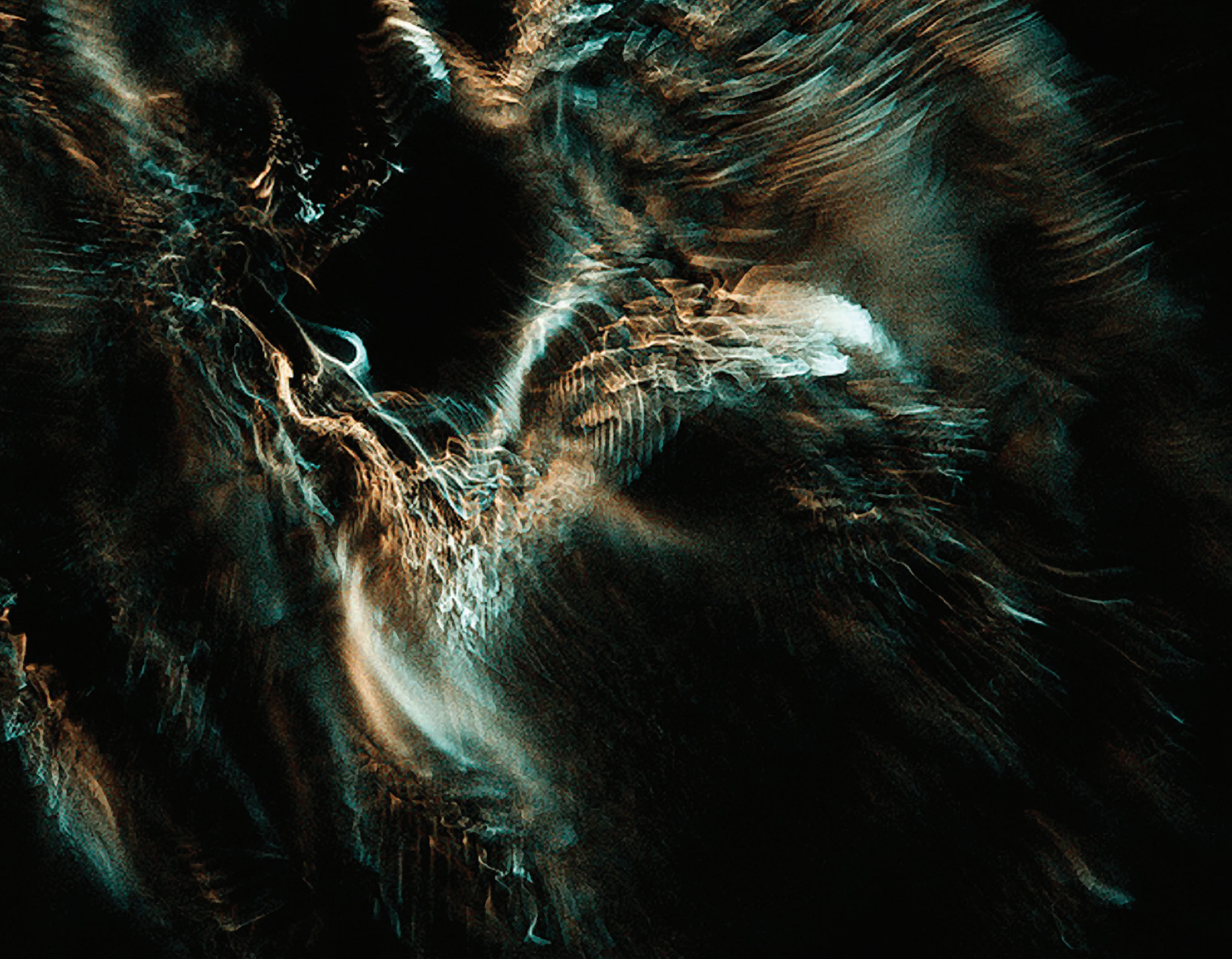

ACADIA // 2016

POSTHUMAN FRONTIERS:
DATA, DESIGNERS, AND COGNITIVE MACHINES

Projects Catalog of the 36th Annual Conference of the Association for Computer Aided Design in Architecture

University of Michigan Taubman College of Architecture and Urban Planning, Ann Arbor

