

Design Studio • **Rapidly Deployable Shelter** • WS2022 • USTUTT

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Supervisor: Jun. Prof. Dr.-Ing. Maria Matheou (ILEK)

ADDitively Manufactured OPTimized Structures by means of Machine Learning
Institute for Lightweight Structures and Conceptual Design (ILEK) | University of Stuttgart

Acknowledgments

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ILEK



Rapidly Deployable Shelter

Winter 2022-2023

Authors:

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Supervision:

Jun-Prof.Maria Matheou

Moon Young Jeong

REGION

REGION PROFILE





ETHIOPIA:

LARGEST POPULATED COUNTRY IN THE HORN OF AFRICA

ONE OF THE OLDEST COUNTRIES OF THE WORLD

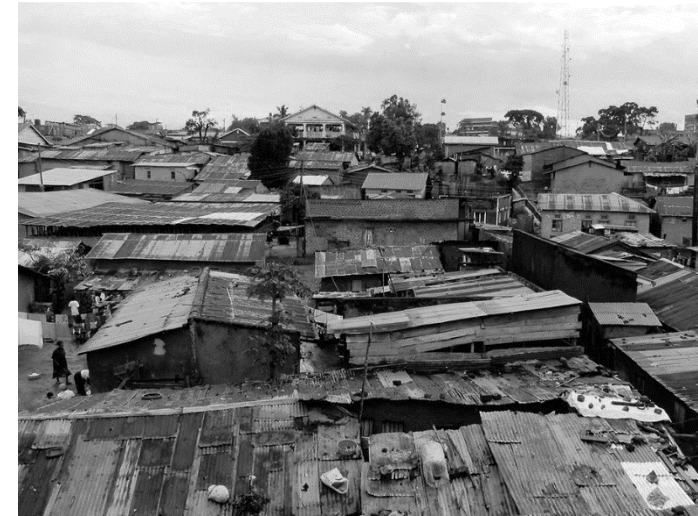
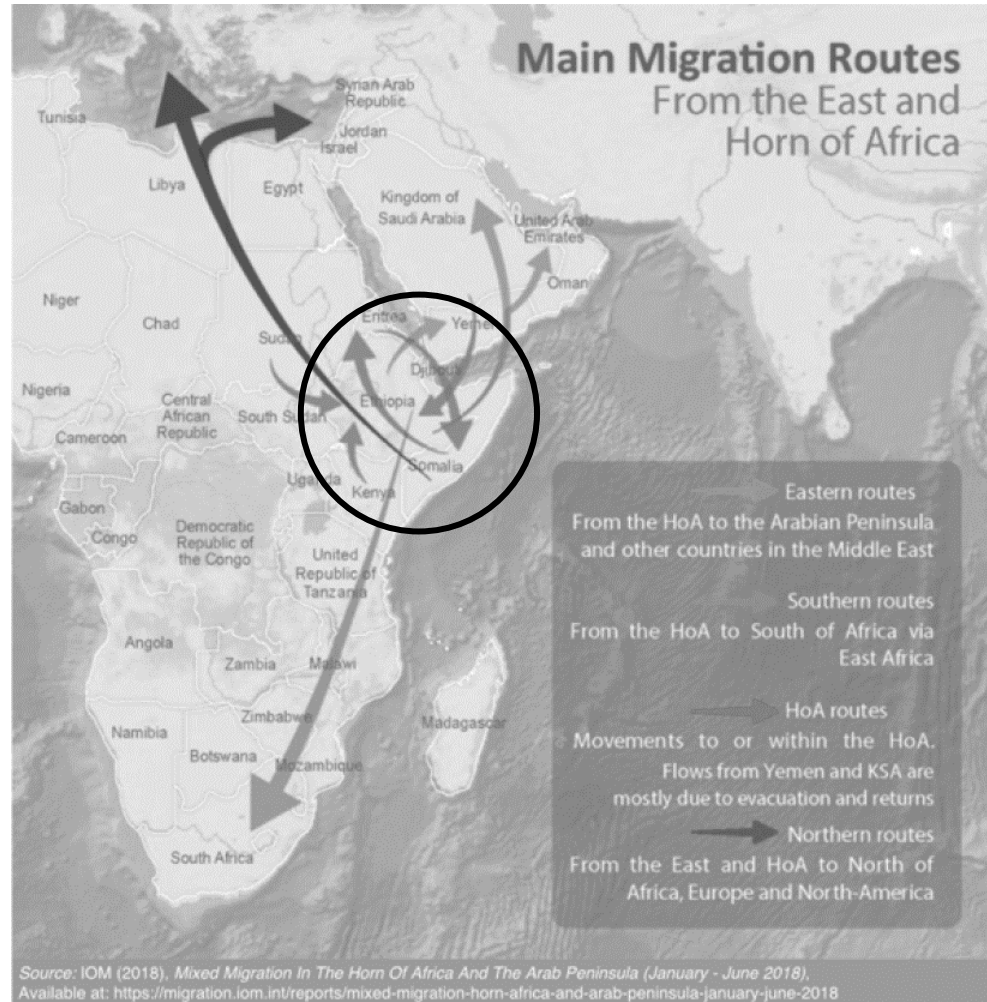
‘COUNTRY OF CONTRASTS’

LANDSCAPE RANGES FROM TROPICS TO STEPPE

CITIES ARE VERY DEVELOPED BUT ONLY 1/5 OF THE POPULATION LIVES IN URBAN AREAS

PEOPLE: VERY DIVERSE IN ETHNICITY AND CULTURE

REGION PROFILE



ETHIOPIA:

924,000 REFUGEES HOSTED FROM ABROAD

3.5 MILLION INTERNALLY DISPLACED

> NEED FOR REFUGEE SHELTERS

> PEOPLE SETTLE AT OUTSKIRTS OF CITIES (SLUMS)



AFAR PEOPLE:

GROUPS OF FAMILIES

NOMADIC LIFESTYLE (NO LONGER RETAINABLE)

LIFESTOCK BREEDING

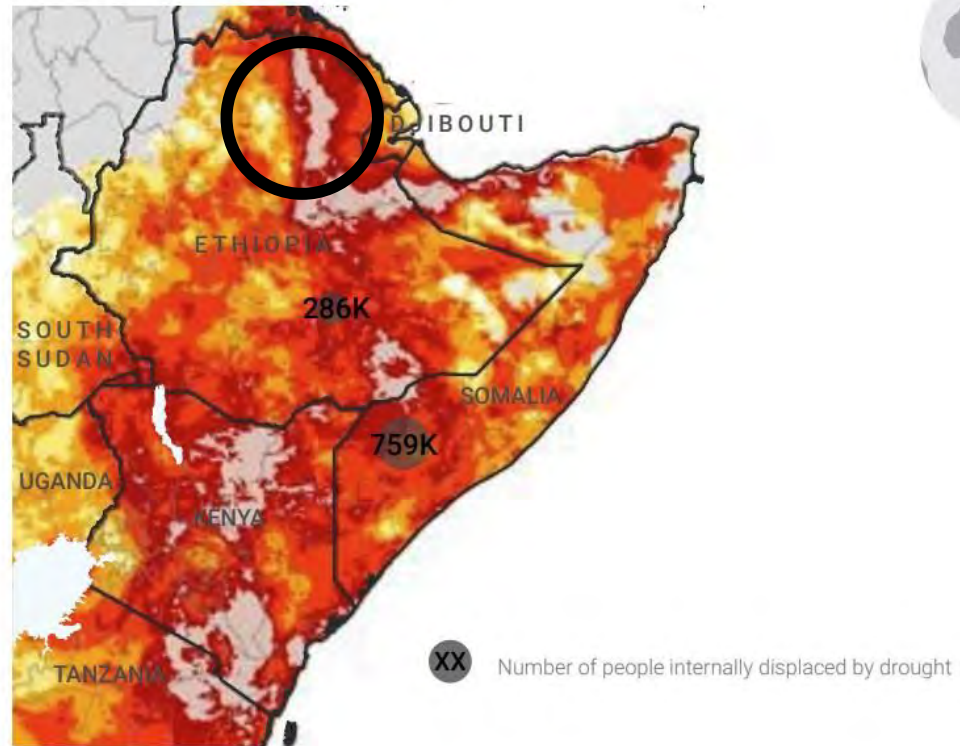
> NEED FOR FLEXIBLE SETTLEMENT POSSIBILITY

> TRANSITION FROM NOMADIC TO SEDENTARIST LIFESTYLE

REGION CHALLENGES & POTENTIALS

REGION PROFILE

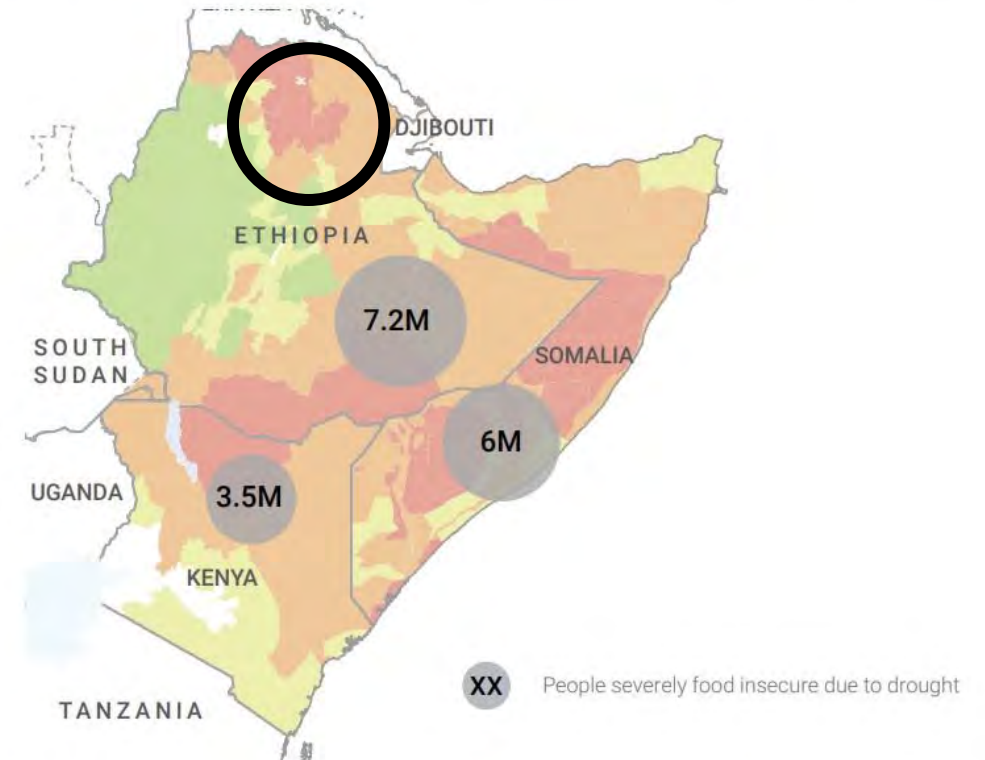
EARLY SEASON RAINFALL DEFICIT & DROUGHT-RELATED INTERNAL DISPLACEMENT



Rainfall Anomalies - % of normal (01 March - 15 April 2022)⁹



ACUTE FOOD INSECURITY WITH SPOTLIGHT ON THE DROUGHT



IPC Food Insecurity Phase



REGION CHALLENGES



EXTREME HEAT



DROUGHT &
EROSION



FLOODS
(WHEN RAIN)



