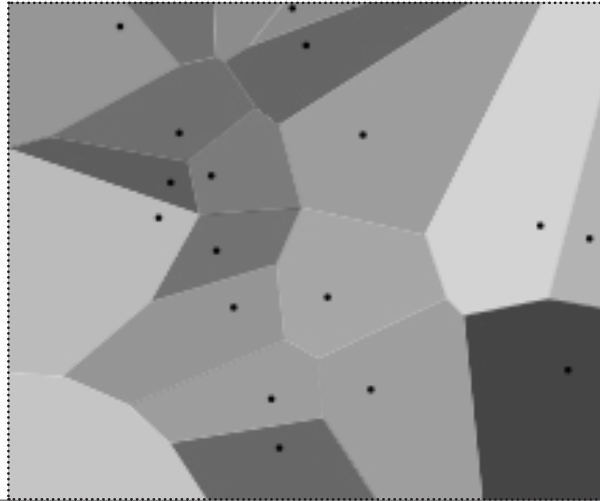
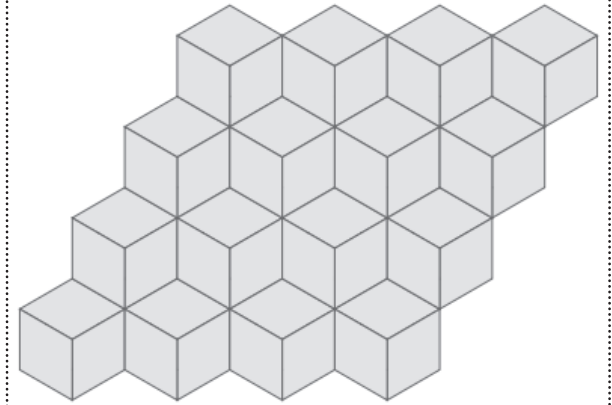
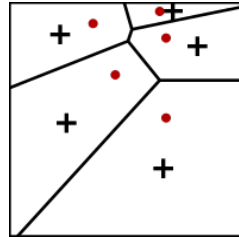
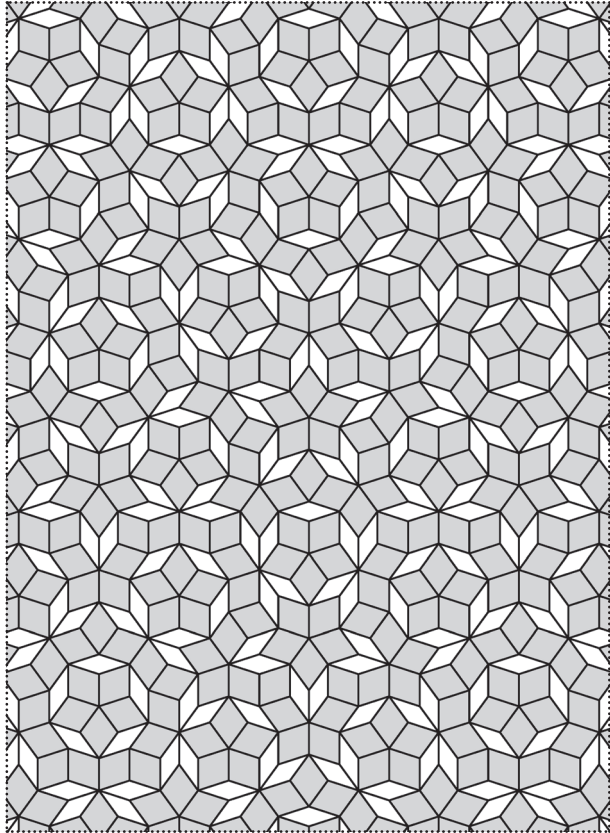
periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
<u>narrow width</u>	d=20% l [m]	d=50% l [m]	d=150% l [m]




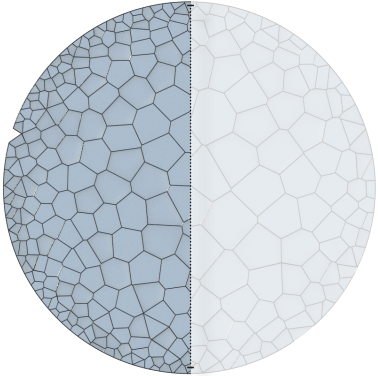
ABOUT



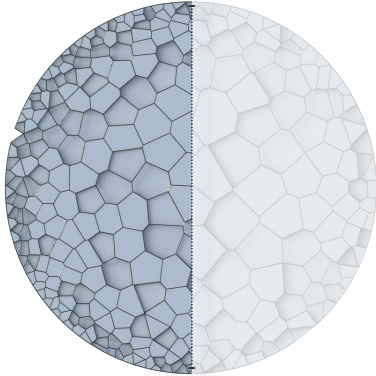
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



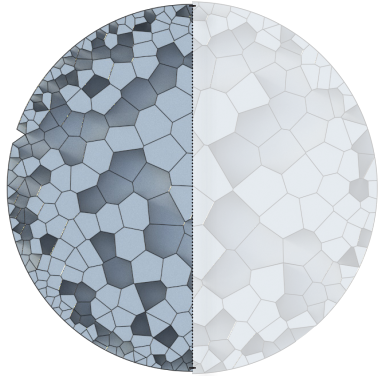
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L | EXTRUDED




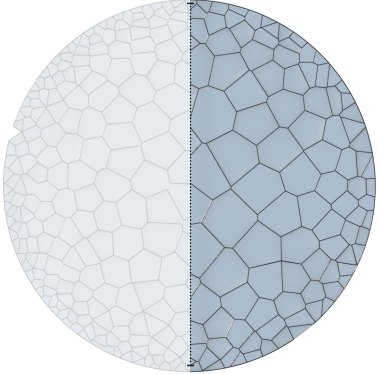
L:0.05 [M] | D:50%L | EXTRUDED



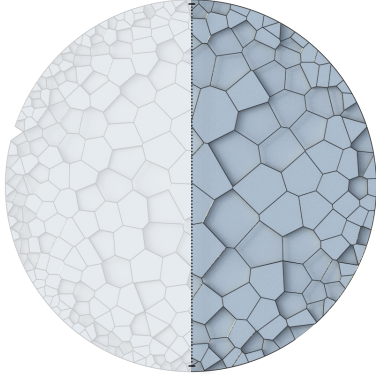
L:0.05 [M] | D:150%L | EXTRUDED

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

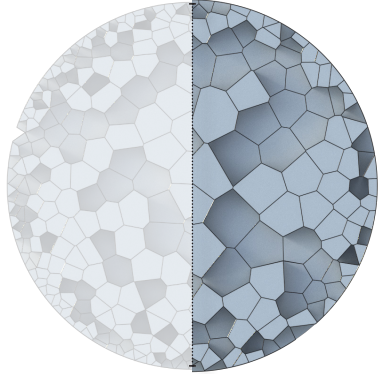
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.085 [M] | D:20%L | EXTRUDED



L:0.085 [M] | D:50%L | EXTRUDED



L:0.085 [M] | D:150%L | EXTRUDED

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]
			d=200% l [m]: 3

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

L:0.05 [m] | D:20%L

L:0.05 [m] | D:200%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
<u>various depths</u>	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]


ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

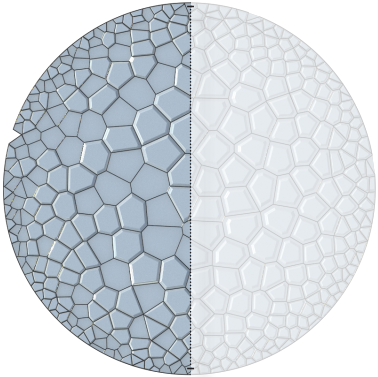
L:0.05 [M] | D:20%L

L:0.05 [M] | D:50%L

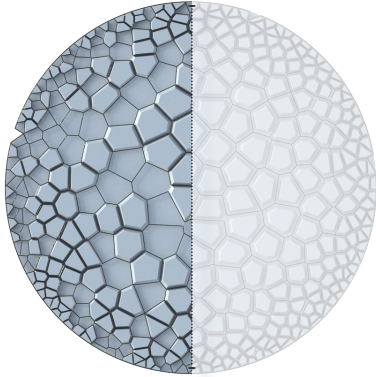
L:0.05 [M] | D:150%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
narrow width	d=20% l [m]	d=50% l [m]	d=150% l [m]