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Edited by Kathy Velikov, Sandra Manninger, Matias del Campo, Sean Ahlquist, Geoffrey Thün

TAUBMAN COLLEGE
architecture + urban planning
University of Michigan

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PROJECTS

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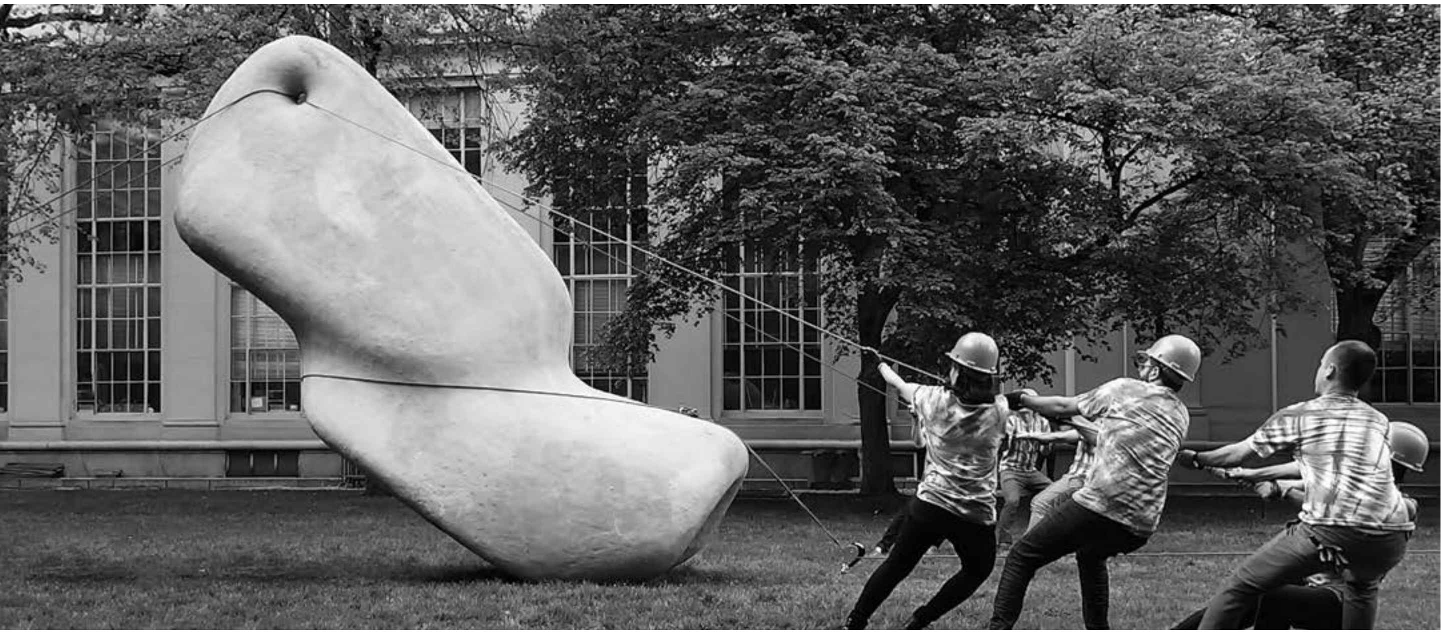
The McKnelly Megalith