DEATH OF
LIFESTOCK

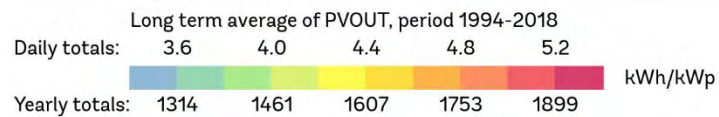
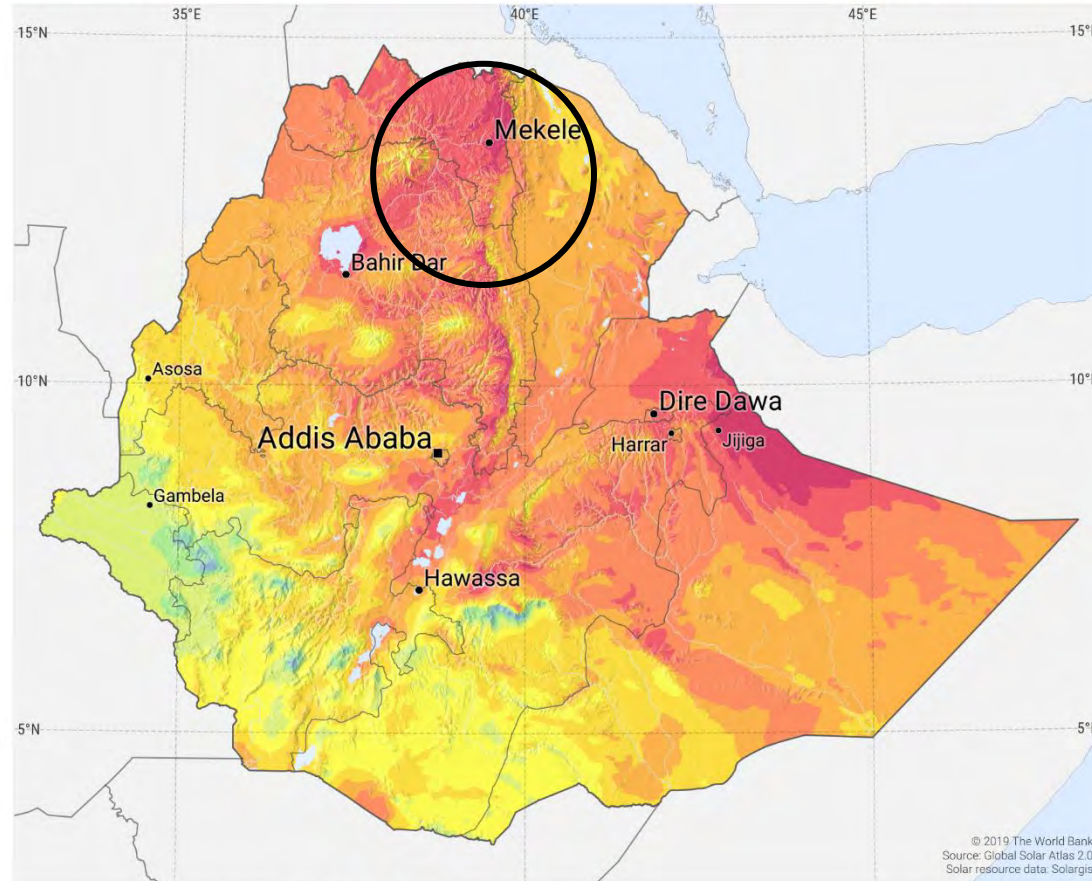


DEPENDENCY
ON FOOD AID

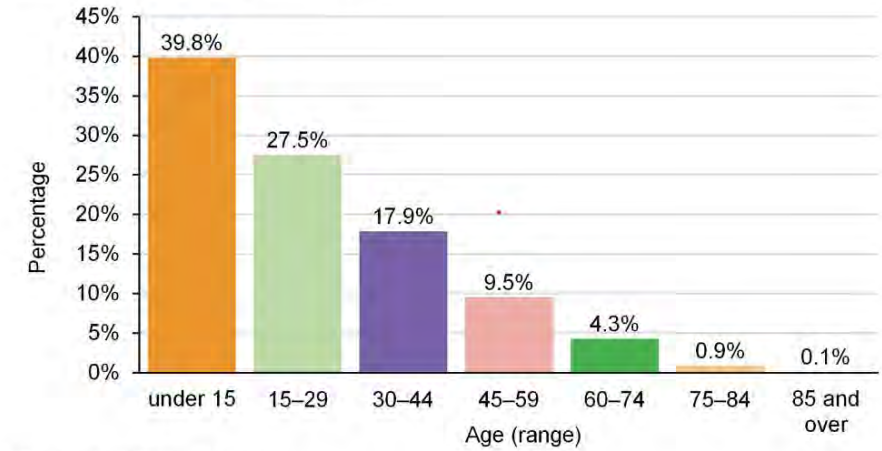
REGION POTENTIALS

SOLAR RESOURCE MAP

PHOTOVOLTAIC POWER POTENTIAL ETHIOPIA



Ethiopia age breakdown (2020)



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Ethiopian Companies to Watch in Africa 2021

baobabinsights.com/companies



Baobab Insights.

CONCEPT



ADAPT TO CLIMATE
CONDITIONS



RESPECT CULTURE
TRADITIONS



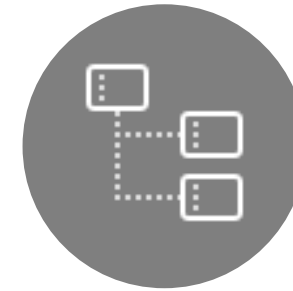
SUSTAINABLE
RESSOURCES



EASY & QUICK
ASSEMBLY



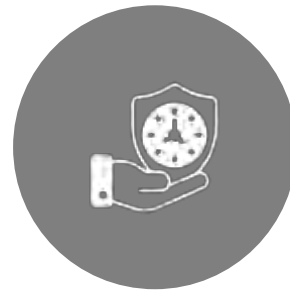
PARTICIPATION



MULTIPLE
TYPOLOGIES



EMERGENCY
SHELTER



DURABLE
SOLUTIONS

DESIGN IS MEANT TO WORK AS AN
INVESTMENT INTO THE FUTURE OF THE
AFFECTED POPULATION
TO (RE-) BUILD THEIR LIFE AND IMPROVE
LIVING CONDITIONS LONG-TERM

CONCEPT



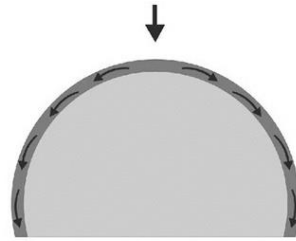
TRADITIONAL AFAR NOMAD DWELLING



CONCEPT FORM



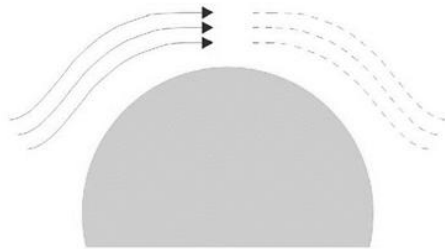
SELF
SUPPORTING



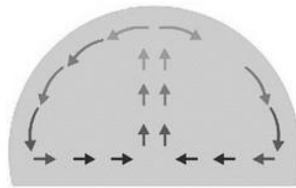
LOAD
DISTRIBUTION



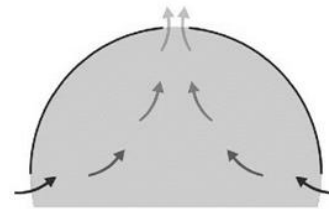
MODULAR
CONSTRUCTION



WIND AND STORM
RESISTANCE



AIR FLOW /
CIRCULATION

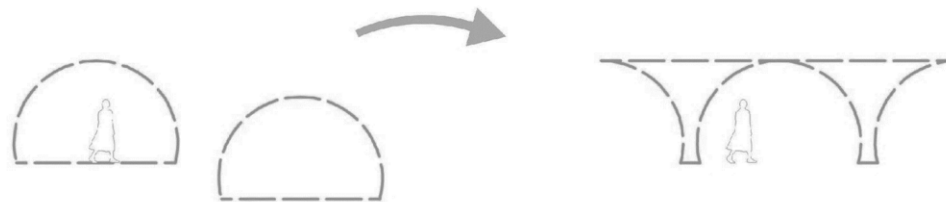


CHIMNEY EFFECT

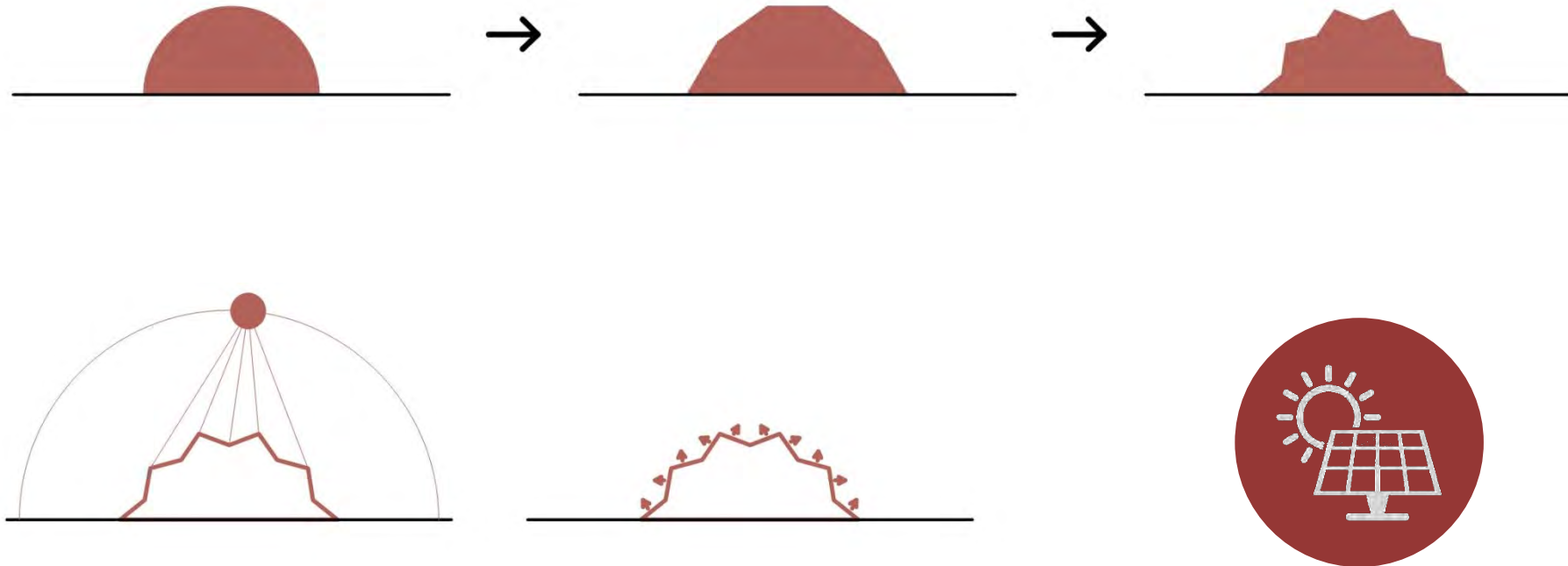


UNIFORM
TEMPERATURE

CONCEPT REUSABILITY



FORM ADJUSTMENTS



INSPIRATION AND RESEARCH

REFERENCE PROJECTS - STRUCTURE

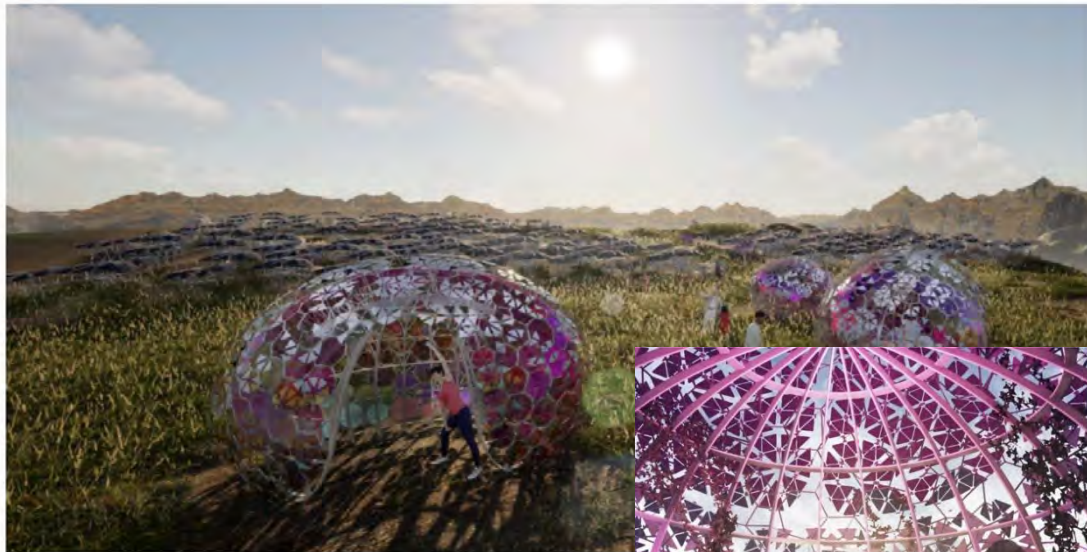


OMBRES LUMINOISES, Sukkahville 2013



ARBOSKIN, University of Stuttgart (itke)

REFERENCE PROJECTS - ENERGY



Agrivoltaic Architecture
Energy Pods, Green Weave, & Light Meander
Designing for Light and the Environment at the Nexus of Energy, Food, Water and Shelter

Agrivoltaic Architecture intertwines contemporary building-integrated agrivoltaics, advanced material-conscious computational design and digital fabrication, and playful community-building architectures to create a series of environmentally sensitive dynamic waypoints prototypes within the otherworldly landscape of Fly Ranch: Village Pavilions (Energy Pods), Agrivoltaic Surface Farming (Green Weave), and Canopy Light Networks (Light Meander). Agrivoltaic Architecture embraces holistically the sustainable initiatives proposed by LAGI & Burning Man at Fly Ranch and Black Rock-High Rock NCA.