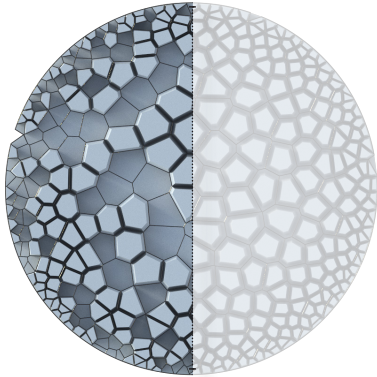
ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



L:0.05 [M] | D:20%L



L:0.05 [M] | D:50%L



L:0.05 [M] | D:150%L

periodicity	parameters	profile	constrains
<ul style="list-style-type: none"> • aperiodic • periodic • non-periodic 	<ul style="list-style-type: none"> • cells • period • well 	<ul style="list-style-type: none"> • extruded • tapered 	<ul style="list-style-type: none"> amount production
well	depth-to-length ratio		
two depths	d=20% l [m]	d=50% l [m]	d=150% l [m]
various depths	d=20% l [m]: 3		d=200% l [m]: 3
<u>narrow width</u>	d=20% l [m]	d=50% l [m]	d=150% l [m]

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

	periodicity	parameters	profile	con- strains
steps	aperiodic	<ul style="list-style-type: none"> cells period well 	<ul style="list-style-type: none"> extruded tapered 	amount finite set

CHOOSE APERIODIC PATTERN

⇓

CONSTRAINS: MINIMIZE AMOUNT + AVOID VARIABILITY OF ELEMENTS AND DEPTH

⇓

INVESTIGATE DIFFERENT VERTICAL PROFILES

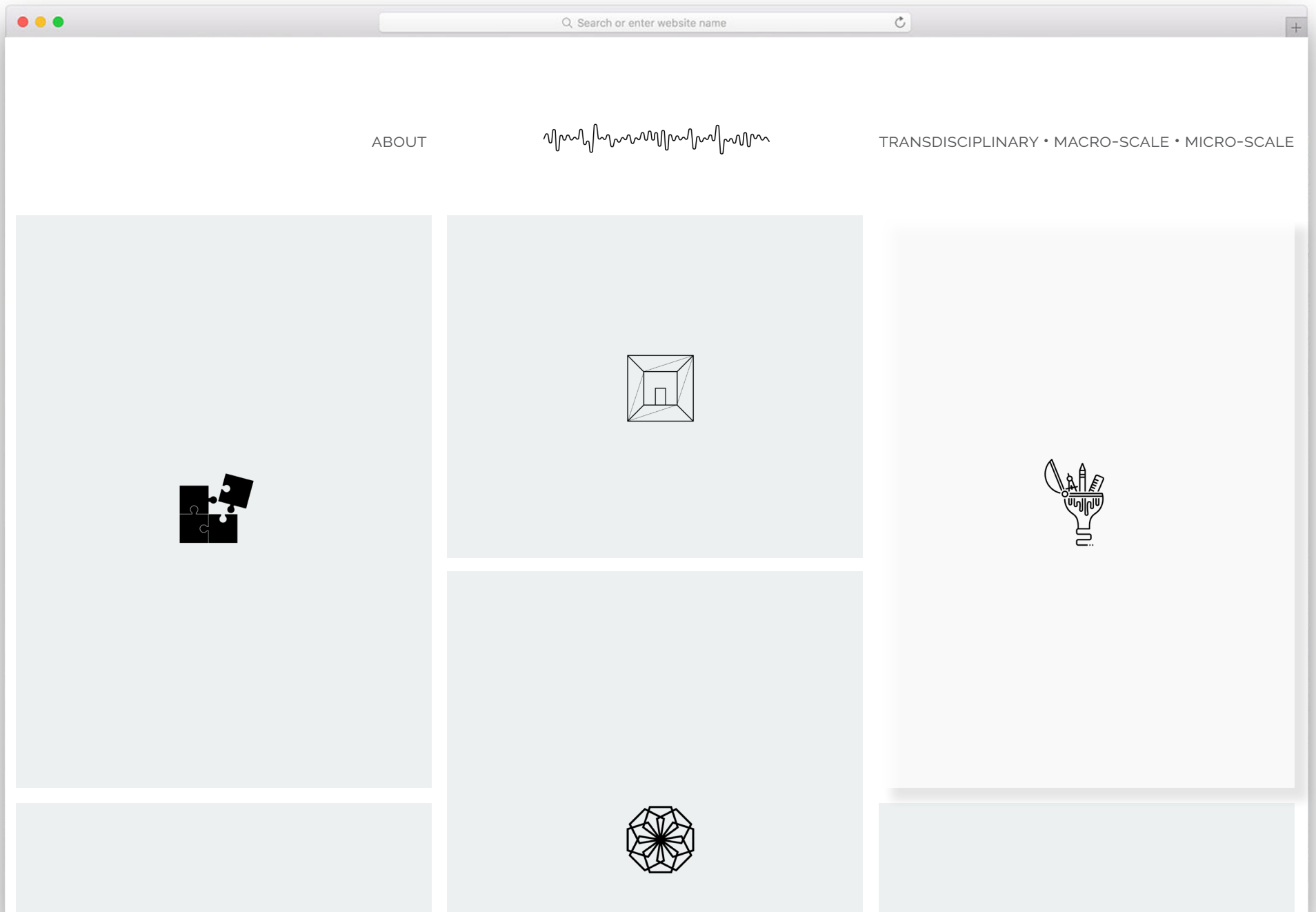
⇓

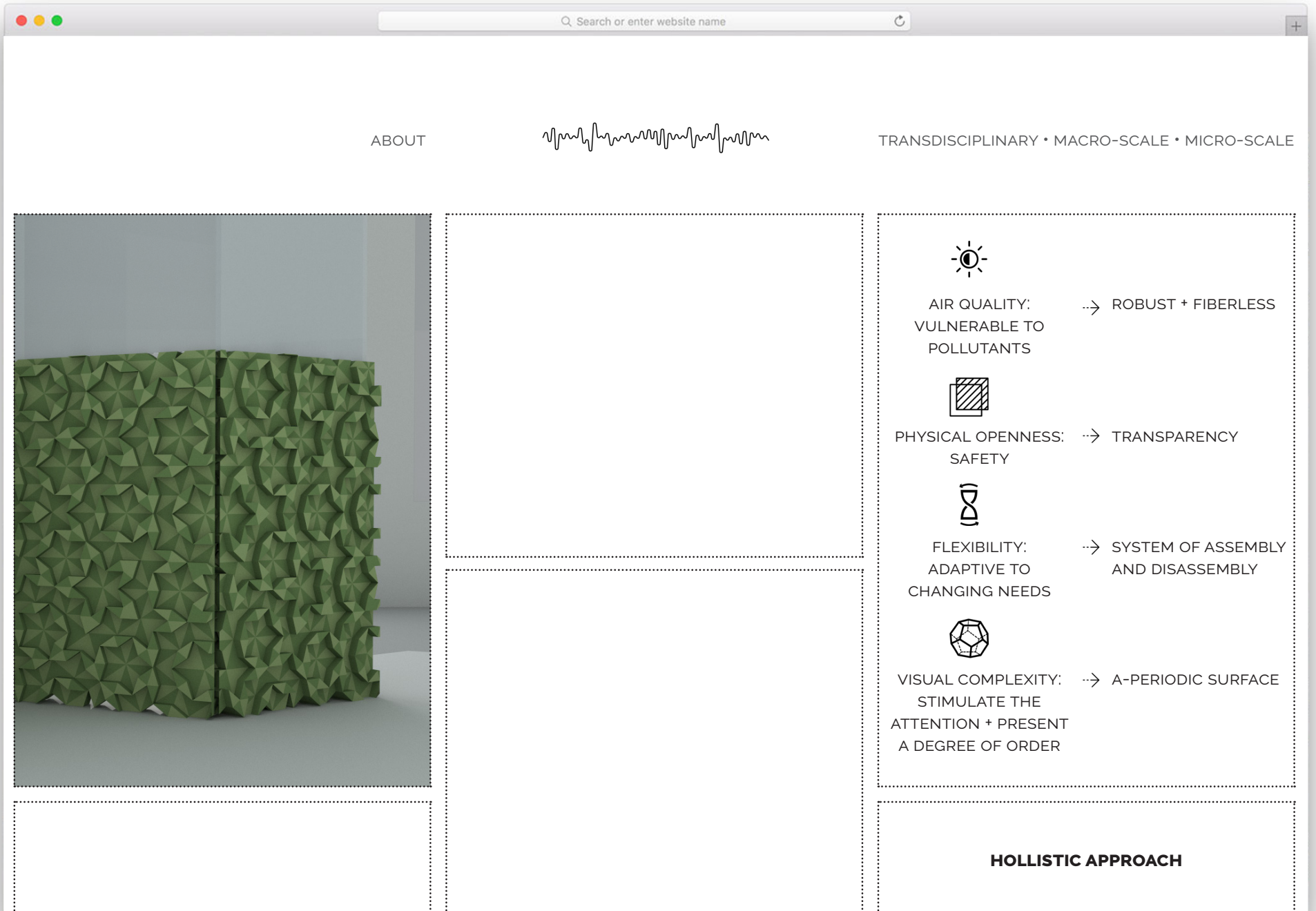
PARAMETERS: DEPTH-TO-LENGTH RATIO + PERIOD [BIG] + WELL [NARROW]

