SHAPE MORPHING AND CONTROL OF FLEXIBLE SURFACES FOR AEROSPACE APPLICATIONS

H. Baier, L. Datashvili

Institute of Lightweight Structures (LLB), Technische Universität München, Germany

ABSTRACT

Massively shape morphing structures require an actuation system as well as flexible structural elements which are to be morphed. This not only puts strong requirements onto the actuation system, but at least equally also to the morphing part. In addition to flexibility the latter has often to satisfy other nearly conflicting requirements such as high load carrying capability on morphing wings or low thermal expansion and space compatibility for reconfigurable satellite reflectors. In both application scenarios, flexible structural surfaces and their interaction with the actuators are key points.

1. INTRODUCTION

The word "morphing" comes from metamorphose, which describes the process of (often massive) changes in shape or status. Morphing structures then are to be composed of the surface to be morphed and the actuation part often consisting of many actuators, and possibly further elements such as sensing and control loops. In order to make the discussion concrete, two reference examples will be used, namely a morphing wing and a morphing or geometrical reconfiguring satellite antenna reflector. Though there are quite different conditions and requirements, the simulation and optimization *process* for these tasks is quite similar. Moreover, the considerations on flexible surface materials and structures and their interaction with the actuators lead to several common aspects.

2. MORPHING WINGS

Aircraft wings usually are optimized for a specific design point considering the Mach and Reynolds numbers, apart from general system requirements such as flight distance, payload etc. At this design point the wing reaches its best aerodynamic performance and efficiency. With the change of the flight conditions the efficiency decreases. A morphing wing then shall adapt its shape in a certain range to improve performance for a wider flight regime such as that of fig. 1.

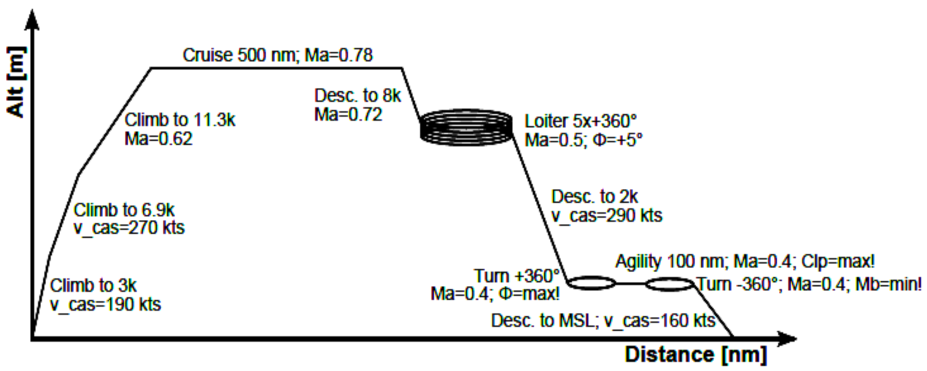

Fig. 1: Flight regime for a size passenger aircraft as used in [1] with a morphing wing

As quantified by Wittmann [1], the wing's morphing geometry like chord length, height, chamber, cant angle etc. do have different consequences on different criteria for this passenger aircraft flight regime, as shown in fig. 2. In this figure the absolute contribution for these criteria as well as the individual parameter contribution for a certain criterion is given. Fuel savings can be in the order of 7.5%, and wing root loading might be significantly reduced as well, possibly leading to a saving in structural mass. Wittmann also highlights the need for low mass actuation systems, since otherwise the benefits from fig. 2 might be significantly reduced.