Agrivoltaic Architecture innovates the design and engineering of building-integrated Photovoltaics (BiPV) through computational design and 3D printing for highly customized non-standard filters and panels that result in site-specific non-mechanical tracking solar collection systems. By leveraging the beauty and performance of nature's toolkit, Agrivoltaic Architecture demonstrates an adaptable system through 3 linked prototypes (Energy Pods, Green Weave, & Light Meander) with low greenhouse gas emissions, showcasing the potential of sustainable design for a resilient land use model to provide an integrated approach to food, water, energy, and shelter.



DESIGNER
Kyriakos Chatziparaskevas

TECHNOLOGIES
dye-sensitized solar cell (DSSC) laminated in ETFE sheets, piezoelectric energy harvesting from wind and pavement

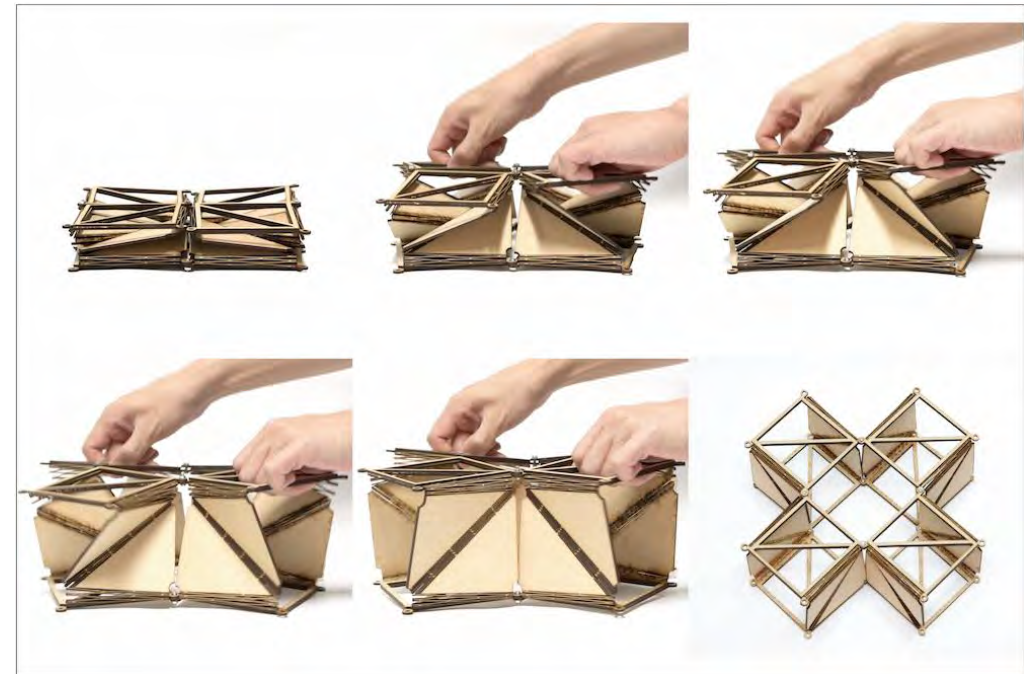
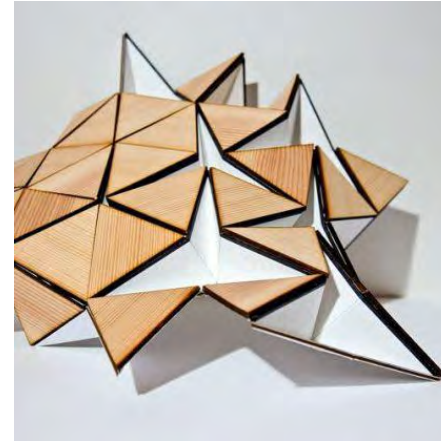
ANNUAL CAPACITY
500 MWh

A submission to the 2019 Land Art Generator Initiative design competition for Abu Dhabi—LAGI 2019.

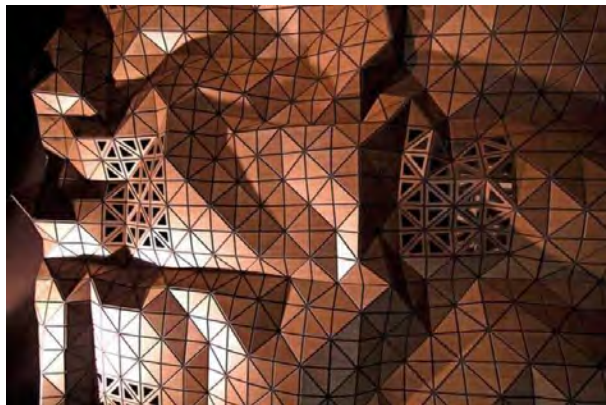
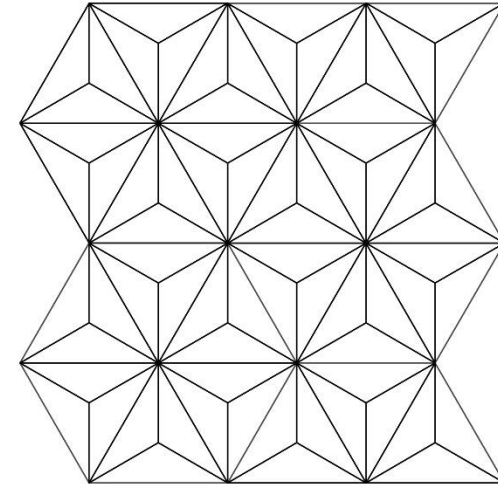
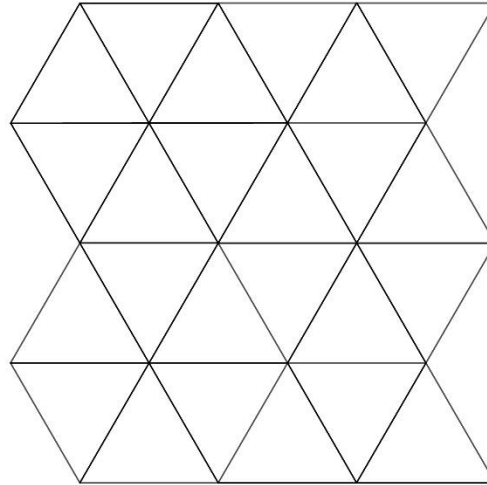
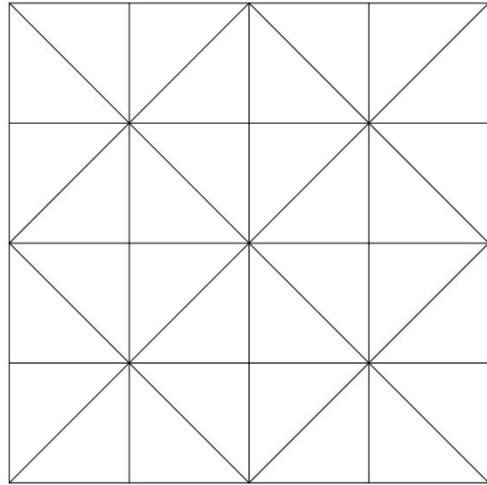
AGRIVOLTAIC ARCHITECTURE, Ithaca, USA (LAGI)

RENEWABLE OASIS, Kyriakos Chatziparaskevas (LAGI)

INSPIRATION - ASSEMBLY

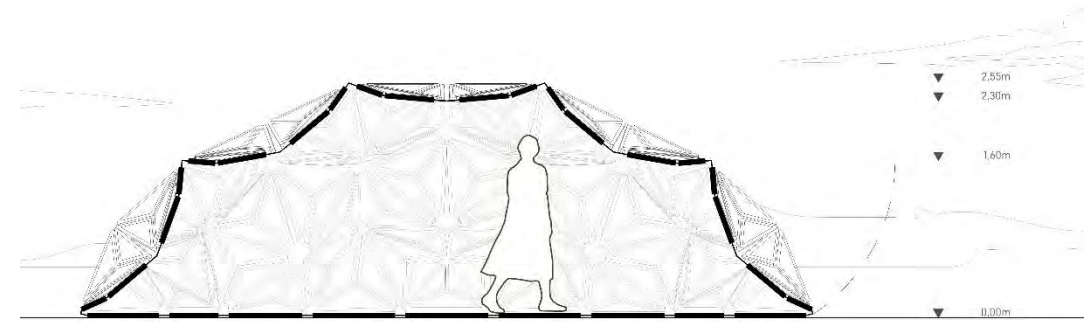
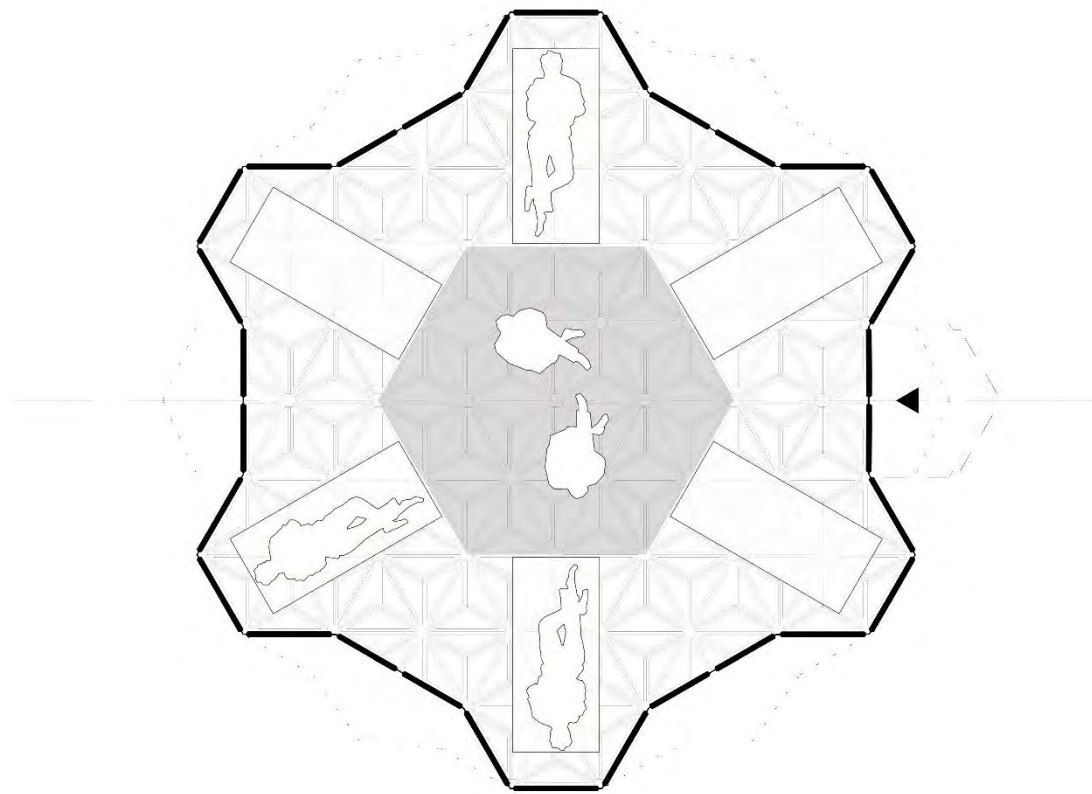