⇓

AVOID MORE THAN 50% DEPTH-TO-LENGTH RATIO FOR IMPROVED SPEECH INTELLIGIBILITY

well	depth-to-length ratio			
two depths	d=20% l [m]	d=50% l [m]		
narrow width	d=20% l [m]	d=50% l [m]		





ABOUT



TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE



AIR QUALITY:
VULNERABLE TO
POLLUTANTS

→ ROBUST + FIBERLESS



PHYSICAL OPENNESS:
SAFETY

→ TRANSPARENCY



FLEXIBILITY:
ADAPTIVE TO
CHANGING NEEDS

→ SYSTEM OF ASSEMBLY
AND DISASSEMBLY




VISUAL COMPLEXITY:
STIMULATE THE
ATTENTION + PRESENT
A DEGREE OF ORDER

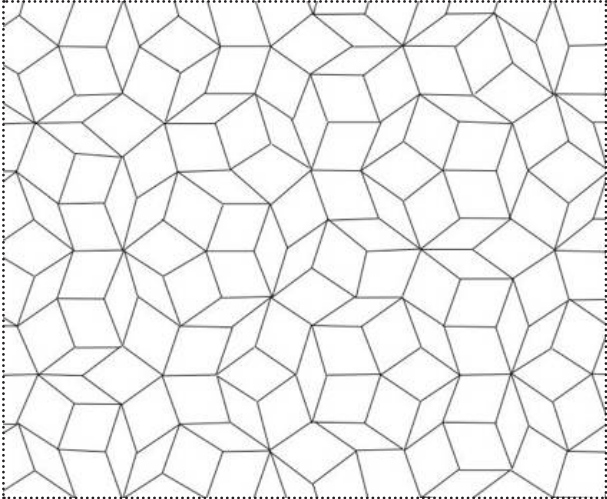
→ A-PERIODIC SURFACE

HOLLISTIC APPROACH

Q Search or enter website name
+


ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

pattern ▼	profile ▼	parameters ▼
Penrose tiles		
Robinson tiles		
Ammann tiles		
Shield tiles		
Danzer triangles		
Wang tiles		
Robinson triangle		



[open source platform]

