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COCOMAT—improved material exploitation of composite airframe structures by accurate simulation of postbuckling and collapse

Richard Degenhardt [a,*], Raimund Rolfes [b], Rolf Zimmermann [a], Klaus Rohwer [a]

[a] *DLR, Institut für Faserverbundleichtbau und Adaptronik, Lilienthalplatz 7, 38108 Braunschweig, Germany*
[b] *Universität Hannover, Institut für Statik und Dynamik, Appelstr. 9A, 30167 Hannover, Germany*

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Abstract

European aircraft industry demands for reduced development and operating costs, by 20% and 50% in the short and long term, respectively. The 4-year running project COCOMAT contributes to this aim by reducing structural weight at safe design; it exploits considerable reserves in primary fibre composite fuselage structures by accurate and reliable simulation of collapse. Collapse is specified by that point of the load–displacement-curve where a sharp decrease occurs thus limiting the load carrying capacity. COCOMAT, which is supported by the European Commission within the 6th Framework Programme started on 1 January 2004. This paper deals with the main objectives and expected results of the project as well as the planned theoretical and experimental work.

Keywords: Collapse; Buckling; Postbuckling; Composites; Simulation tools; Experiments; Degradation; Skin-stringer separation

1. Introduction

European aircraft industry demands for reduced development and operating costs, by 20% and 50% in the short and long term, respectively. Supported by the European Commission the 4-year project COCOMAT, which started in January 2004, contributes to this aim. COCOMAT stands for *Improved MATerial Exploitation at Safe Design of COmposite Airframe Structures by Accurate Simulation of Collapse* and is co-ordinated by DLR, Institute of Composite Structures and Adaptive Systems. The project aims at allowing for a structural weight reduction by exploiting considerable reserves in primary fibre composite fuselage structures through an accurate and reliable simulation of postbuckling and collapse.

The COCOMAT project is fully based upon the results of the POSICOSS project, which lasted from January 2000 to September 2004 (cf. Fig. 1). POSICOSS is the acronym of *Improved POstbuckling SImulation for Design of Fibre COmposite Stiffened Fuselage Structures* and was co-ordinated by DLR, Institute of Structural Mechanics (from 2005 the name was changed into Institute of Composite Structures and Adaptive Systems). The POSICOSS team has developed improved, fast and reliable procedures for buckling and postbuckling analysis of fibre composite stiffened panels of future fuselage structures. For the purpose of validation comprehensive experimental data bases were created. Finally, design guidelines were derived. An overview and more details about the POSICOSS project can be found in [1] and [2].

The COCOMAT project extends the POSICOSS results and goes beyond by a simulation of collapse. That requires knowing about degradation due to static as well as low cycle loading in the postbuckling range. It is well-known that thin-walled structures made of carbon fibre reinforced plastics are able to tolerate repeated buckling without any change in their buckling behaviour. However, it has to be found out, how deep into the postbuckling regime loading one can go without severely damaging the structure, and how this can be predicted by fast and precise simulation procedures. This issue is dealt with by COCOMAT.

* Corresponding author. Tel.: +49 531 295 3059; fax: +49 531 3059.
E-mail address: richard.degenhardt@dlr.de (R. Degenhardt).

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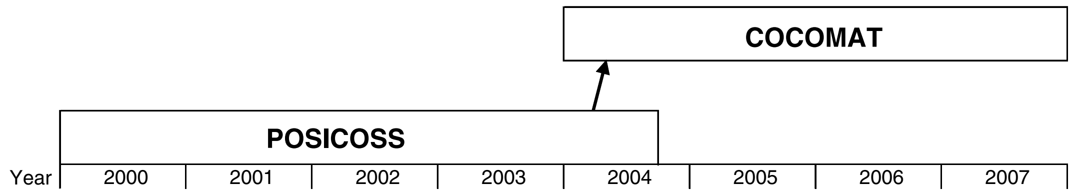

Fig. 1. Timetable of the EU projects POSICOSS and COCOMAT.