PATTERN

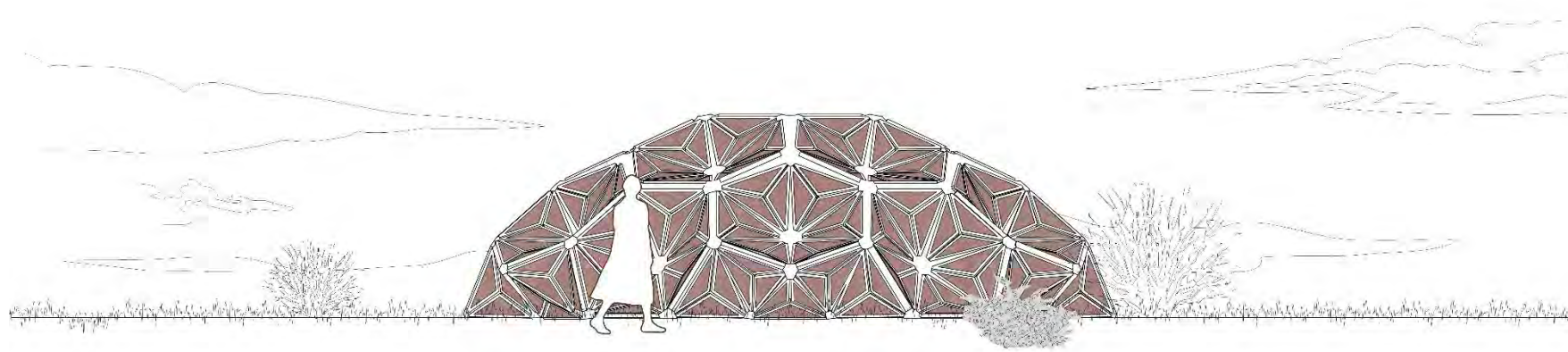


DESIGN

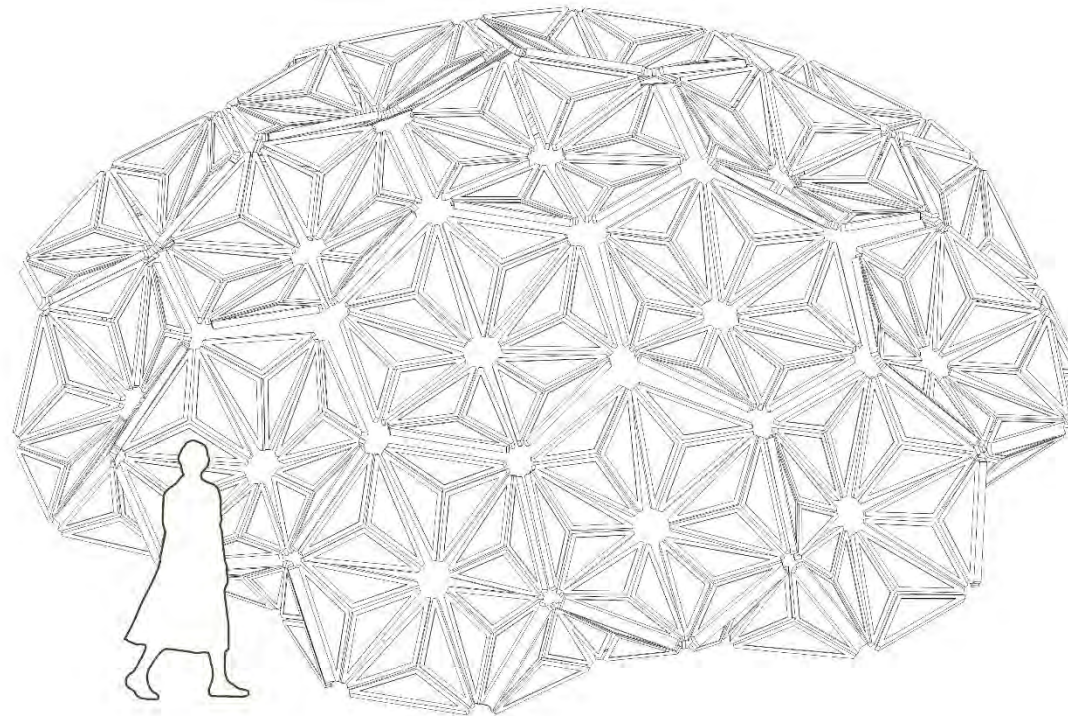
GROUND PLAN AND SECTION



ELEVATION



AXONOMETRY



DEPLOYMENT

DEPLOYMENT



KIT OF PARTS
SYSTEM



PREFABRICATION



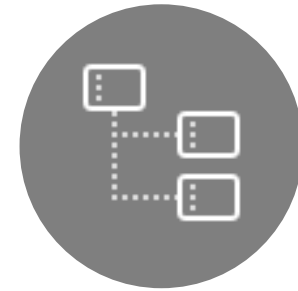
LIGHTWEIGHT



EASY & QUICK
ASSEMBLY

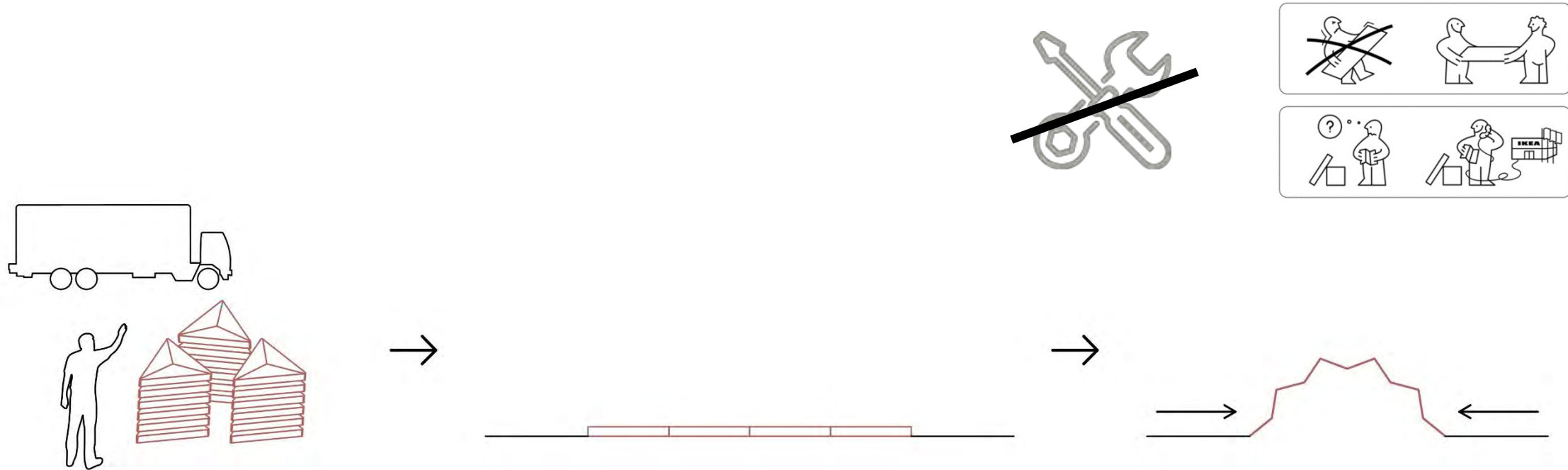


PASSIVE ADAPTIVE

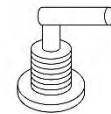
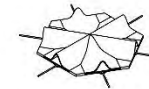
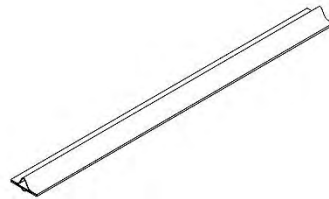
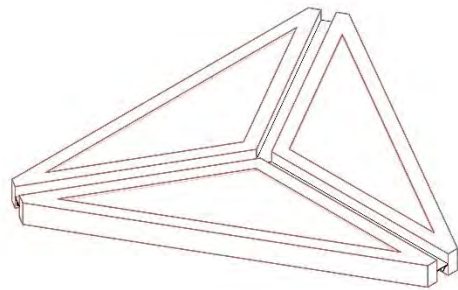


MULTIPLE
TYPOLOGIES

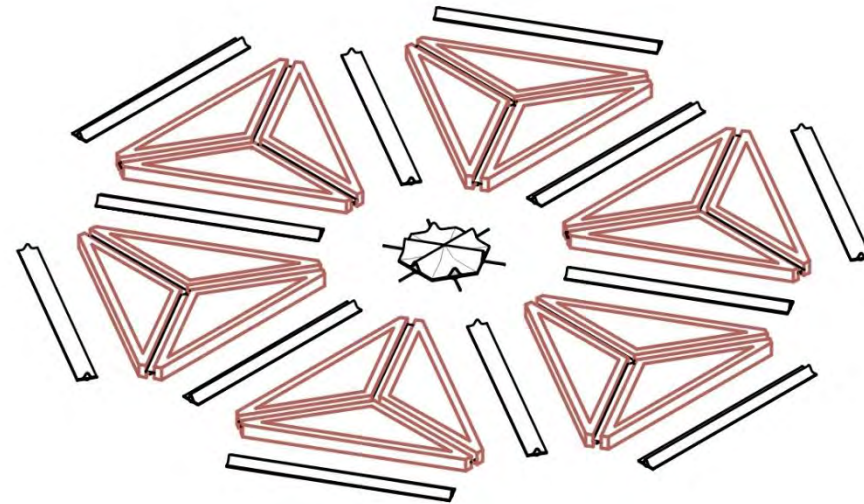
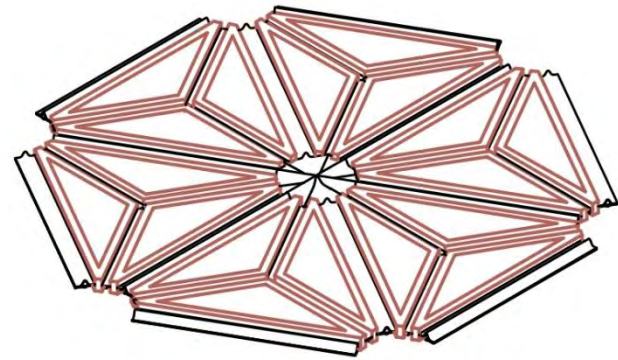
DEPLOYMENT