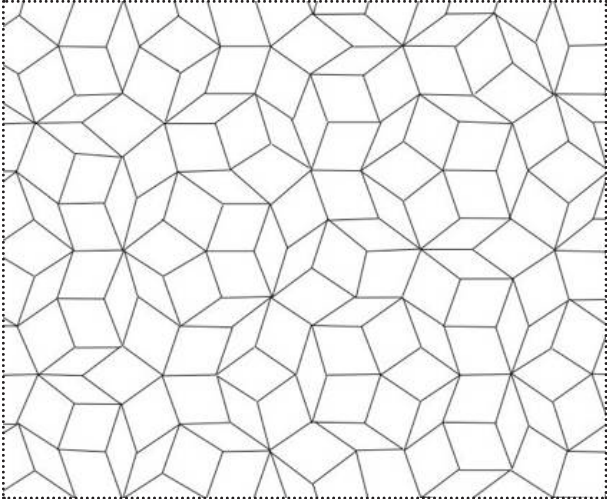
ABOUT

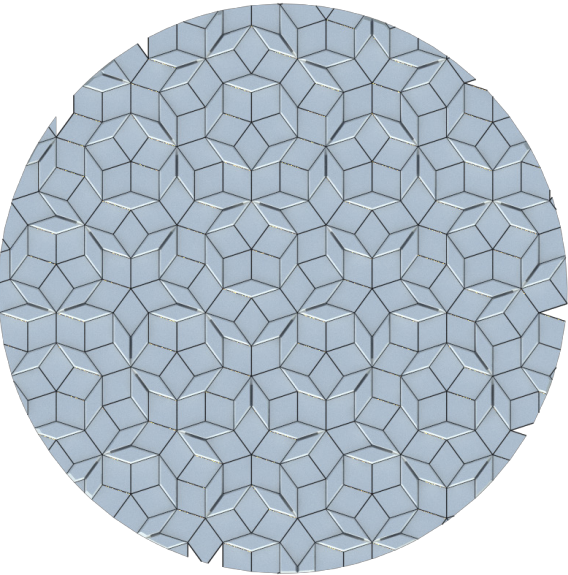

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

pattern ▼
profile ▼
parameters ▼

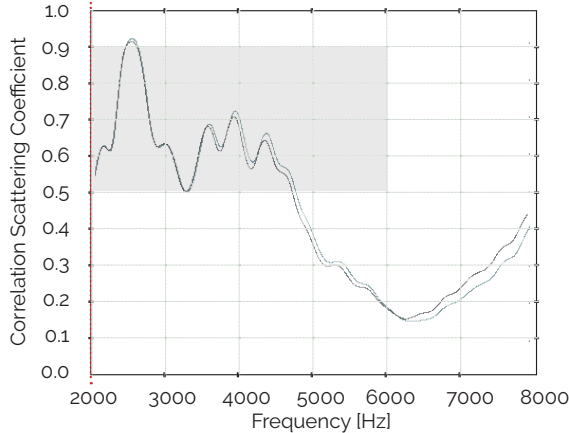
tapered

extruded






L:0.05 [M] | D:20%L | EXTRUDED; TAPERED



COR. SCATTERING COEFFICIENT

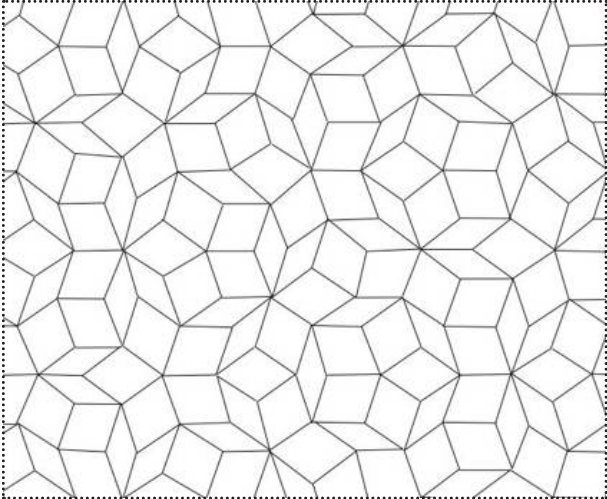
ABOUT

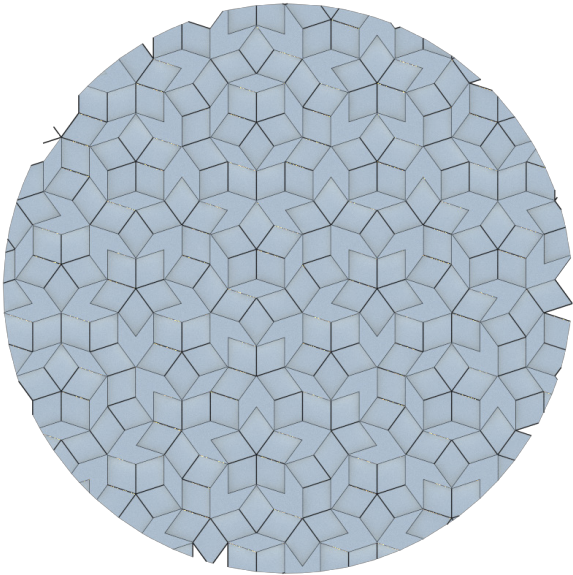

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

pattern ▼
profile ▼
parameters ▼

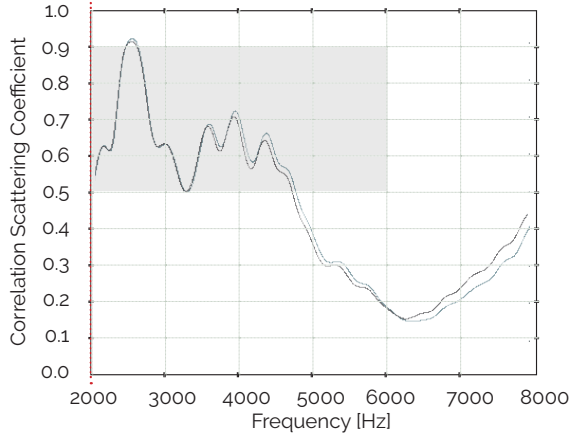
tapered

extruded

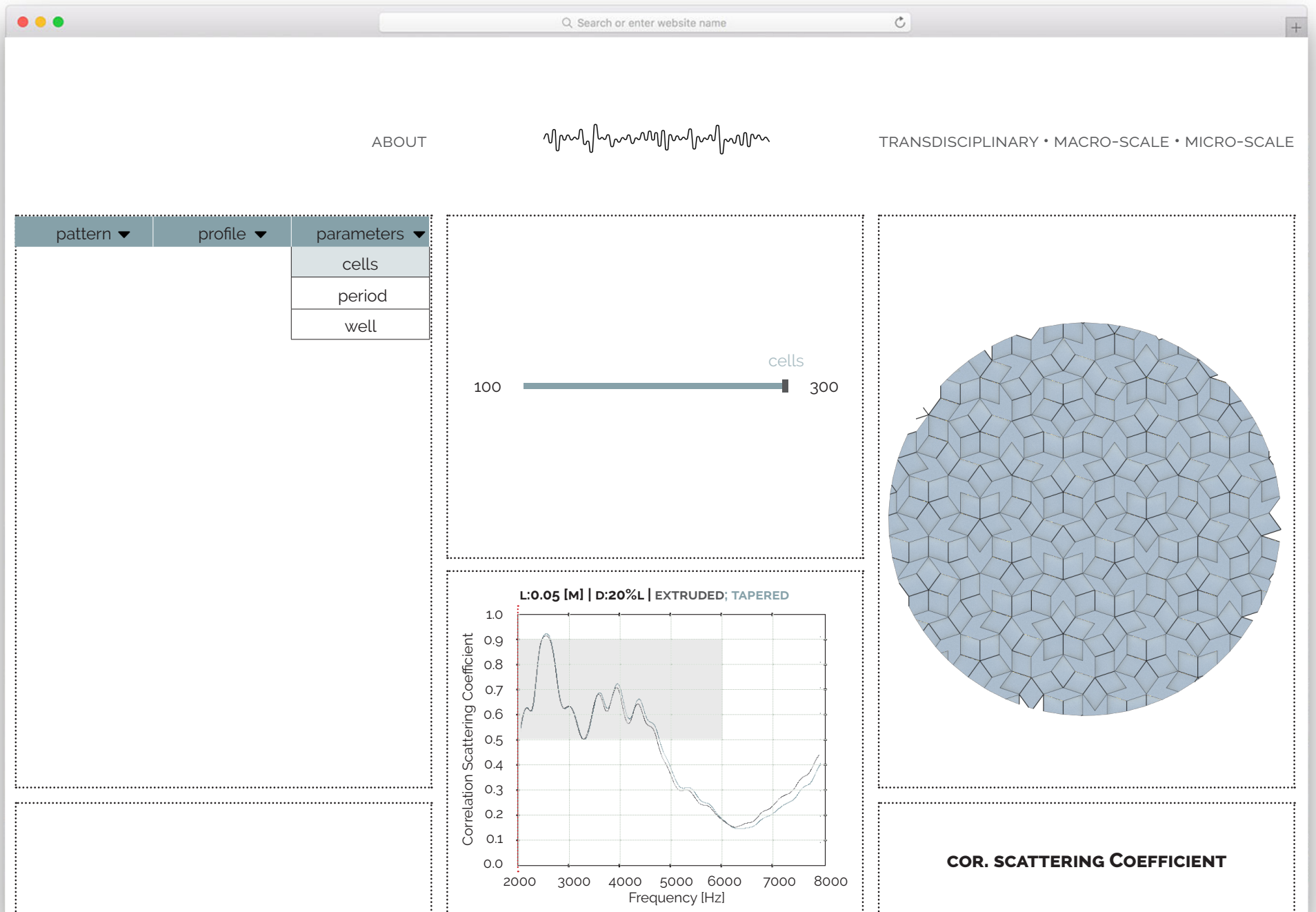





L:0.05 [M] | D:20%L | EXTRUDED; TAPERED



COR. SCATTERING COEFFICIENT



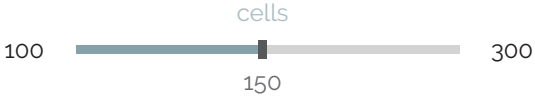
ABOUT

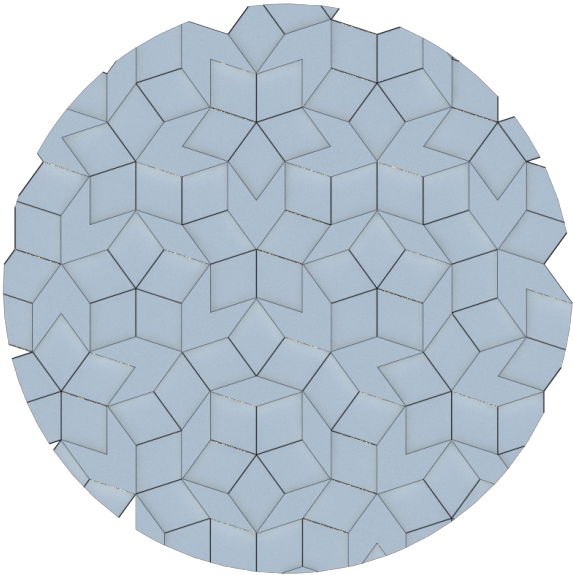


TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

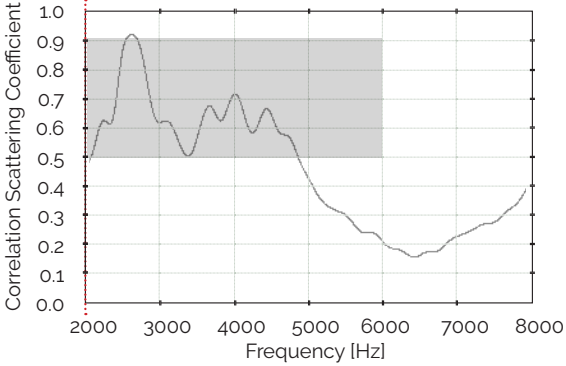
pattern ▼	profile ▼	parameters ▼
		cells
		period
		well

cells





L:0.085 [M] | D:20%L | EXTRUDED



COR. SCATTERING COEFFICIENT

Q Search or enter website name
+

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

pattern ▼
profile ▼
parameters ▼

cells

period

well

period

0.01 [m] 0.1 [m]

0.085 [m]

L:0.085 [M] | D:20%L | EXTRUDED

COR. SCATTERING COEFFICIENT

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

pattern ▼
profile ▼
parameters ▼

cells

period

well

DEPTH ▼

two heights

various heights

20%

0.01 [m] 0.1 [m]