Brandon Clifford
MIT / Matter Design



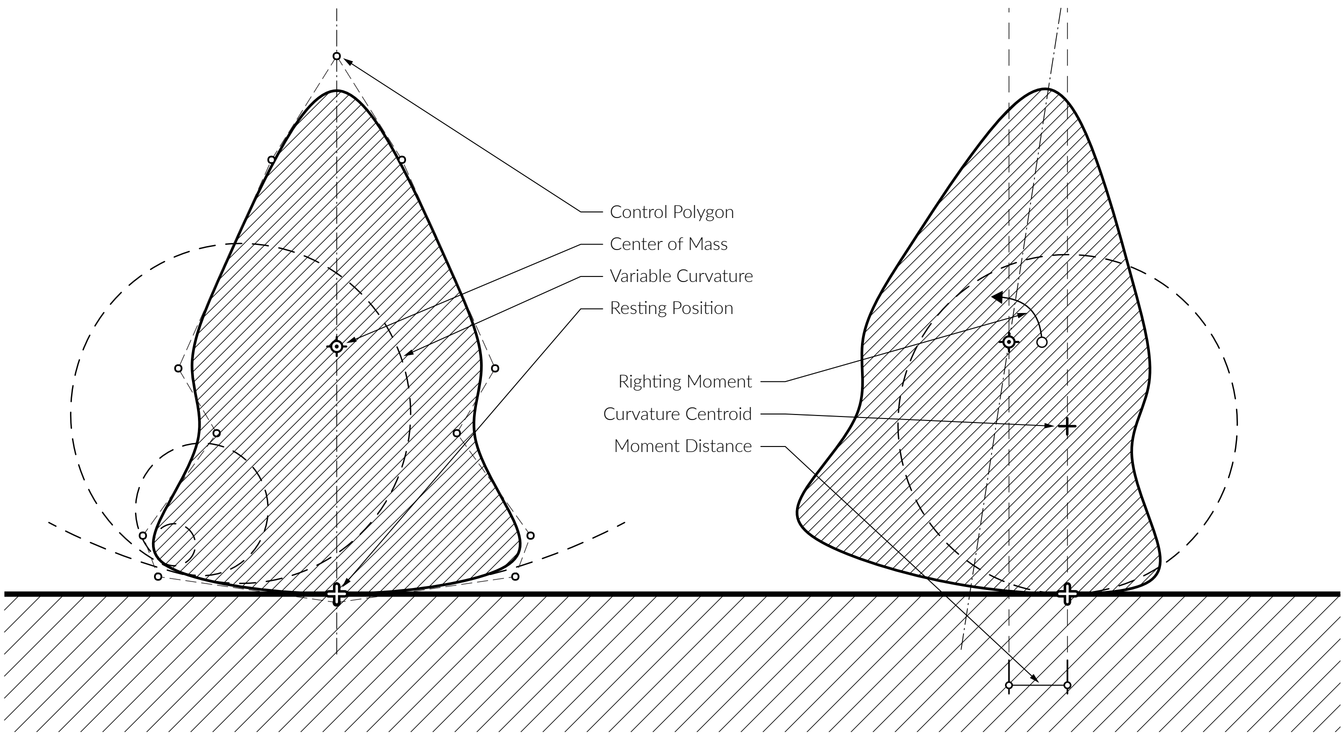
1 Erecting, *McKnelly Megalith*, Killian Court: MIT, 2015 (Kilian, 2015).

Megalithic civilizations held tremendous knowledge surrounding the deceptively simple task of moving heavy objects. Much of this knowledge has been lost to us from the past. This research mines, extracts, and experiments with this knowledge to test what applications and resonance it holds with contemporary digital practice. As an experiment, a sixteen-foot tall megalith is designed, computed, and constructed to walk horizontally and stand vertically with little effort. This research contributes to ongoing efforts around the integration of physics-based solvers into the design process. It goes beyond the assumption of statics as a solution in order to ask questions about the potential for mass to contribute to the assembly and erecting of architectures to come. It engages a megalithic way of thinking which requires an intimate relationship between the designer and the center of mass. In doing so, it questions conventional disciplinary notions of stasis and efficiency.

With carving starting around 1100 A.D., the Moai of Rapa Nui (Easter Island) weigh up to eighty tons apiece. Since the Dutch discovery of this Pacific island in 1722, visitors have wondered at these megalithic figures, asking the inhabitants how their ancestors possibly moved the statues from quarry to site. The Rapa Nui claim their ancestors never moved the Moai; rather, the Moai walked themselves. For centuries, this anthropomorphic explanation was considered superstitious poppycock by all but the islanders. It is this mystery that has fostered book titles such as *The Mystery of Easter Island* (Routledge 1919) and *Aku-Aku: the Secret of Easter Island* (Heyerdahl 1958) by early researchers to the island. It wasn't until 2012 that archaeologists Carl Lipo and Terry Hunt

PRODUCTION NOTES

Year:	2015
Site:	Cambridge, MA
Location:	MIT Killian Court
Course:	Megalithic Robotics
Size:	6' X 8' X 16'
Materials:	GFRC, EPS Foam



2 Section describing the relationship between the curvature of the belly geometry and the height of the center of mass. When tipped to a side, a righting moment is produced resulting in a stable positioning on a single point to allow for rotation (Clifford, 2015, © Matter Design).

were able to prove the Moai were in fact transported in a vertical position (Lipo 2012). In a similar manner to how one might shimmy a refrigerator into place, the Moai were pulled back and forth by ropes employing momentum to transport these unwieldy megaliths. This (re)discovery brings new meaning to the assumed folklore that the statues ‘walked themselves’ from the quarry to the Ahu (platforms).

