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TOPOLOGY OPTIMIZATION FOR ADDITIVE MANUFACTURING – NEW METHODS AND APPLICATIONS

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ABSTRACT

Additive Manufacturing (AM) encompasses a diverse set of techniques that share one defining strength: they impose very few restrictions on design freedom. This makes AM an attractive option for producing the complex geometries generated by topology optimization (TO). As with any manufacturing process, however, both manufacturability and cost remain strongly design-dependent. A case in point are overhanging features, which many AM processes cannot produce without sacrificial supports. Poor designs lead to excessive build times, build failures, and extensive post-processing, all of which significantly reduce cost-effectiveness. It is therefore not surprising that manufacturing constraints found their way into design optimization early on: a TO formulation imposing a minimum overhang angle on the design was one of the earliest and most influential milestones in TO for AM.

Today, the TO toolbox supporting Design for AM goes far beyond the canonical overhang problem. New challenges arise from at least three directions. First, **rarely studied or new AM techniques, process chains, and materials** exhibit characteristics that deserve explicit consideration — examples include hybrid AM, additive casting, multi-axis WAAM, concrete printing, and niche technologies such as binder jetting of silicon carbide, a very brittle material that is becoming popular in the space industry yet is highly sensitive to stress concentrations. Second, **new applications of AM** bring with them practical requirements that can significantly impact the design, such as inspectability or repairability. Third, the **cost of AM parts must be reduced further**, which calls for considering the AM process itself and also the upstream and downstream process steps — for instance, reducing the amount of sacrificial support structures, limiting warpage, overcoming build-space limitations, increasing the number of parts built simultaneously, and improving tool accessibility during support removal and machining.

This session invites contributions on **new or improved topology optimization methods** addressing current challenges in Design for AM, including but not limited to those outlined above. **Industrial and academic case studies** assessing the applicability and effectiveness of TO for AM, as well as contributions identifying future research needs, are highly welcome.