

# Aeroelastic Co-Simulation Flight Loads Toolkit

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**A** part of the Expleo Group of companies, Stirling Dynamics is a fast-growing, advanced engineering company that delivers a range of complex systems and technical services to the aerospace and marine markets. Trading since 1987, the company has accumulated a wealth of knowledge on over 70 different aircraft types and delivered to both civil and military programmes around the globe. Recognised as leading experts in the areas of aircraft loads, fluid dynamics and aeroelastics, Stirling Dynamics is approved to the global aerospace quality standard AS9100 as well as being a member of the ITAR Approved Community.

## Introduction

Stirling Dynamics has developed a non-linear aeroelastic toolkit for aircraft loads (Reference 1) as part of a UK NATEP (National Aerospace Technology Programme) initiative in collaboration with MSC Software UK and supported by the end-user, BAE Systems. Aircraft loads assessments (like gusts and manoeuvre loads) are typically performed using linear aircraft models and, although this is generally considered to be an acceptable means of analysis, including non-linear terms improves the modelling accuracy and reliability. Non-linear aeroelastic solutions are generally only available to the major aerospace OEMs who have their own tailored toolkits. The current processes used by most aircraft companies, excluding the two largest OEMs, is based on linear assumptions and this has been accepted as means of

compliance for generating gust and manoeuvre loads for aircraft design by the certification authorities. This puts smaller OEMs into a disadvantageous position as the linear models are generally considered to be overly conservative. The project objective for Stirling Dynamics was to develop their own in-house toolset. In parallel, as part of the same programme, tool development at MSC Software UK was aimed at developing a commercially available product. A more detailed description of the MSC development is covered in the following sections.

## MSC Software Co-Simulation CFD-FEA Coupling

A key feature of the *Aeroelastic CFD Manoeuvres Toolkit* is that it is based on the widely used MSC Nastran for FEA structural analysis, and scFLOW from Cradle for CFD, plus inputs from the end-user, BAE Systems. The tool allows for increased fidelity of the nonlinear aeroelastic effects that contribute to the loads experienced by an aircraft over a wide design-of-experiment (DoE) design space. The tool takes nonlinear aerodynamic effects into account from shock movements or flow separations around an aircraft, improving the accuracy and simplicity of loads modelling on flexing structures such as aircraft wings. MSC Software provided a robust and reliable commercial CFD and FEA solver co-simulation toolset to enable this. The toolkit also automates the simulation process very substantially. The toolkit includes new methods and it provides for:

- Extraction of aeroelastic loads from multiple scFLOW CFD analyses
- Application of the fluid load to an aeroelastic MSC Nastran model for various trim conditions



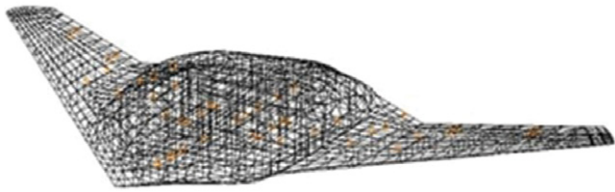


Figure 1: Generic UAV Model for this study (courtesy of BAE Systems)

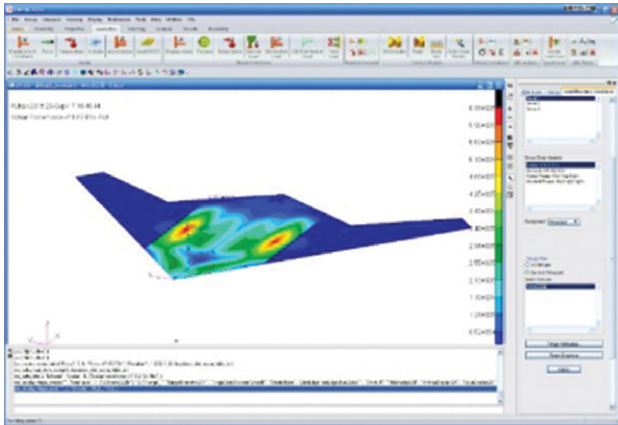


Figure 2: Generic UAV Model inside the Toolkit user interface



Figure 3: Non-linear UAV shape prediction of wing deflection displayed in the Toolkit

- Coupling of the aerodynamic loads in all 6 degrees of freedom (DOFs) to the structural FEA model

In tandem with BAE Systems, a generic Unmanned Aerial Vehicle (UAV) demonstration was created for BAE Systems to showcase the tool (Figure 1). The toolkit user interface (Figure 2) automates the direct mapping of CFD results from scFLOW onto finite element models from MSC Nastran to then predict and visualise aeroelastic effects.

## Summary

As part of a UK NATEP (National Aerospace Technology Programme) initiative in collaboration with MSC Software UK and supported by the end-user, BAE Systems, Stirling Dynamics has developed a non-linear aeroelastic toolkit for aircraft loads for use in their engineering programmes. In parallel and part of the same

**“Stirling has a long history of developing independent aircraft design tools. Working on this NATEP project together with MSC Software and BAE Systems has been an excellent opportunity to develop our capabilities further and to use these new tools for future aircraft design.”**

R&D Manager, Stirling Dynamics,  
Dr Simon Hancock

programme, MSC Software has been able to develop an innovative non-linear structural analysis-CFD solution with MSC Software simulation tools that will lead to more optimised aircraft aeroelastic models, and higher simulation fidelity resulting in the reduction of uncertainties in fluid-structure analysis predictions.

The *Aeroelastic CFD Manoeuvres Toolkit* means that uncertainties in the aircraft modelling process will be reduced, which results in increased accuracy in the CAE models produced, less conservative aircraft designs and lighter future aircraft. The key benefit of lighter aircraft will be less fuel burn and therefore more fuel-efficient flights and significant cost savings to aircraft manufacturers and users; this ultimately has environmental benefits for us all.

A demonstration of this toolkit by way of a generic UAV model was produced for BAE Systems in the UK. This toolkit will be valuable to aid in future aircraft certification requirements for emerging and small OEM aircraft manufacturers.

## Reference

1. UK NATEP Website Projects: <http://www.natep.org.uk/project-design-modelling> and <http://www.natep.org.uk/documents/ADS%20Natep%20210%20x%20210%20Supplement%20v5.pdf>