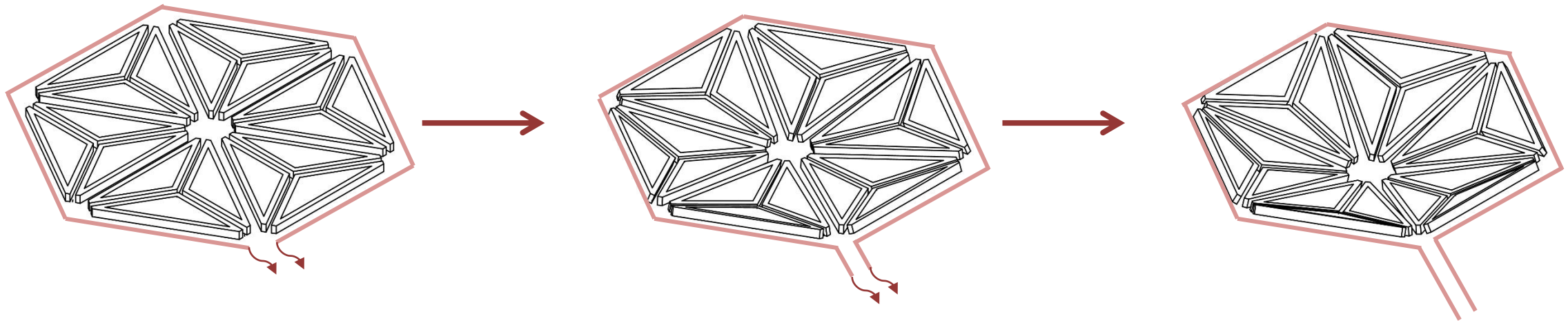
DEPLOYMENT KIT



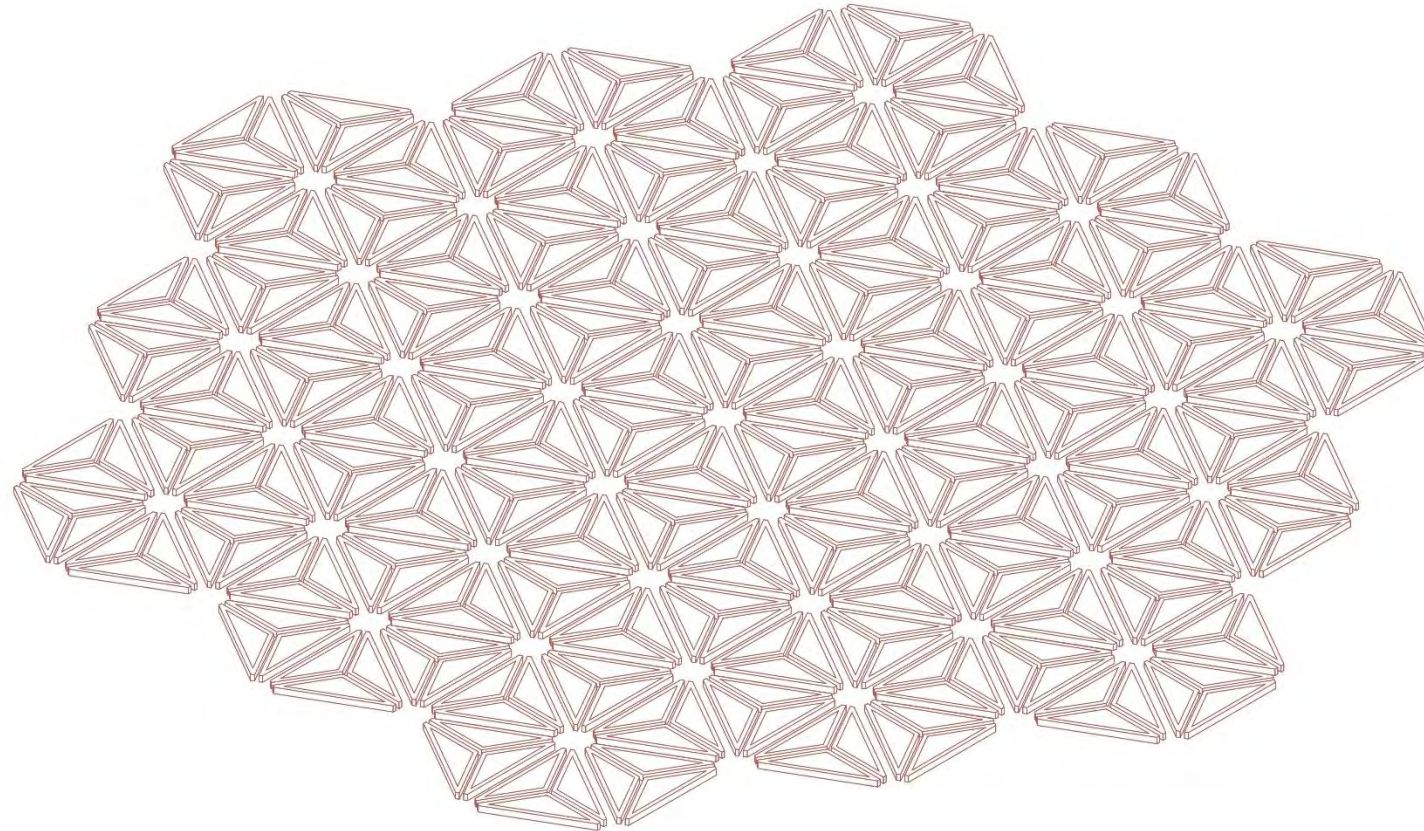
HINGE DETAIL



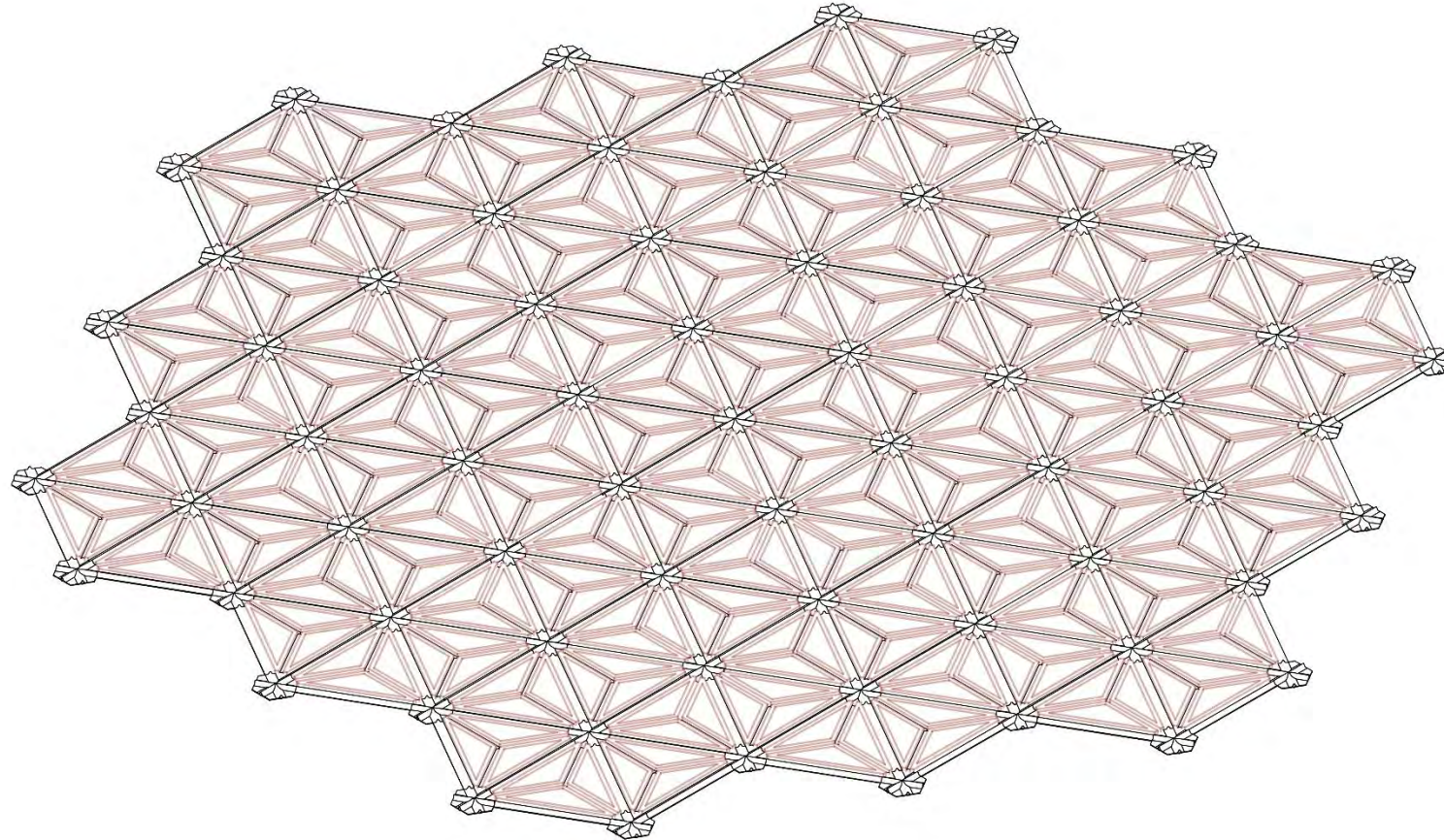
DEPLOYMENT



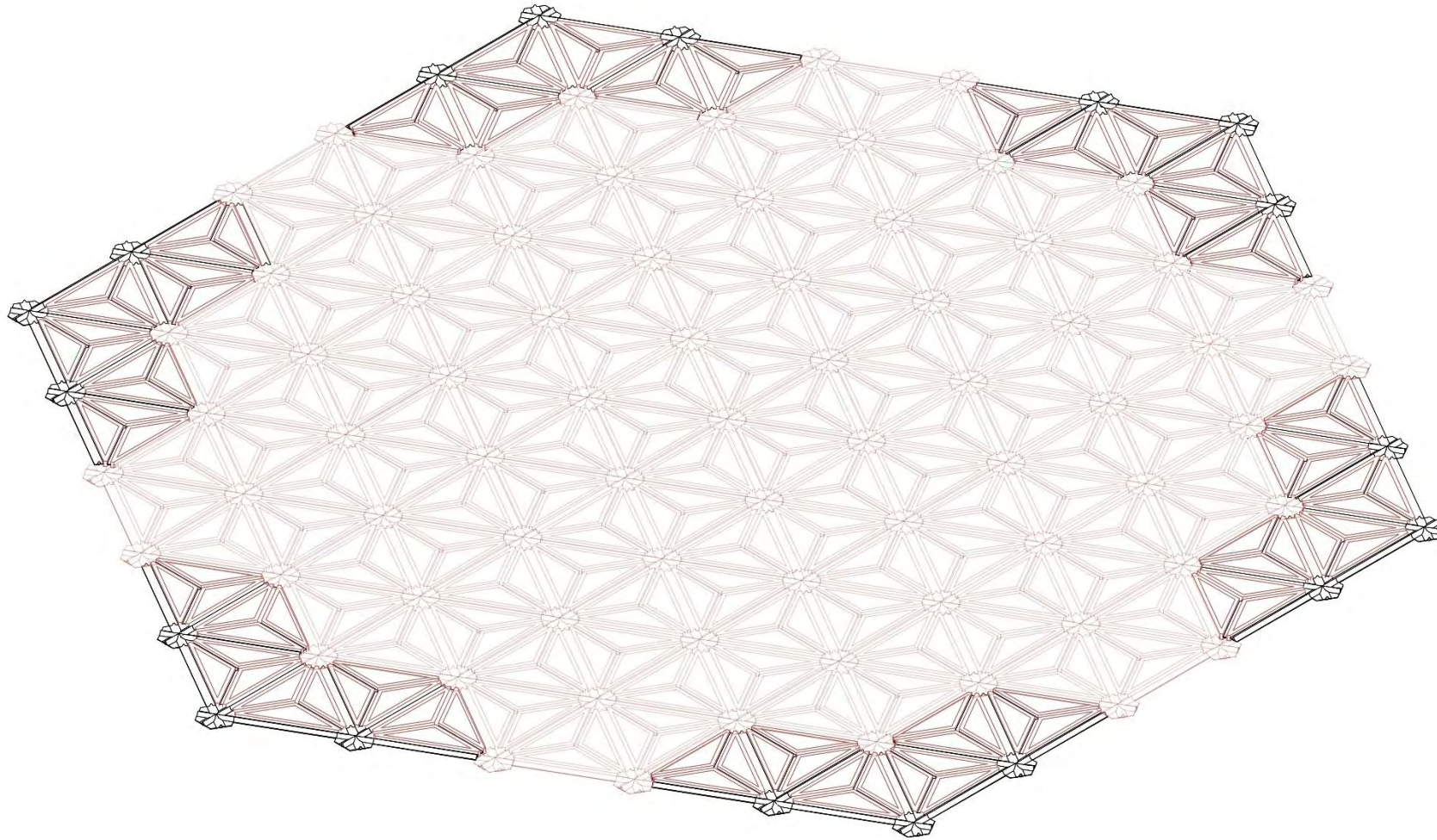
DEPLOYMENT



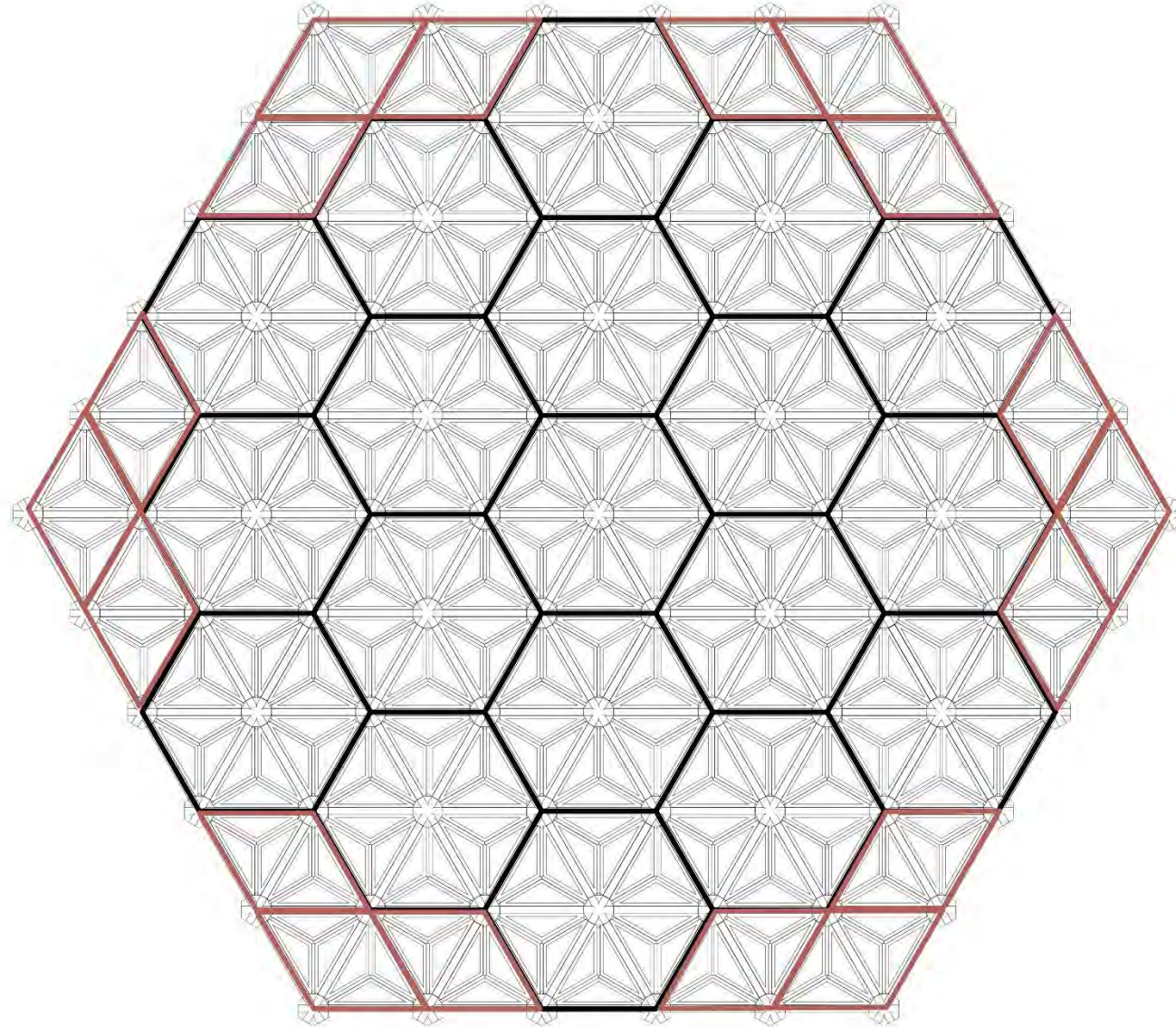
DEPLOYMENT



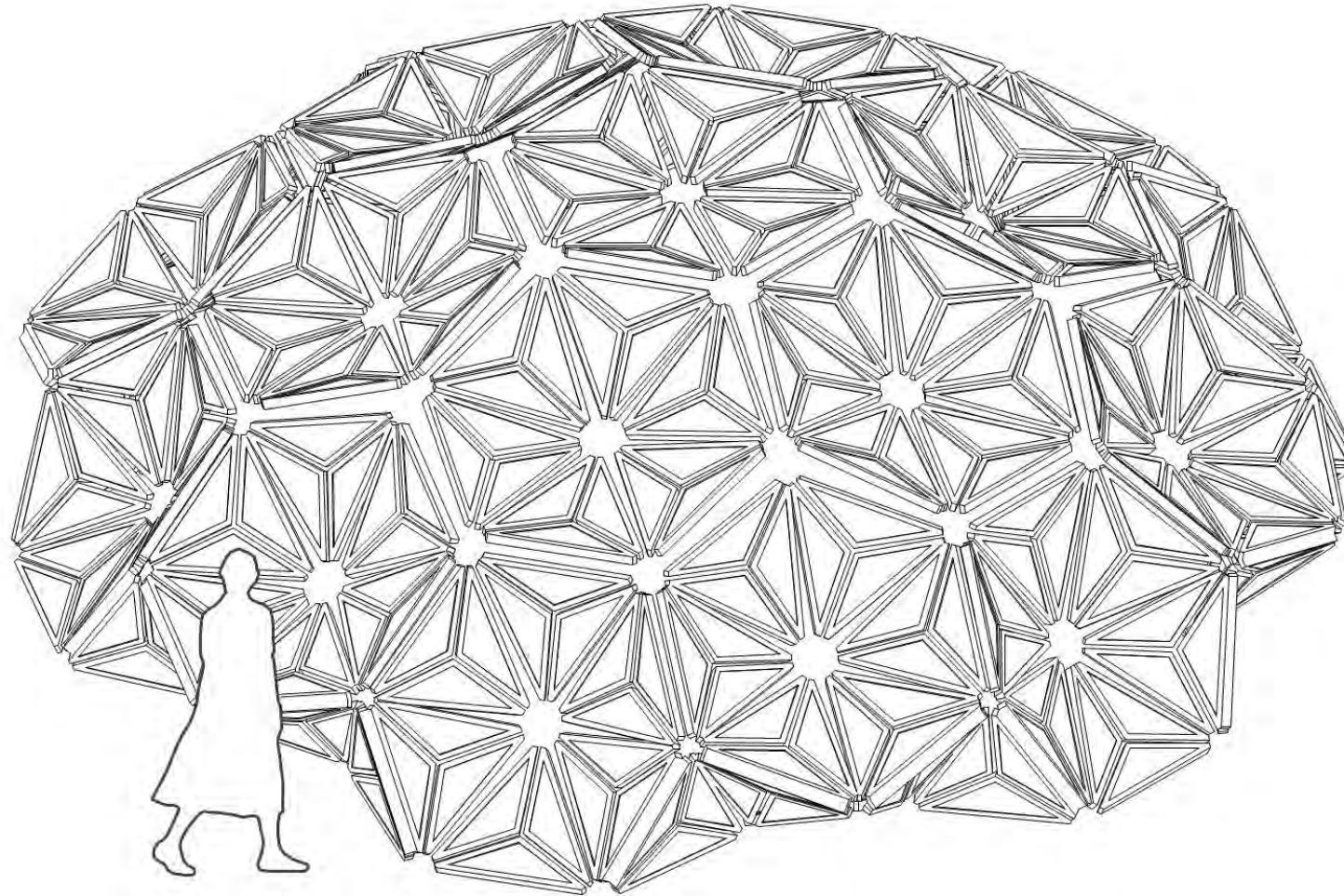
