# PNEULASTICS, pneumatically activated differentiated stretchable membranes

Anna RIZOU[*], Enrique SORIANO[a], Ramon SASTRE[a]

*Universitat Politécnica de Catalunya
Aragó 247, 08007, Barcelona, Spain
anna.rizou23@gmail.com

[a] CODA / LiTA BarcelonaTech

## Abstract

The object of this research is the integrative design of pneumatic structures that consist of membranes with differentiated elasticity upon their surface, in order to adapt to complex geometries when pneumatically distended. We introduce *pneulastics*, initially flat, pneumatically activated stretchable membranes with areas of differentiated thickness- and therefore elasticity- that respond with a different expansion rate and create complex tension conditions on their surface when sealed and pneumatically inflated.

Previous work [1], [2], has already shown interest in the analysis and acquisition of control over the geometry of inflatable structures, by introducing tension conditions upon the uniform pressure stresses, frequently by means of additional third members other than air and membrane, raising the complexity of the structure. Other precedents [3] manage to embody constraints in pneumatic activation, laying emphasis on the activation itself rather than the final shape. *Pneulastics* introduce the integration of active material strategies in order to encode the differentiated activation into one single skin, on an architectural scale, approximating predetermined shapes with form-found efficiency.

With a series of physical experimentations that confirm the initial hypothesis, that *pneulastics* can provide a wide range of doubly curved shapes, we empirically decipher and describe material behavior into digital simulation. Starting with a target shape input, our design method translates curvature and topology into flat membrane configuration, and optimizes thickness differential, shape and zone boundaries, to obtain the best approximation of the initial shape by inflation.

We see a special potential of this programmable form-finding as a design tool for compact shell solutions in future architectural applications, where there is a prospect of efficiency in pressurized spaces due to diverse atmospheric and relative pressure conditions.

## References

[1] Konaković-Luković, Mina, Panetta, Julian, Crane, Keenan and Pauly, Mark, *Rapid Deployment of Curved Surfaces via Programmable Auxetics,* Advances in Architectural Geometry 2018, pp.94-111.

[2] Baranovskaya, Yuliya, Prado, Marshall, Dörstelmann, Moritz and Menges, Achim, *Knitflatable Architecture - Pneumatically Activated Preprogrammed Knitted Textiles,* Complexity & Simplicity - Proceedings of the 34th eCAADe Conference - Volume 1, University of Oulu, Oulu, Finland, 22-26 August 2016, pp. 571-580.

[3] Paul Poinet, Ehsan Baharlou, Tobias Schwinn, Achim Menges, *Adaptive Pneumatic Shell Structures: Feedback-driven robotic stiffening of inflated extensible membranes and further rigidification for architectural applications*, Complexity & Simplicity - Proceedings of the 34th eCAADe Conference - Volume1, University of Oulu, Oulu, Finland, 22-26 August 2016, pp. 549-558.