When calibrating the center of mass to perform the movement behavior from quarry to site, the Rapa Nui were solving a multi-variable problem that bears similarities with the types of computation designers are working with today; however, the Moai are not the result of a problem-solving approach (engineering), nor an exclusively aesthetic concern (sculpture). Moai are a cultivated result of a conflated design practice that engenders practical concerns with cultural performance, which results in a marvel. This paper presents research into translating this ancient knowledge into contemporary computation methods. The result is a physical spectacle.

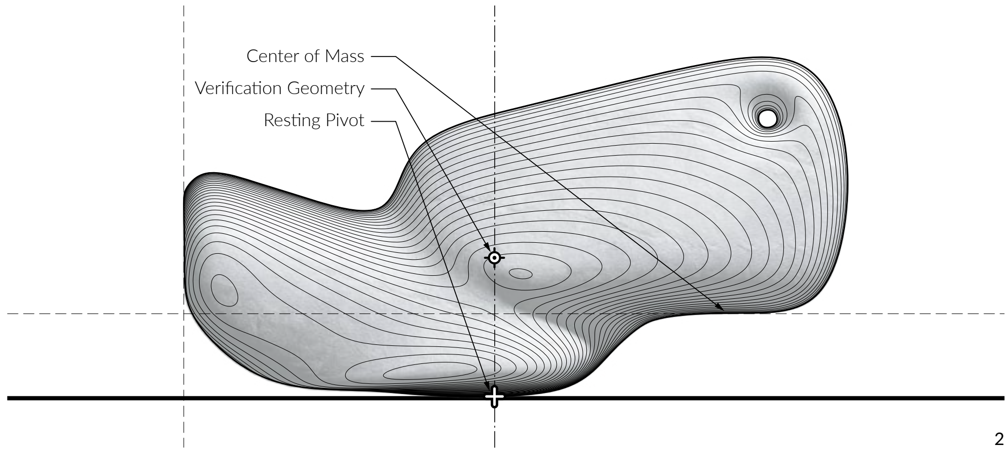
Multi-Variable Computation

Three positions are required to perform the action of walking horizontally and standing vertically. These three positions include the resting position, the weighted step position, and the standing position. While it is possible to design an artifact to perform any one of these positions, it is significantly more difficult to accommodate all three in a single object. The resting position is a horizontal position where the megalith rests on the belly geometry. This position needs a base that is able to pivot, and therefore is required to balance on a point. In this position, the megalith needs to be able to spin, but should resist rolling over. The weighted step position occurs by adding the mass of a single person to one end, shifting the center of mass and allowing a new equilibrium position to be found. This new position should be far enough from the resting position to consider it a step. This weighted step position maintains the same program and constraints of the resting position, as the megalith will rotate 180 degrees in plan to release it back to the resting position—a second step has occurred. The standing position is ninety degrees in elevation relative to the

3 Resting Position - In this position, the center of mass is directly over the resting pivot, resulting in a stable equilibrium. Two verification geometries can be drawn from this position, the foot geometry is vertical to the ground and the chin is parallel.

4 Weighted Step Position - With the additional mass of one person to the eyehole geometry, the combined center of mass is disturbed, pulled closer to the head. This shifting of the COM results in a moment relative to the resting pivot rolling the megalith forward on the belly. Ultimately it finds a new stable position when the upper verification geometry strikes a horizontal.

5 Standing Position - Once in the standing position, the original center of mass is above the 'C' shaped foot geometry, resulting in a stable condition.