DEPLOYMENT



DEPLOYMENT

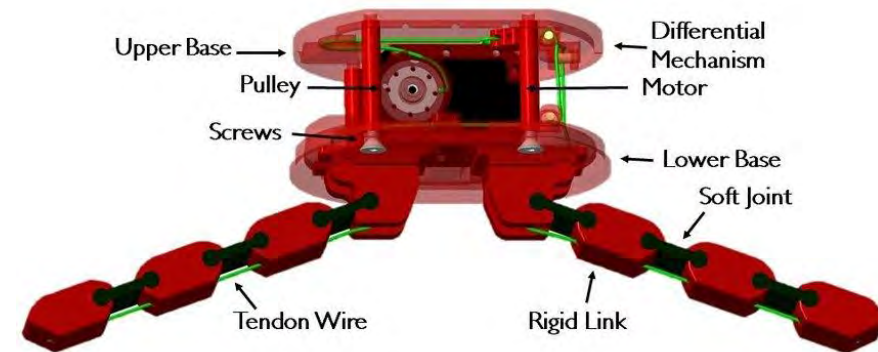
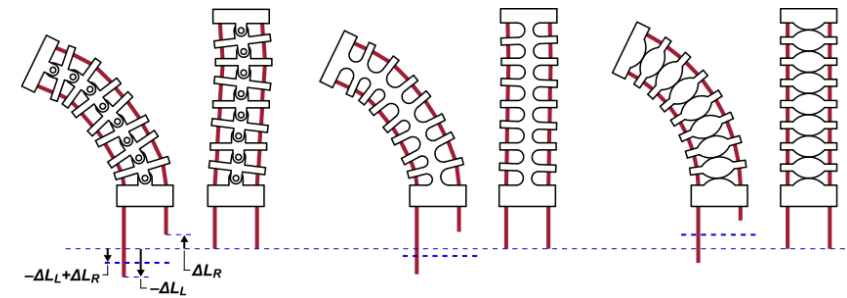
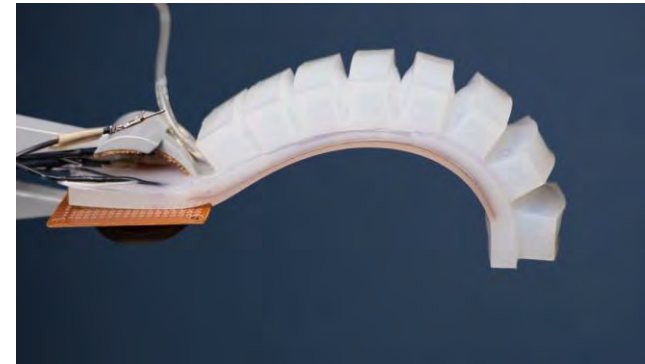
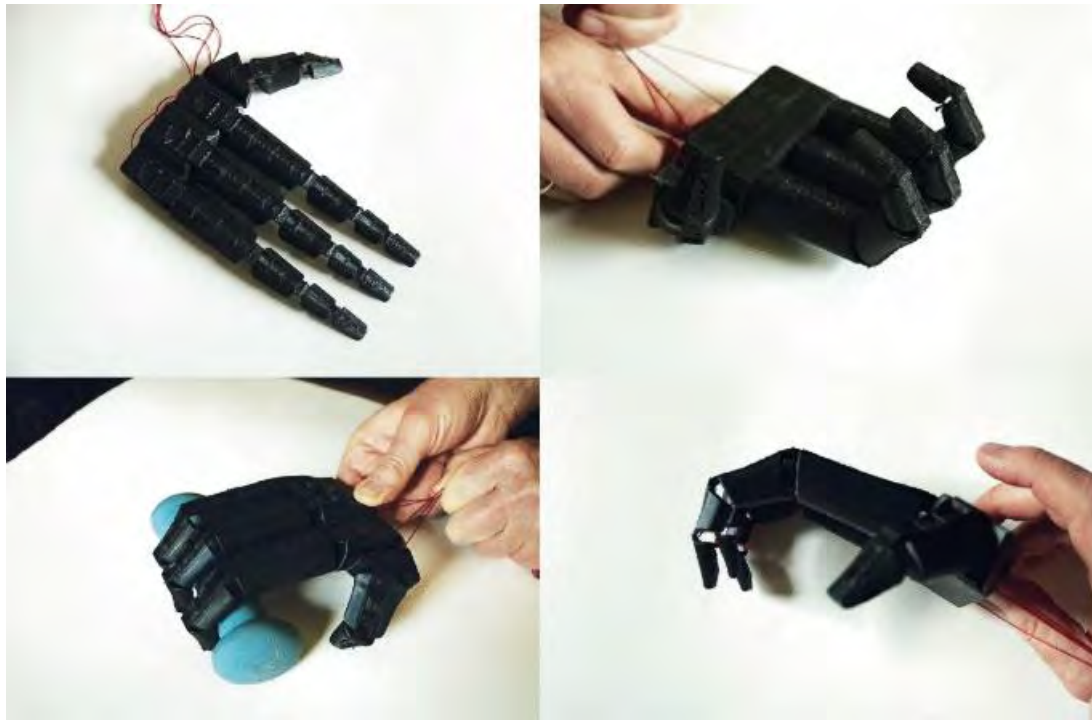


DEPLOYMENT

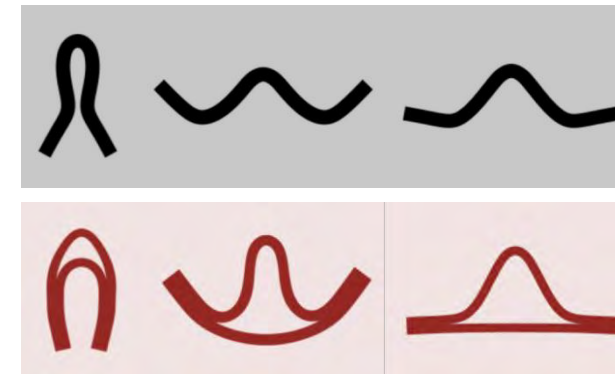
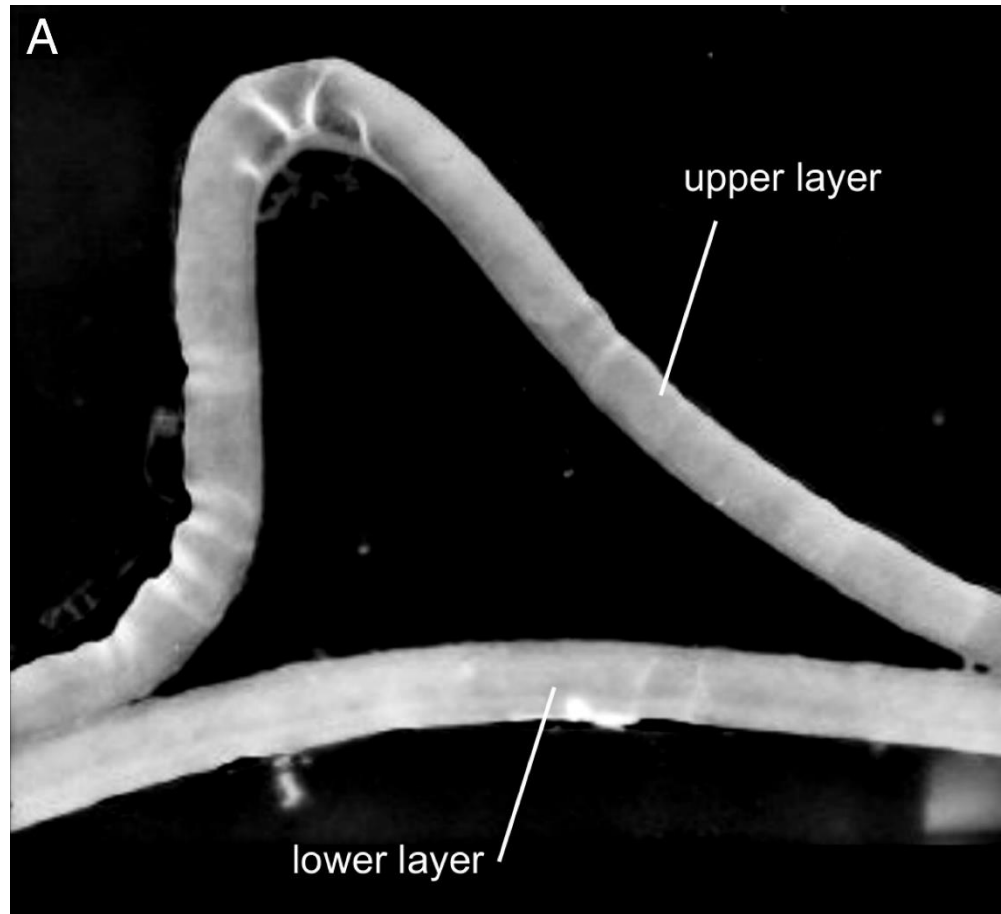