COCOMAT will improve existing slow and fast simulation tools and will set up design guidelines for stiffened panels which take skin-stringer separation and material degradation into account. Reliable fast tools allow for an economic design process, whereas very accurate but necessarily slow tools are required for the final certification. The results will comprise a substantially extended data base on material properties and on collapse of undamaged and pre-damaged structures subjected to static and low cycle loading, degradation models, improved slow and fast computation tools as well as design guidelines.

Regarding loads and characteristic dimensions, the projects POSICOSS and COCOMAT are oriented towards an application in the field of fuselage structures, but the results are transferable to other airframe structures as well. With the new design guidelines the aircraft industry will have a tool at its disposal, which substantially contributes to the objectives of reducing development and operating costs, by 20% and 50% in the short and long term, respectively.

The paper deals with the main objectives of the COCOMAT project, the planned theoretical and experimental work as well as the expected results.

2. Objectives

COCOMAT mainly strives for accomplishing the large step from the current to a future design scenario of typical stringer stiffened composite panels demonstrated in Fig. 2. The left graph illustrates a simplified load-shortening curve and highlights the current industrial design scenario. Three different regions can be specified. Region I covers loads allowed under operating flight conditions and is bounded by limit load; region II is the safety region and extends up to ultimate load; region III comprises the not allowed area which reaches up to collapse. In aircraft design ultimate load amounts to 150% of limit load. There is still a large unexploited structural reserve capacity between the current ultimate load and collapse. The right graph of Fig. 2 depicts the design scenario aspired in future, where ultimate load is shifted towards collapse as close as possible. Another difference to the current design scenario is, that the onset of degradation is moved from the not allowed region III to the safety region II. This is comparable to metallic structures where plasticity is already permitted in the safety region. However, it must be guaranteed that in any case the onset of degradation must not occur below limit load. Moreover, the extension requires an accurate and reliable simulation of collapse, which means to take into account degradation under static as well as under low cycle loading, in addition to geometrical nonlinearity.

3. Consortium

The COCOMAT consortium (cf. Fig. 3) merges knowledge from 5 large industrial partners (AGUSTA from Italy, GAMESA from Spain, HAI from Greece, IAI from Israel and PZL from Poland), 2 enterprises belonging to the category of SME (SAMTECH from Belgium and SMR from Switzerland), 3 research establishments (DLR from Germany, FOI from Sweden and CRC-ACS from

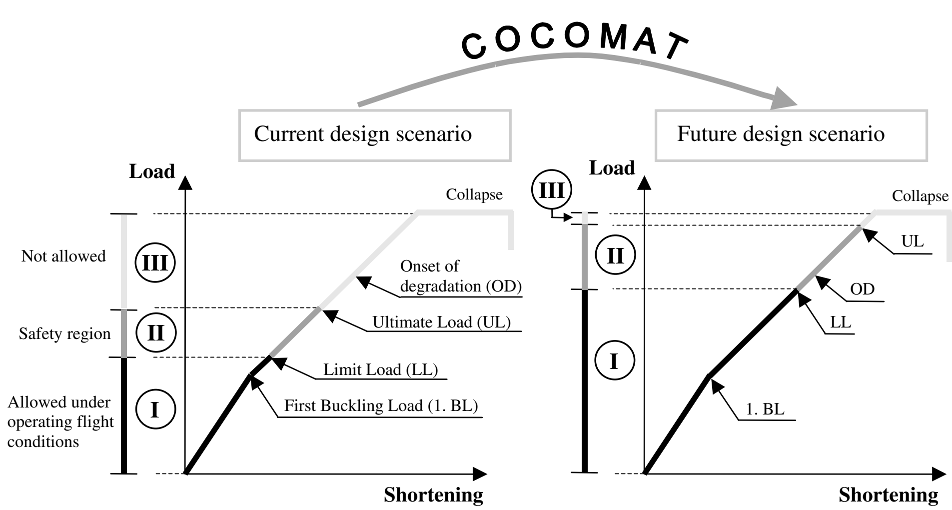

Fig. 2. Current and future design scenarios for typical stringer stiffened composite panel.