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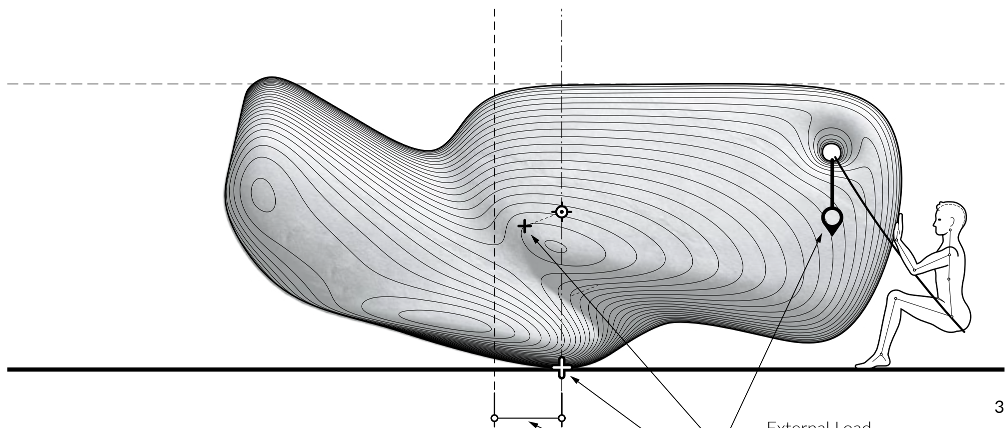

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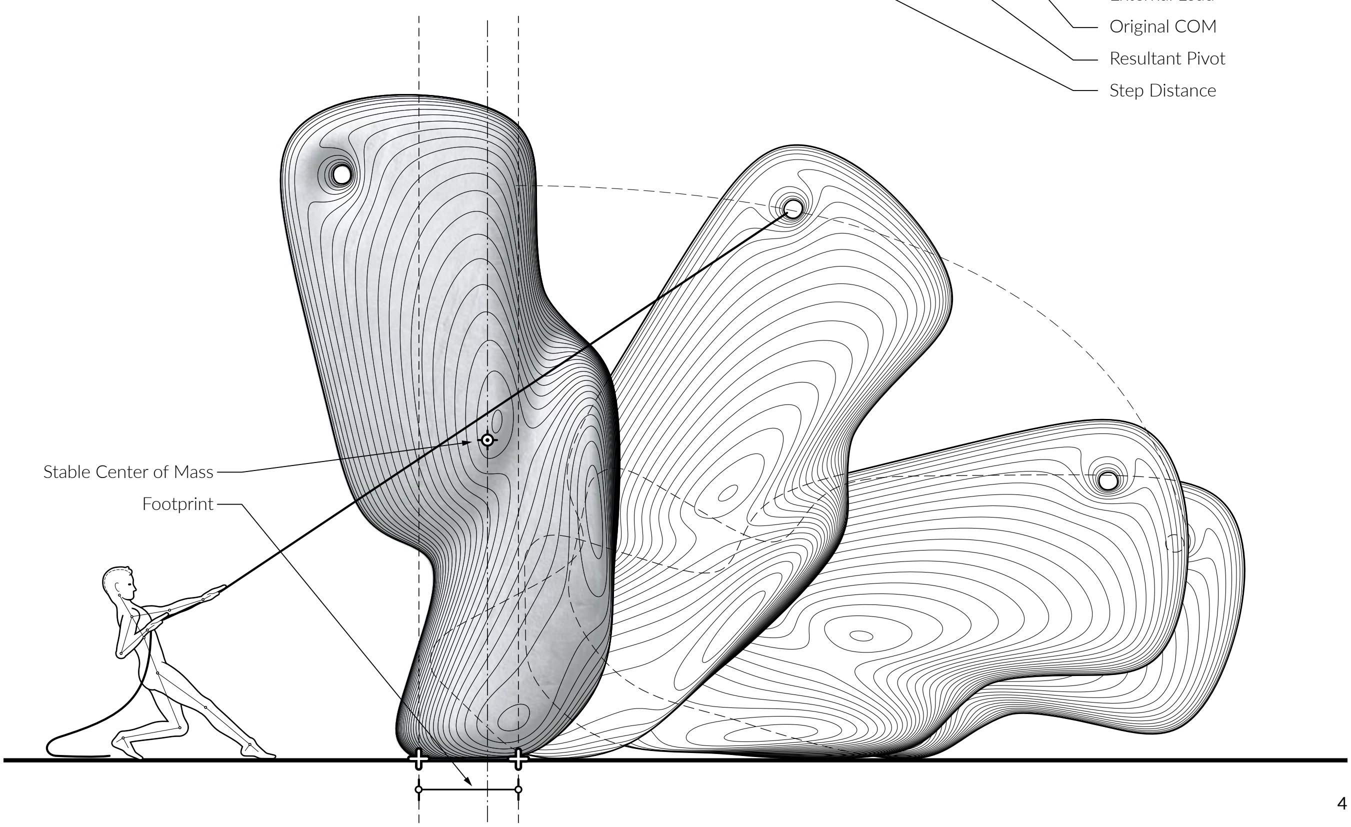