DETAIL

INSPIRATION FLEXIBLE HINGE JOINTS

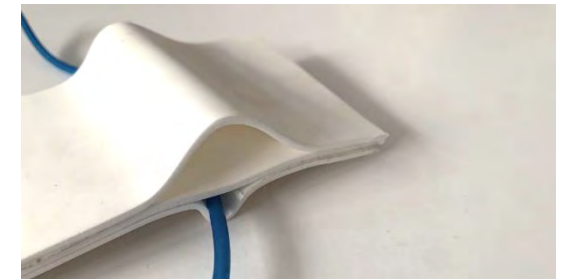
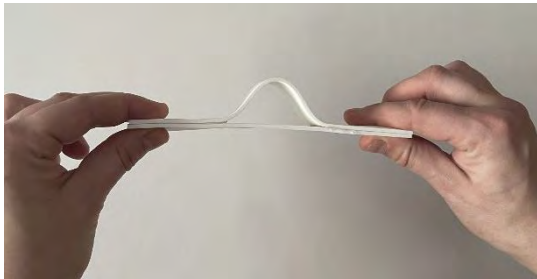


HINGE INSPIRED BY BEETLE WING

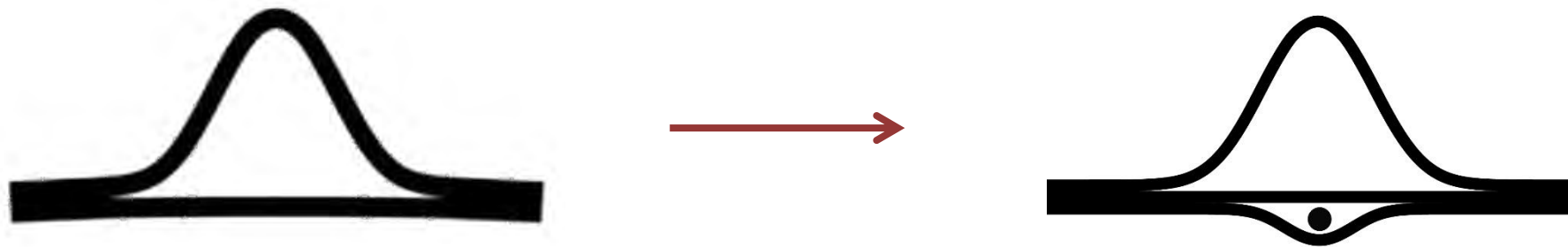


PNAS, Vol. 119 No. 45

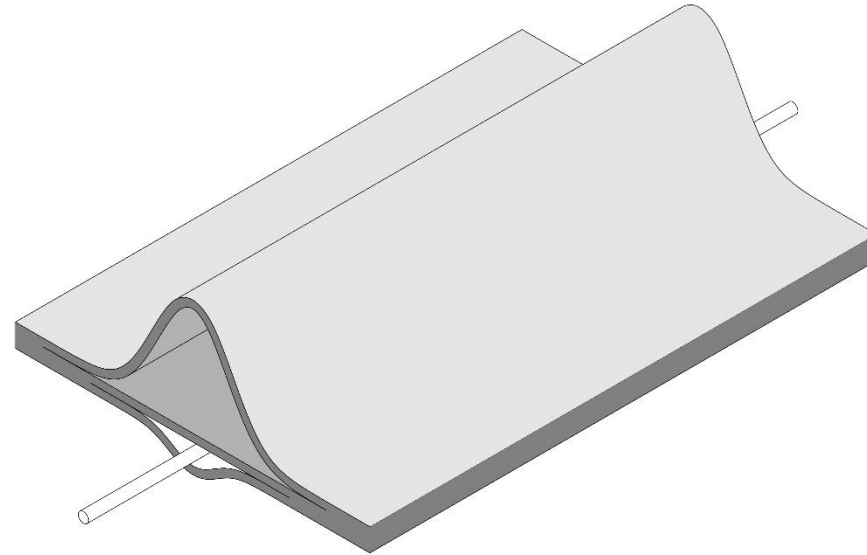
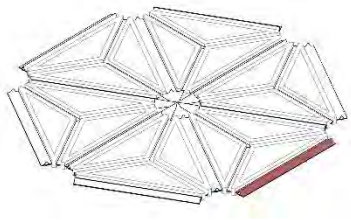
HINGE DEVELOPMENT



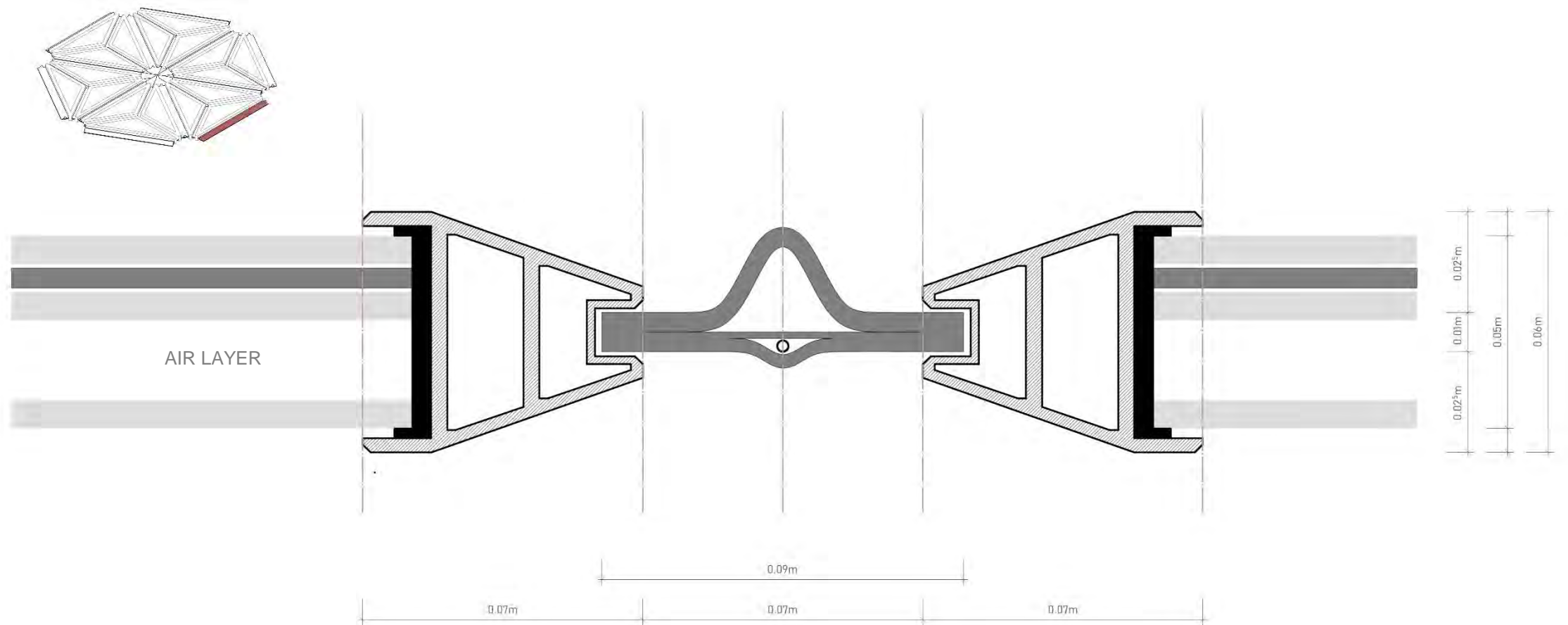
HINGE DEVELOPMENT



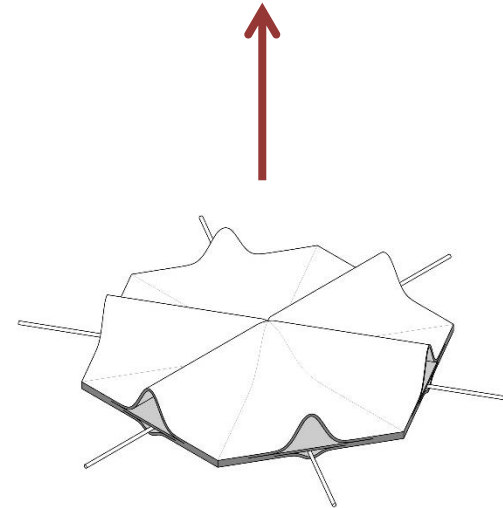
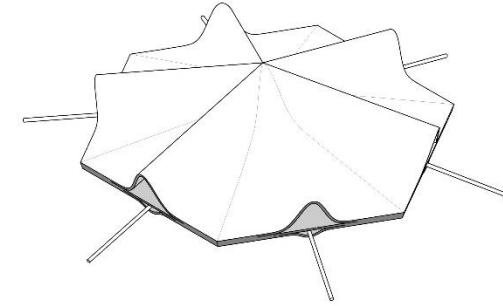
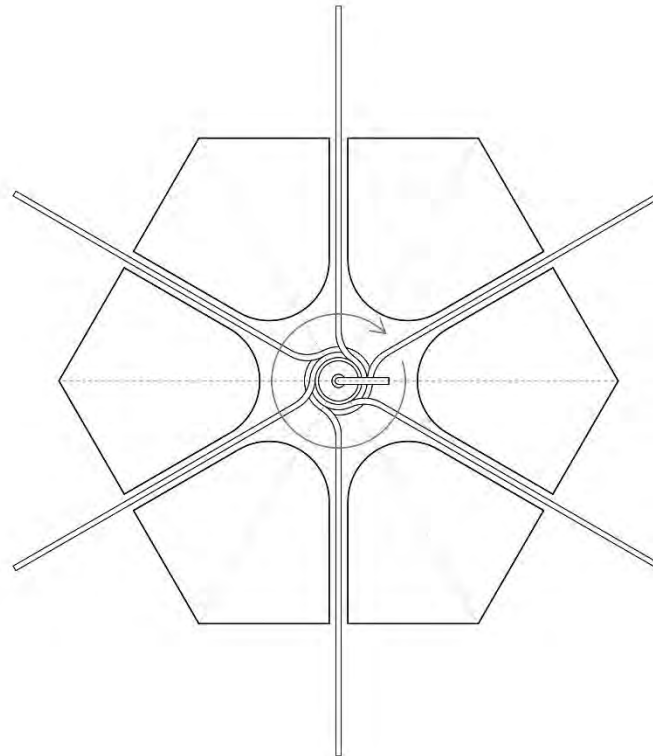
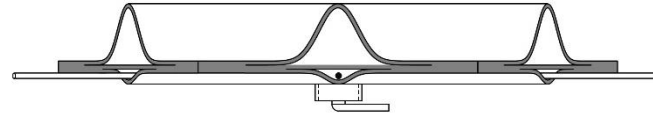
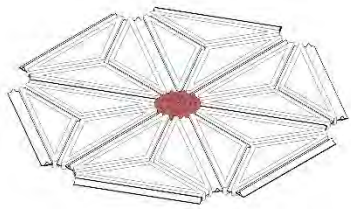
HINGE DETAIL



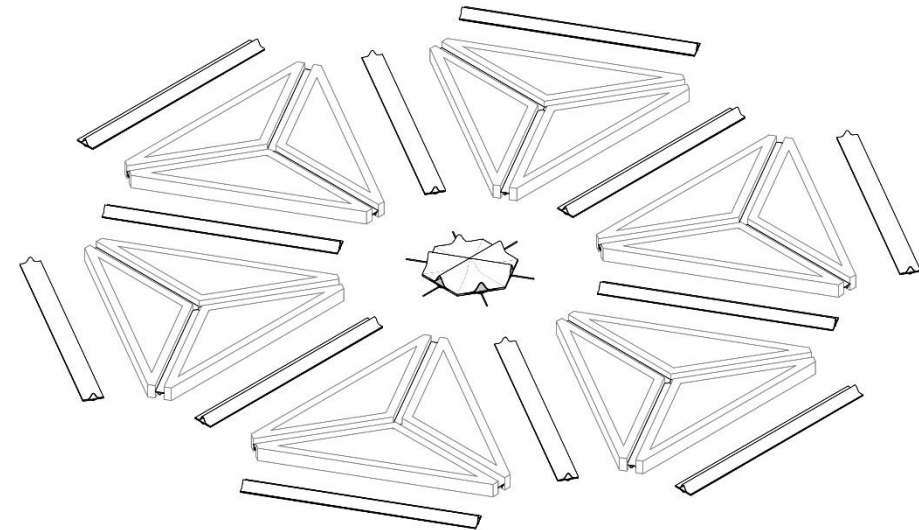
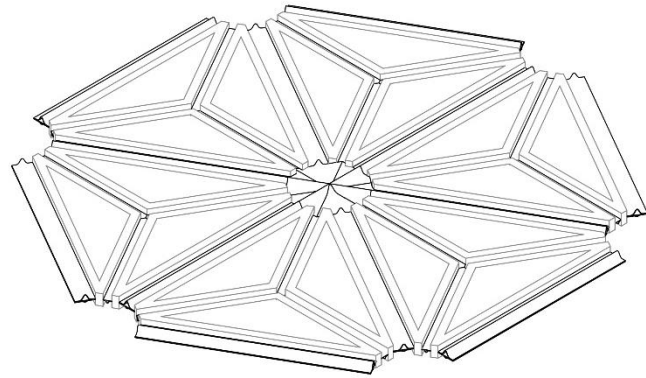
HINGE DETAIL