WIDTH ▼

element size

narrow

L:0.085 [M] | D:20%L | EXTRUDED

COR. SCATTERING COEFFICIENT

COR. SCATTERING COEFFICIENT

ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

pattern ▼
profile ▼
parameters ▼

cells

period

well

DEPTH ▼

two heights

various heights

50%

0.01 [m] 0.1 [m]

0.025 [m]

WIDTH ▼

element size

narrow

L:0.085 [M] | D:50%L | EXTRUDED

Frequency [Hz]

COR. SCATTERING COEFFICIENT


ABOUT
TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

absorption ▼	material ▼	system ▼
porous		
plate		
membran		
helmholtz		
mf		
tube resonator		


--- 15% PERFORATION RATIO, THICKNESS 0.4 MM

Frequency [Hz]	Absorption Coefficient α
125	0.15
250	0.45
350	0.55
450	0.55
550	0.65
650	0.85
750	0.95
850	0.85
950	0.65
1050	0.55
1250	0.35
1500	0.25
2000	0.15

ABSORPTION COEFFICIENT

ABOUT

TRANSDISCIPLINARY • MACRO-SCALE • MICRO-SCALE

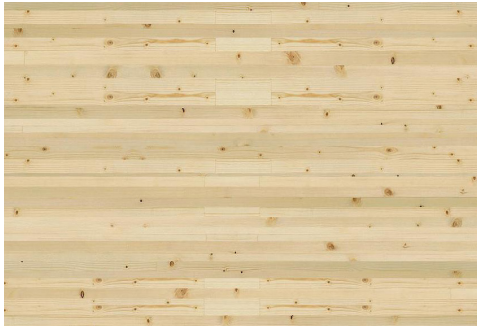
absorption ▼	material ▼	system ▼
	cork	
	bamboo	
	desert sand	
	bioplastics	
	timber	
	mycelium	




WEIGHT: HIGH FREQUENCIES REQUIRE LESS WEIGHT TO REFLECT SOUND

SENSITIVE USERS: ANTIMICROBIAL, NON-ALLERGENIC, FIRE RETARDANT


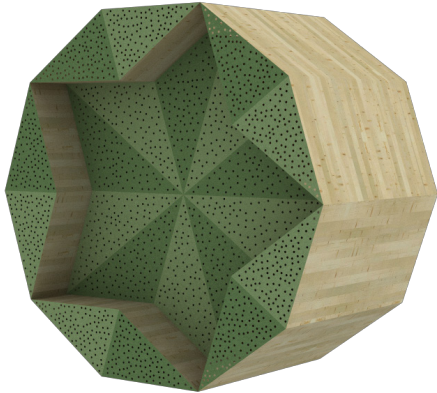
SUSTAINABILITY: HARVESTED FROM THE BARK OF LIVING CORK OAK TREES, AFTER 10 YEARS REGROWS



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absorption ▼	material ▼	system ▼
		hybrid device
		dual function
		upcycling

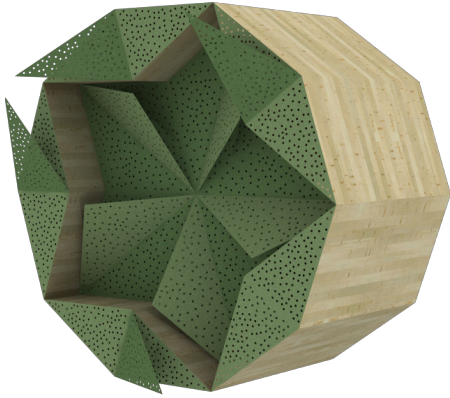


ASSEMBLY - DISASSEMBLY

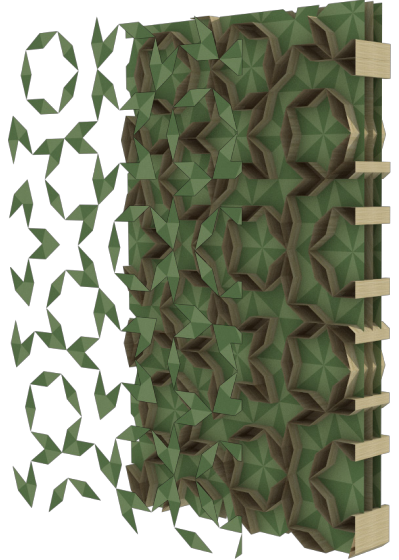
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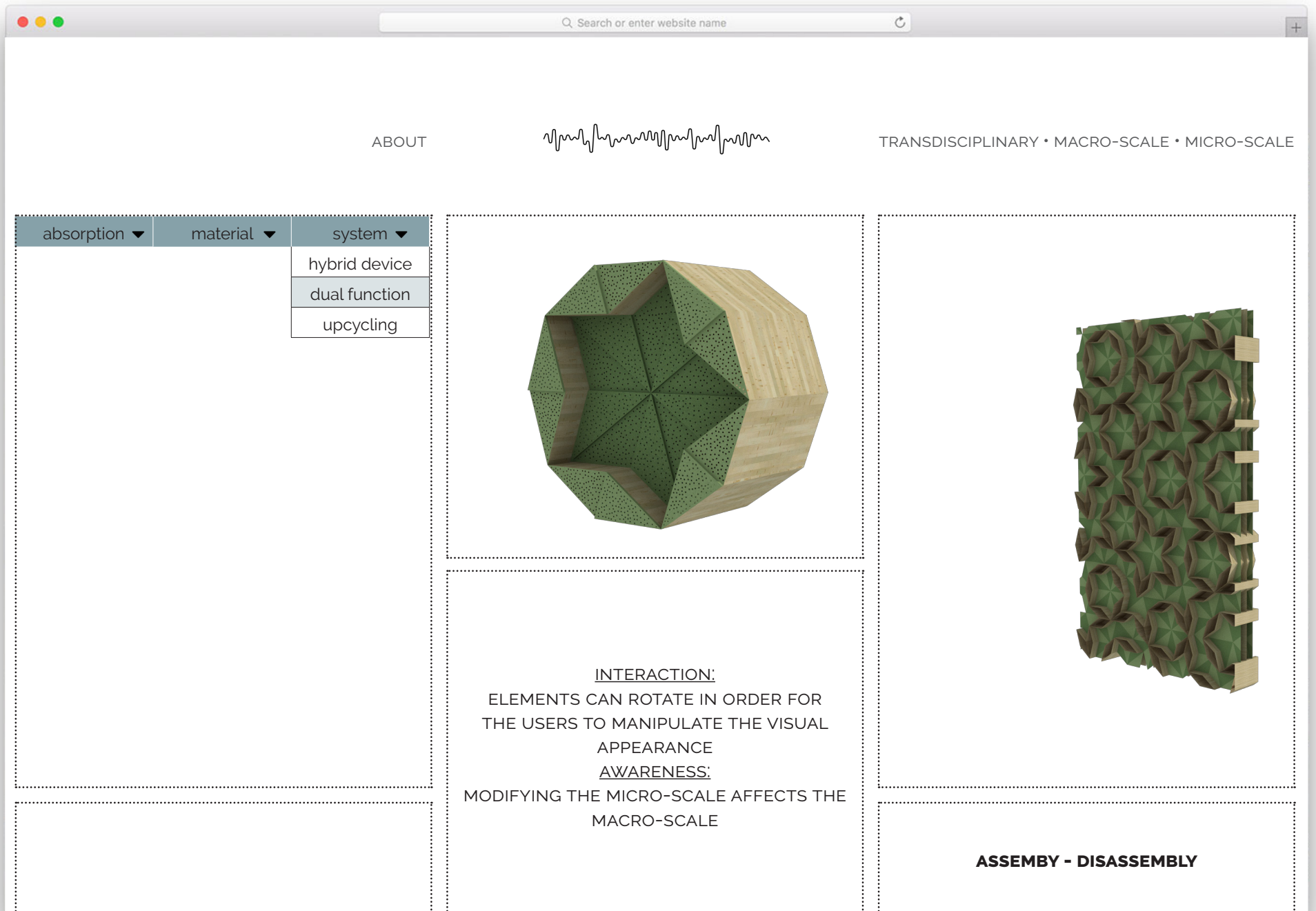
absorption ▼	material ▼	system ▼
		hybrid device
		dual function
		upcycling