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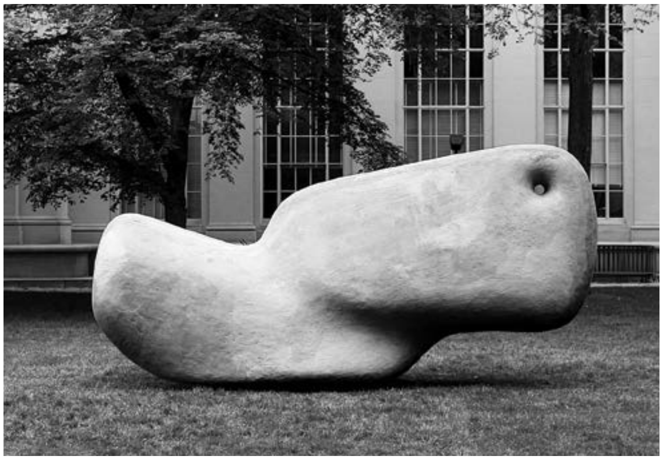
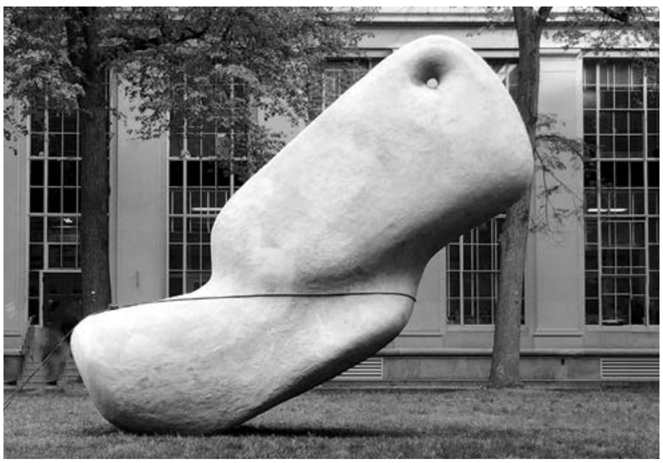
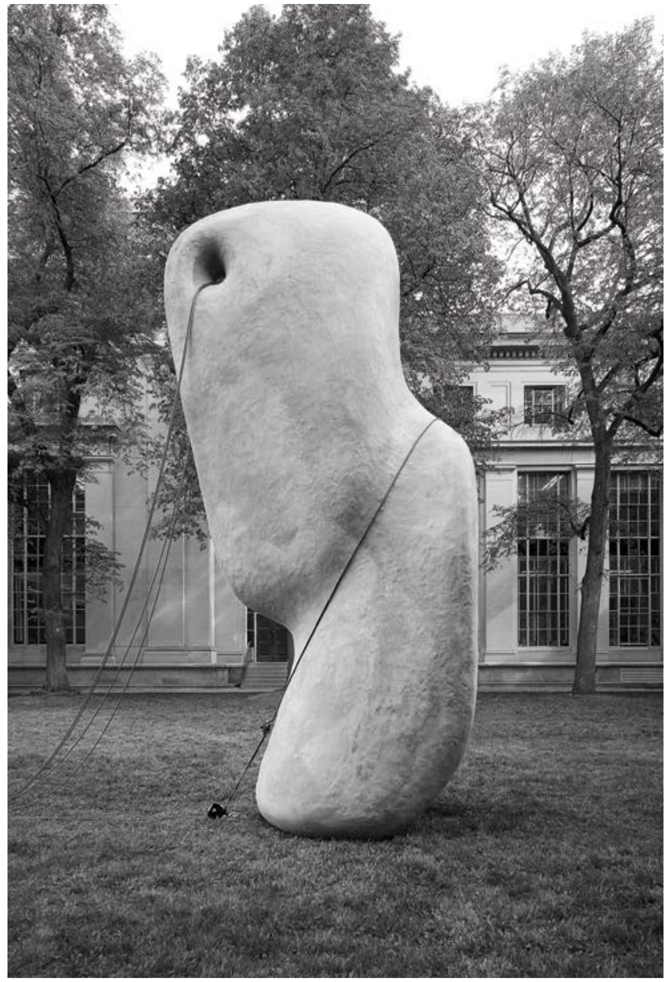