CROSSPOINT DETAIL

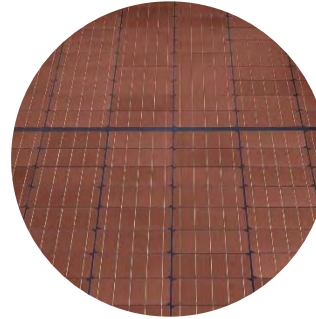
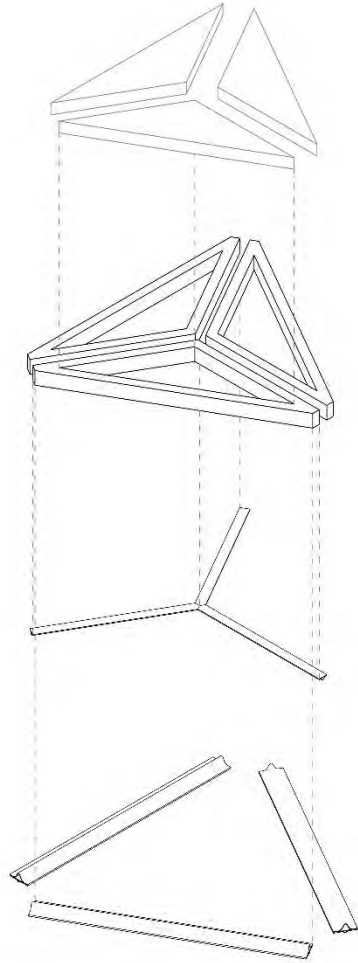


CONNECTION



REUSABILITY

MODULE STRUCTURE



SOLAR PANELS
semitransparent, tinted

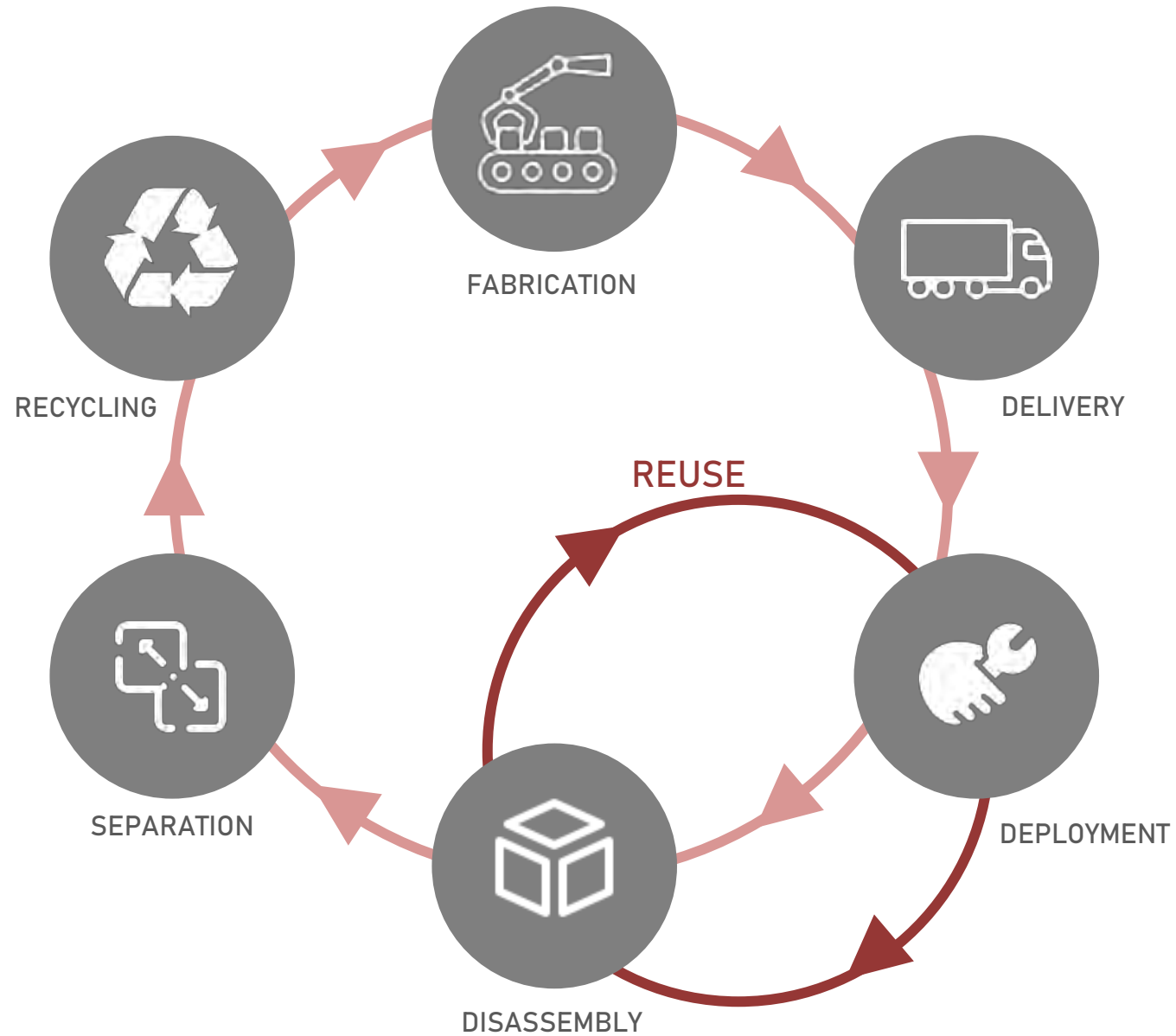


BIOPLASTIC
100% biobased & recyclable
i.e. **ARBOBLEND®**

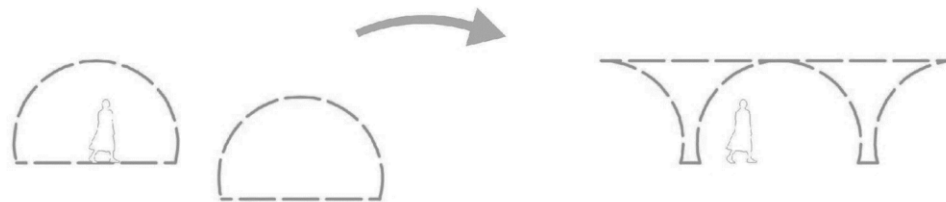


TPU
flexible, 3D printable, recyclable

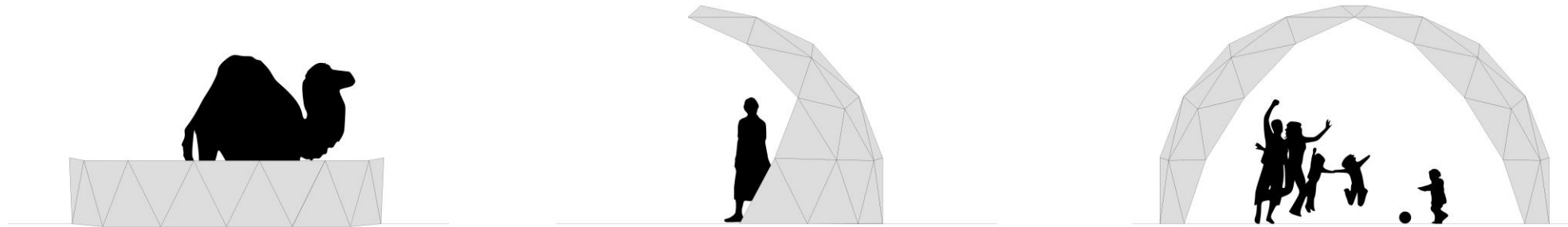
LIFECYCLE



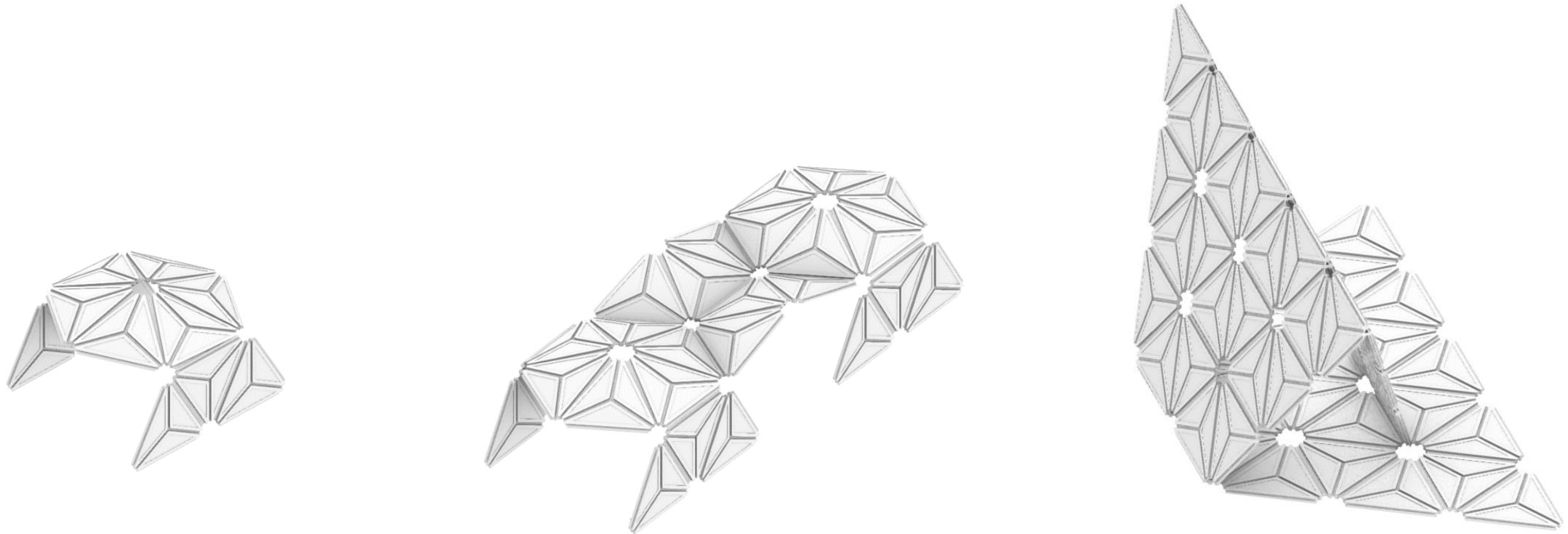
DESIGN FLEXIBILITY



DESIGN FLEXIBILITY



DESIGN FLEXIBILITY



VISUALIZATION



VISUALIZATION



THANK YOU FOR YOUR ATTENTION!

REFERENCES

CONCEPT INSPO

- wood skin <https://www.archipanic.com/woodskin/>
- wood textile <https://flextiles.wordpress.com/2011/11/20/the-power-of-making/>
- Plate folding <https://digitalnature.slis.tsukuba.ac.jp/2018/11/novel-structure-using-quasirigid-folding-of-voxel-in-ron-resch-pattern/>
- Origami <https://parametrichouse.com/tag/origami/>
- Ombres lumineuses <https://cargocollective.com/darklyte/OMBRES-LUMINEUSES>
- ArboSkin <https://www.itke.uni-stuttgart.de/research/built-projects/arbo-skin/>
- Afar House <https://www.flickr.com/photos/mytripsmypics/15069870410>
<https://www.alamy.com/young-afar-women-constructing-nomad-tent-afar-region-ethiopia-the-ancestors-of-the-afar-settled-farm-land-in-the-ethiopian-highlands-some-time-befo-image341247476.html>

Renewable Oasis

<http://www.landartgenerator.org/LAGI-FieldGuideRenewableEnergy-ed2.pdf>

Agrivoltaic Architecture

<https://landartgenerator.org/LAGI-2020/agrivoltaic-architecture/>

JOINT INSPO

- Hand https://link.springer.com/chapter/10.1007/978-3-030-80744-3_23
- Rigid-flexible-links https://www.researchgate.net/figure/The-underactuated-tenon-driven-gripper-proposed-in-this-work-has-two-flexible-fingers_fig1_325644880
- Joint with elastic fixtures https://www.researchgate.net/figure/Neutral-and-bent-postures-of-various-under-actuated-bending-joints-a-a-hyper-redundant_fig9_282389660
- Beetle Hinge PNAS, 2022 Vol. 119, No. 45 <https://www.pnas.org/doi/10.1073/pnas.2211861119>