COMPLIANCE AND INSTABILITY IN MORPHING STRUCTURES

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Abstract. Morphing structures continue to attract significant attention as a potential technology for increasing efficiency, multi-functionality and performance for aeronautical systems. In this respect, contemporary morphing systems have departed from a mechanistic approach [1] to embrace compliant based systems achieving the desired deformations with actively controlled actuators [2, 3, 4]. Compliant structures allow for maintaining a smooth aerodynamic profile eliminating gaps and discontinuities, reducing part count and limiting maintenance due to the robustness of monolithic designs [5, 6]. These advantages currently come at the cost of increased actuation needs due to the energy spent deforming the structure [6, 7], which typically results in added actuator-related weight. The aforementioned advantages and costs broadly exemplify the main problem at the heart of morphing structures design: namely, the intimate trade-off between the load-carrying (stiffness) and shape adaptation (compliance) functions. Therefore, to fully exploit the superior performance and augmented functionality promised by morphing, a new class of systems is required in which the load-carrying, deformation and actuation functions are more intimately coupled. The possibility to alter on-demand the stiffness of the structure to enable deformation when needed can offer a very interesting solution to the mentioned trade-off. A particularly interesting methodology to achieve selective stiffness adaptation is to utilise structural nonlinearity and instability carefully design to augment the morphing capabilities [8], while maintaining the load-carrying function of the structures.

This paper presents a review of the efforts in utilising structural nonlinearity and instability in the design of morphing structures conducted by the researchers in the past 5 years [9, 10, 11, 11, 12, 13, 14, 15, 16]. First, a general introduction to the specific challenges regarding compliant-based morphing is presented. Two different avenues describing alternative methodologies for realising selective stiffness adaptation in morphing systems are presented, namely, via aeroelastically driven morphing and by profiting from geometrically multi-stable local elements within compliant structures. The presented results highlight the challenges to
find solutions to the trade-off between load-carrying capacity high shape adaptability, while maintaining light weight at the heart of morphing structures.

REFERENCES