6 Resting Position (McGee, 2015, © Matter Design).



7 In the process of erection (Ariza, 2015).



8 Standing Position (Clifford, 2015, © Matter Design.)

resting position. The challenge of reaching this standing position is significantly greater than the weighted step position, but only with respect to force. It does not have to deal with the pivot constraint. The participants should be able to erect the megalith from a 'safe' distance; defined as a radius around the object equal to its height. Once in the standing position, the megalith should achieve a stable resting position able to resist wind-loads up to sixty miles per hour.

In order to design for a multi-variable problem as described above, a design tool is developed to convey information about the center of mass of the object to the designer. This tool includes a recursion solver to adjust the polygonal calculus-based geometry in order to drive the center of mass to a desired location. This synthetic relationship between a physics concept and the sculpting of a figure, re-introduces concepts from Rapa Nui Moai carving into the digital era.

Results

The resulting *McKnelly Megalith* is sixteen feet long (or high in the standing position) by six feet of depth and eight feet of height. The EPS core occupies 237 cubic feet, weighing 237 pounds. The half-inch thick GFRC shell occupies 268 square feet and weighs 1,763 pounds. In total the megalith weighs 2,000 pounds (1 Ton). While this mass is significantly lighter than the inspiration Moai, it is significantly heavier than one would expect a human to be able to maneuver. Each step travels two feet, allowing it to transport at 300 feet per hour. This project demonstrates a process whereby organic modeling can interact with physics-based information modeling in order to perform megalithic actions. It proves the ability to prototype, test, and manufacture at a large scale. This method could inform architecture with information to aid in the erection and assembly of parts, or it could inform the stability of perceived unstable artifacts.

9 A bias view of the front of the megalith, showing the tapper from the top of the head down to the chin, a result of the solver while trying to pull the center of mass lower (Clifford, 2015, © Matter Design).

ACKNOWLEDGEMENTS

A longer version of this text is concurrently published in *ACADIA 2016 Posthuman Frontiers, Proceedings of the 36th Annual Conference of the Association for Computer Aided Design in Architecture.*

This research was conducted in the graduate options architecture studio titled 'Megalithic Robotics' at the *Massachusetts Institute of Technology* in the Spring of 2015 co-taught by Brandon Clifford and Mark Jarzombek (professors) with Carrie Lee McKnelly (Assistant Instructor). Students include Sam Ghantous, Anastasia Hiller, Karen Kitayama, Dan Li, Hui Li, Patrick Evan Little, Tengjia Liu, Ryan McLaughlin, Kaining Peng, Alexis Sablone, and Luisel Zayas. The computation employs *T-Splines* (www.tsplines.com) as the organic modeler to inform *Grasshopper* (www.grasshopper3d.com), a plugin developed by David Rutten for *Rhinoceros* (www.rhino3d.com), a program developed by Robert McNeil. The *McKnelly Megalith* is dedicated to the memory of Steve and Rendy McKnelly.

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Brandon Clifford is an Assistant Professor at the Massachusetts Institute of Technology and Principal at Matter Design. Brandon received his Master of Architecture from Princeton University in 2011 and Bachelor of Science in Architecture from the Georgia Tech in 2006. He worked as project manager at Office dA from 2006–09, LeFevre Fellow at OSU from 2011–12, and Belluschi Lecturer at MIT from 2012–16. Brandon has been awarded the Design Biennial Boston Award, the Architectural League Prize, as well as the prestigious SOM Prize. Brandon's translation of past knowledge into contemporary practice continues to provoke new directions for digital design.

10 The belly geometry while the *McKnelly Megalith* is in the standing position (Clifford, 2015, © Matter Design).