INTERACTION:
ELEMENTS CAN ROTATE IN ORDER FOR
THE USERS TO MANIPULATE THE VISUAL
APPEARANCE



ASSEMBLY - DISASSEMBLY



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absorption ▼

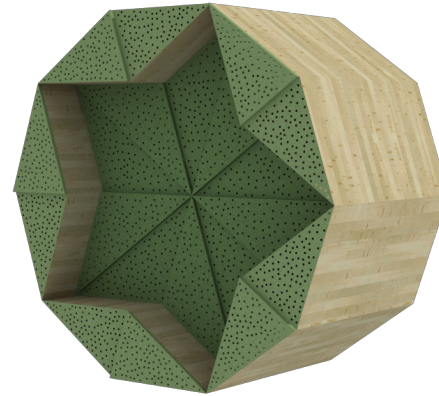
material ▼

system ▼

hybrid device

dual function

upcycling



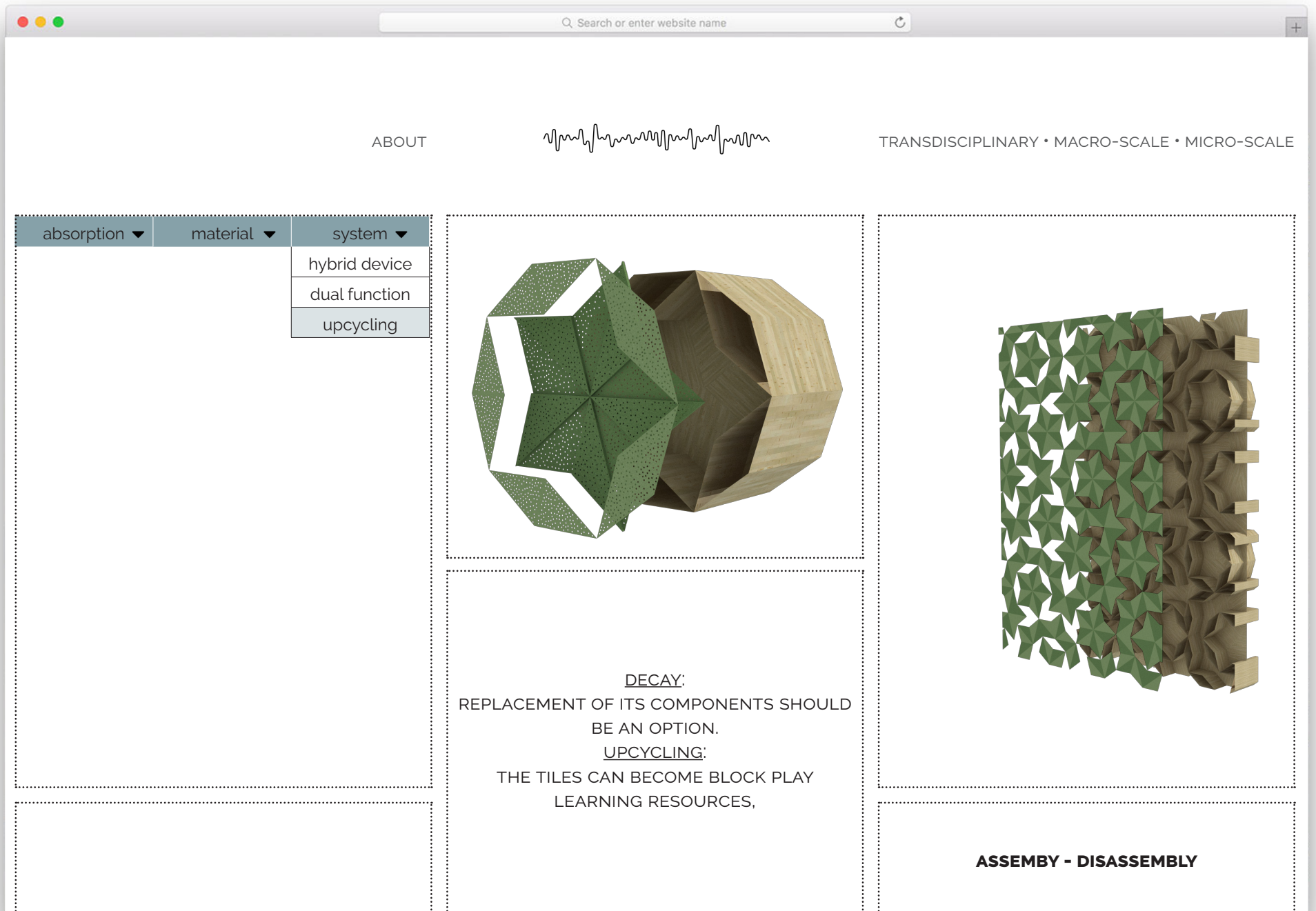
INTERACTION:

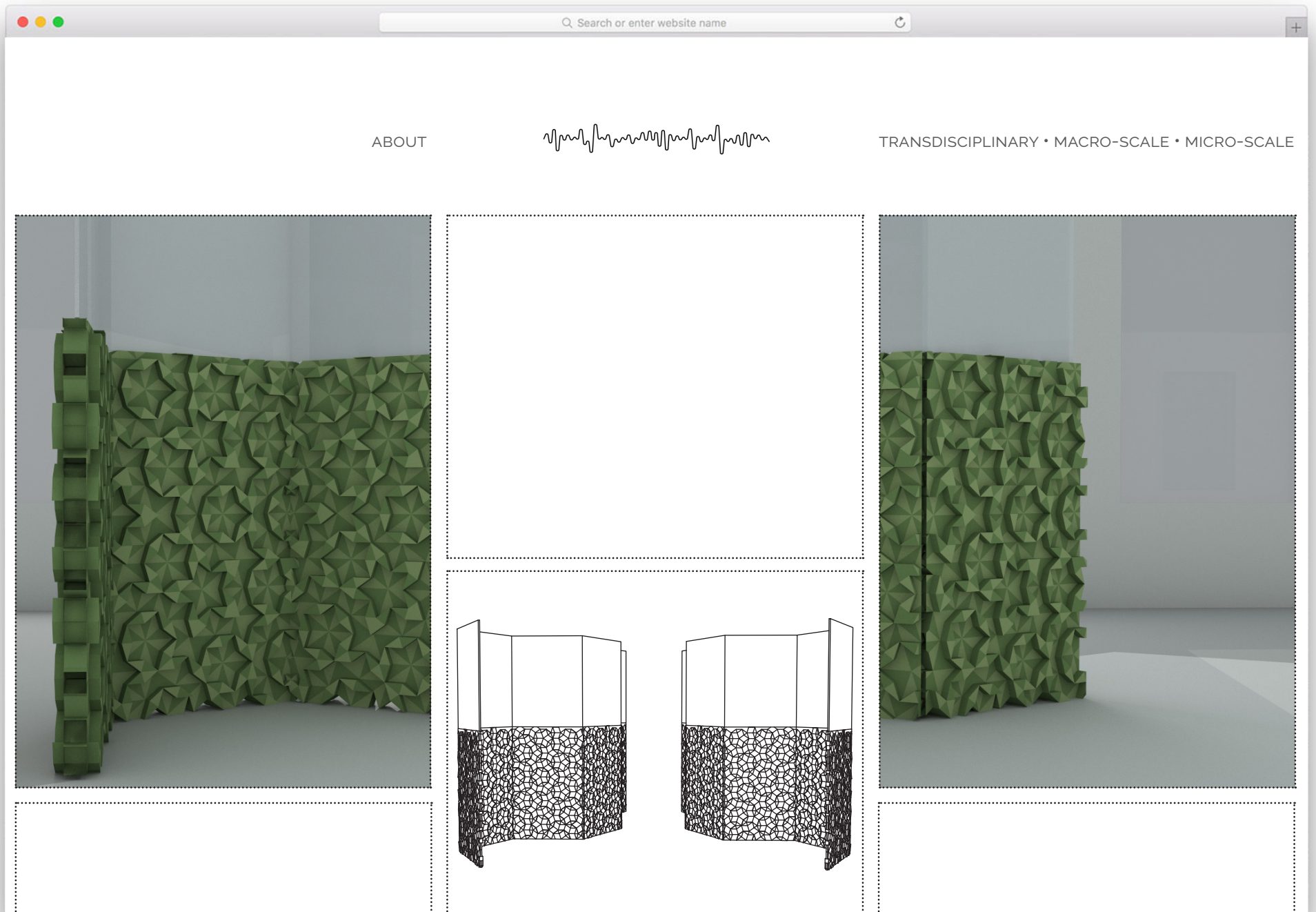
ELEMENTS CAN ROTATE IN ORDER FOR
THE USERS TO MANIPULATE THE VISUAL
APPEARANCE

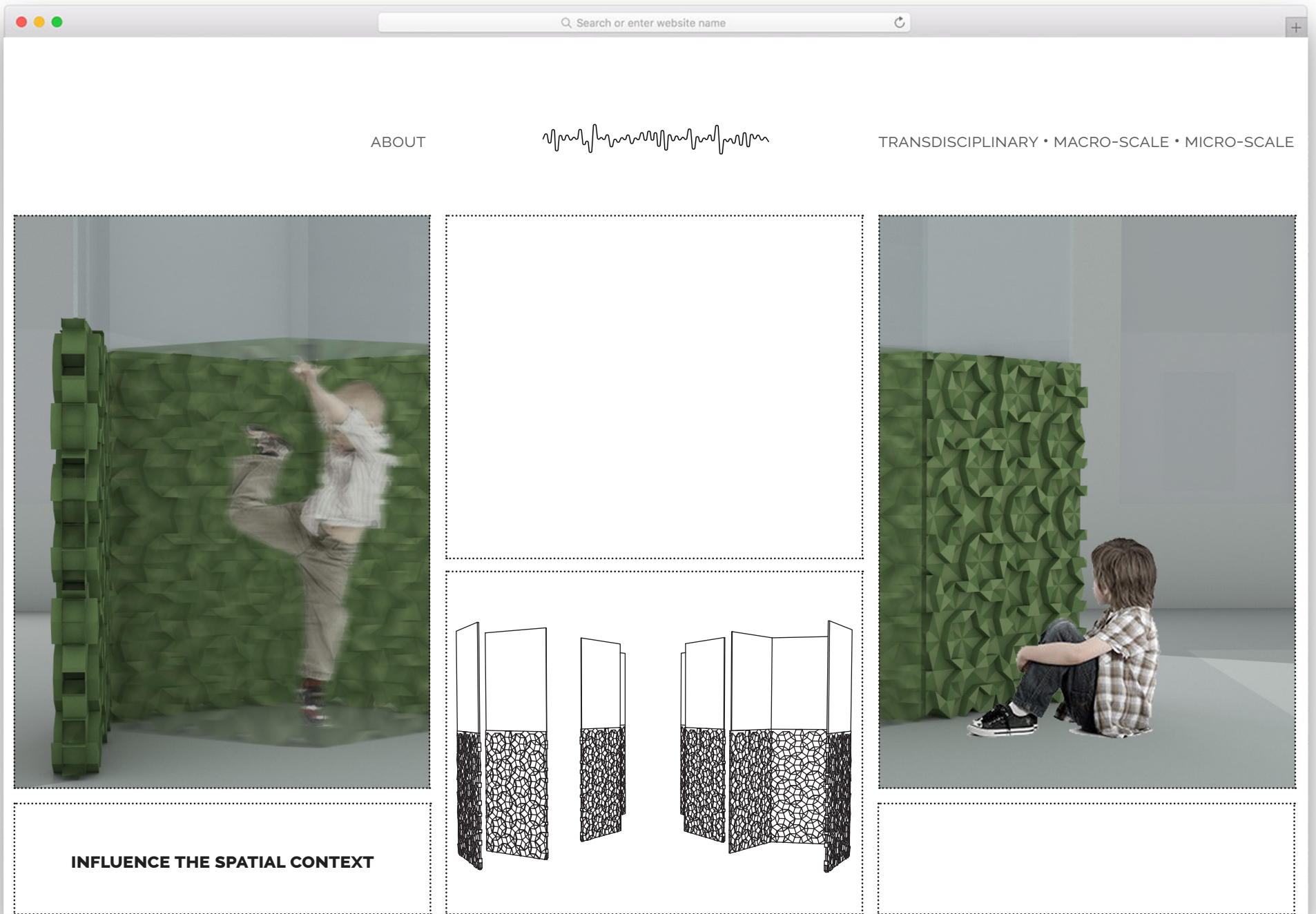
AWARENESS:

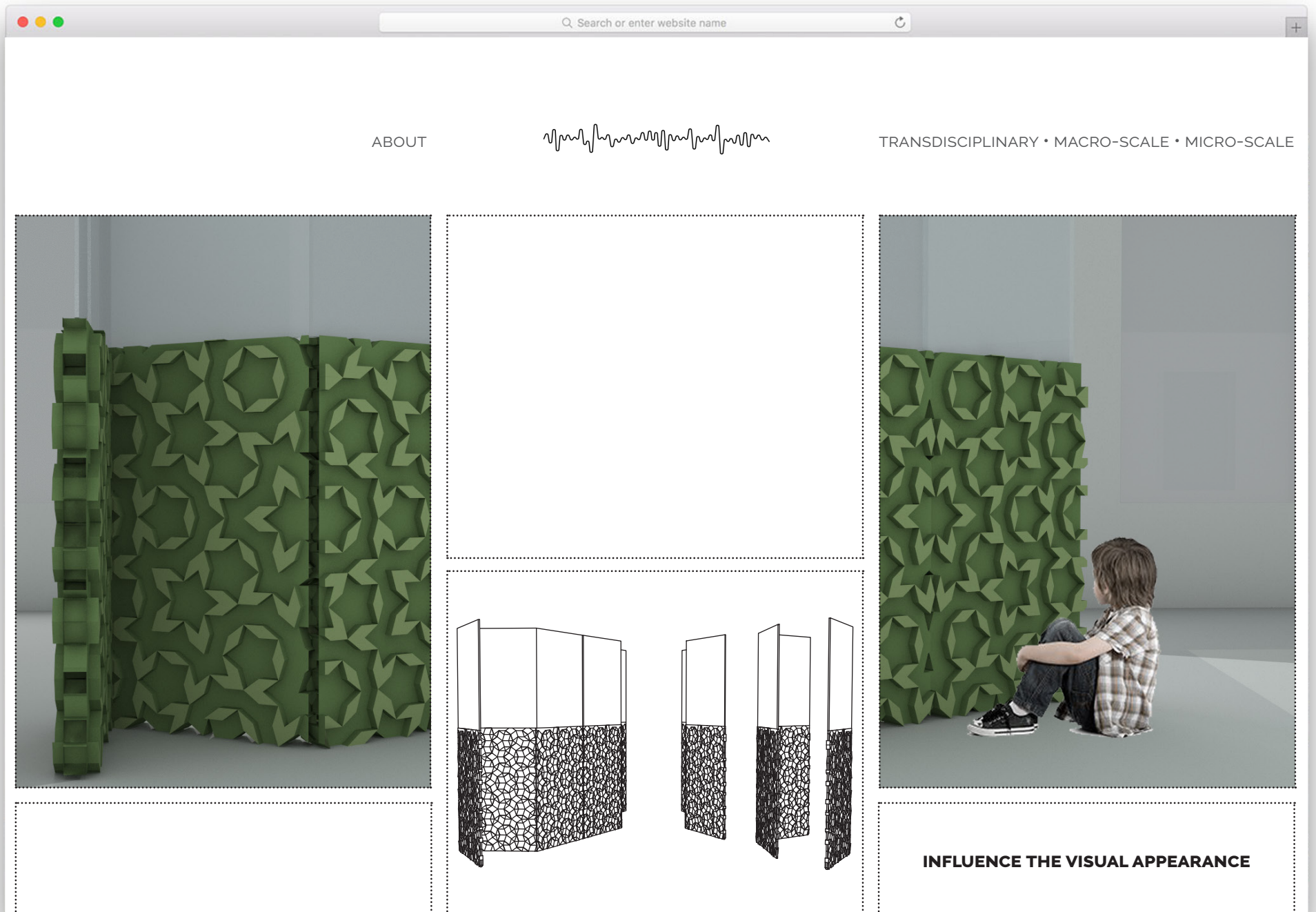
MODIFYING THE MICRO-SCALE AFFECTS THE
MACRO-SCALE

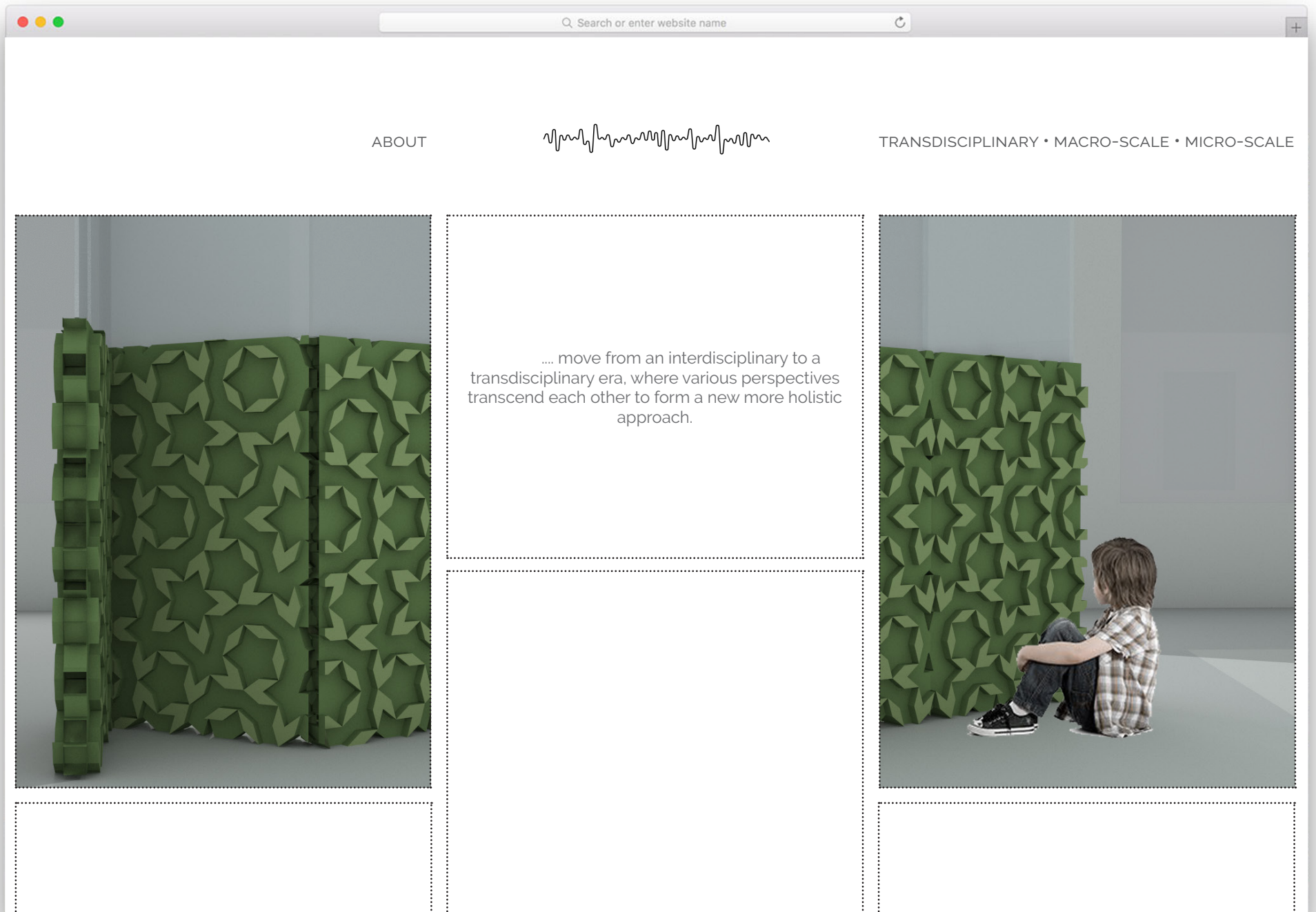
ASSEMBLY - DISASSEMBLY

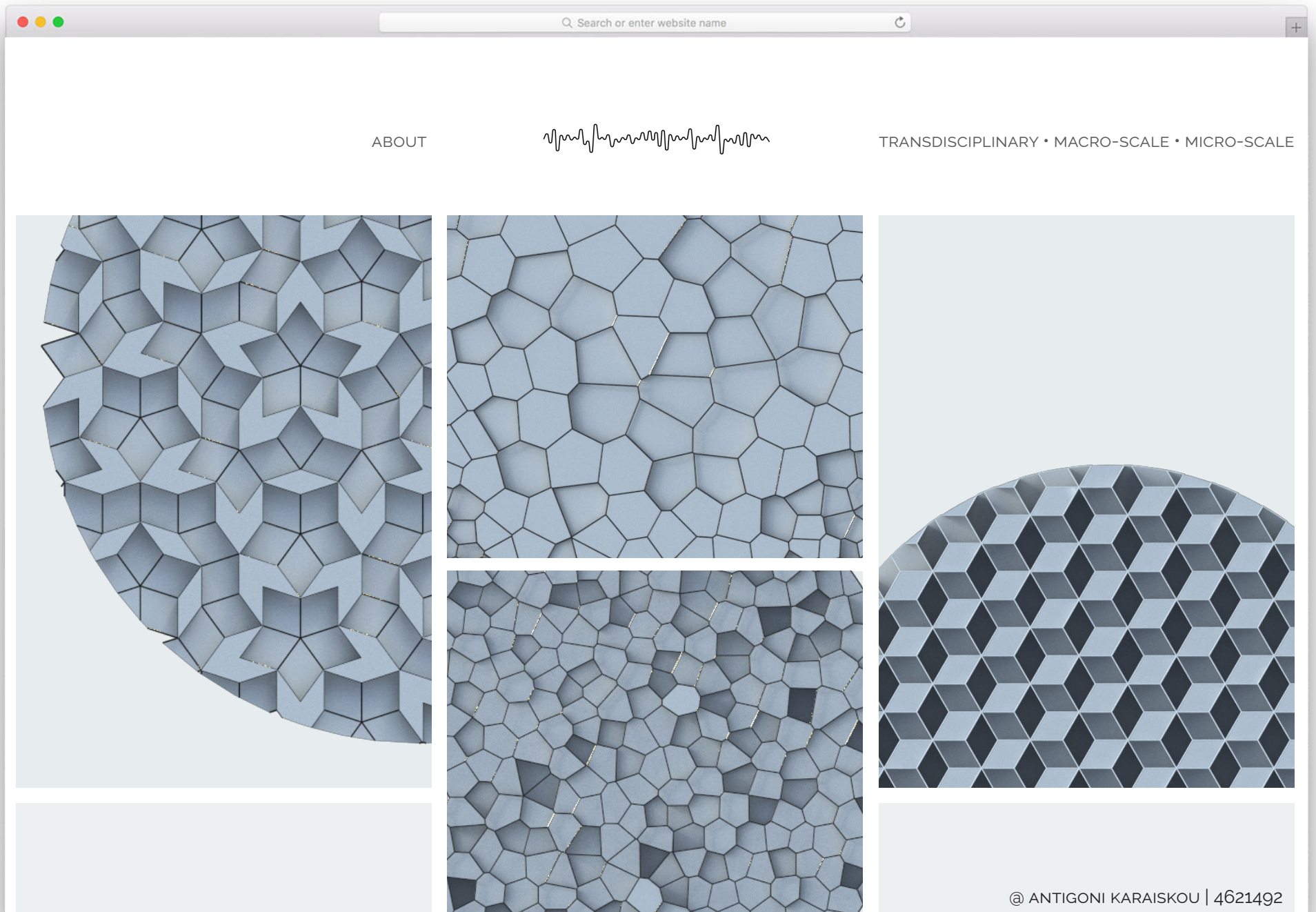












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