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Aircraft Loads

What Are They and Why Are They Important?

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Aircraft Loads – What Are They and Why Are They Important?

"Loads" is the general term referring to the forces that act on any structure, causing them to deflect and vibrate, thus giving rise to stresses and strains. Aircraft are subject to a wide range of static and dynamic loads occurring either in-flight, e.g. from manoeuvers and the effects of turbulence, and also on the ground e.g. landing, take-off, taxiing, braking, etc. These loads involves consideration of the interactions between the aerodynamics, weight and elastic behaviour all over the aircraft, and there are also likely to be discrete forces acting, such as those resulting from the engine thrust.

Calculation of the loads is extremely important for aircraft design, and many hundreds of thousands of calculations need to be made in order to consider all of the possible cases that might be encountered during an aircraft's lifetime. Having determined the loads, engineers can then compute the stresses all over the structure, and thus determine the size of the various structural elements e.g. spars, ribs and skin thicknesses. This entire process has to be repeated several times during the sizing process and is known as a "loads loop". As it is important to design the aircraft to be as light as possible, detailed analysis is required to achieve the balance between ensuring the structure is strong enough to withstand the stresses, whilst minimising the weight as much as possible. Despite this obvious importance, it is somewhat strange that the subject of aircraft loads does not appear in many aerospace engineering degree courses across the world.

There are many difficulties associated with the loads computations in an industrial environment; the most pressing issue is the large volume of calculations needed in a short time. Consequently, there is often a need to trade-off the accuracy of certain calculations (e.g. high fidelity Computational Fluid Dynamics (CFD) aerodynamics vs lower fidelity panel methods, or complex nonlinear structural calculations versus simpler linear models).

ALPES (Aircraft Loads Prediction using Enhanced Simulation[1]) is an EU FP7 Marie Curie European Industrial Doctorate Training Network which runs from 1 October 2013 to 30 September 2017. The aim of the network is to improve the prediction accuracy and efficiency of the loads experienced by an aircraft in-flight and on the ground. The ALPES network involves five Early Stage Researchers (ESRs) who are also registered for PhDs, combining a novel research programme with a highly industrially focused training schedule, including placements at Airbus. The programme contributes towards two key aspects of the EU ACARE2020 and FLIGHTPATH2050 initiatives, with the technologies investigated helping towards environmentally friendly aircraft designs and enabling faster design and certification processes, via the development of novel methods and procedures to improve the accuracy and efficiency of aircraft loads predictions.

ALPES has produced a number of novel technologies that could be used by the aerospace industry to improve and enhance the loads process.

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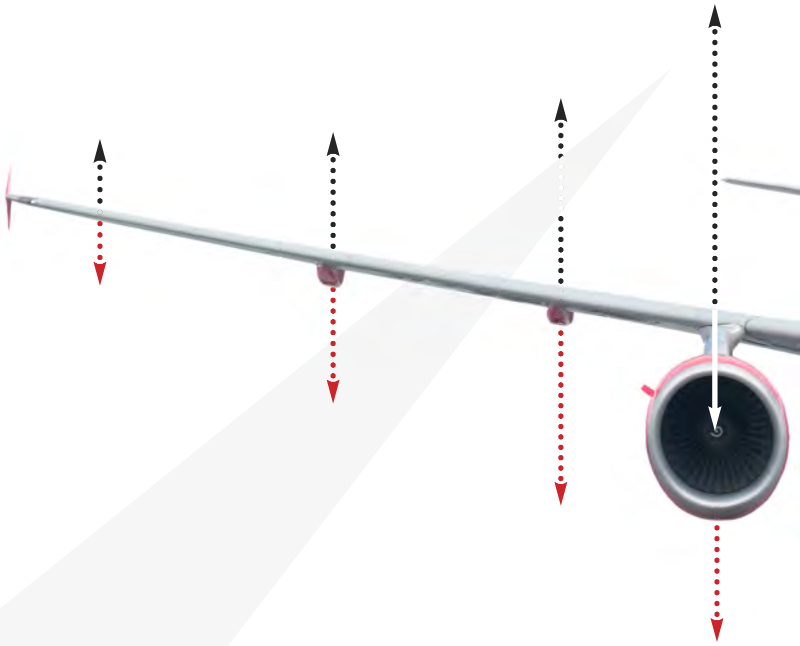
Nonlinear Effects

There are many so-called nonlinear effects which make the aircraft responses much more difficult to compute; examples include transonic aerodynamics shock movement, separated flows due to wing-tip stall, and the deflections of very flexible wings. Several methodologies have been developed in ALPES using Reduced Order Models (ROMs) in order to predict the aircraft response a significant reduction in computational time but still with good accuracy.



More Efficient Loads Processing

The current industrial standard for gust loads modelling is to use the Doublet Lattice Method (DLM) which has been the standard approach for nearly 40 years. There are inaccuracies with computations for transonic aerodynamics flight, but it is not yet feasible to perform full CFD aerodynamic computations due to computational limitations. New techniques have been developed in ALPES that correct the DLM results based upon a few CFD runs, thus enabling gust load predictions that are both fast and accurate. Other computations of interest are the so-called correlated loads, where coincident values of pairs of measured quantities (e.g. bending moments and torques) are plotted against each other against time in order to determine an envelope of the loads behaviour. Novel methods have demonstrated how it is possible to compute the correlated loads envelopes with little reduction in the accuracy, and also to quantify the effects of aerodynamic and structural uncertainties, with a reduction in simulation time of nearly 95%. Such techniques can be used to perform robust multi-disciplinary design optimisation.

It is hoped that some of the methods developed in the ALPES project will be adopted by industry to help design future environmentally efficient aircraft.

1 J.E.Cooper et al. Aircraft Loads Prediction using Enhanced Simulation. 15th AIAA Dynamics Specialists Conference 2016 AIAA-2016-1571.

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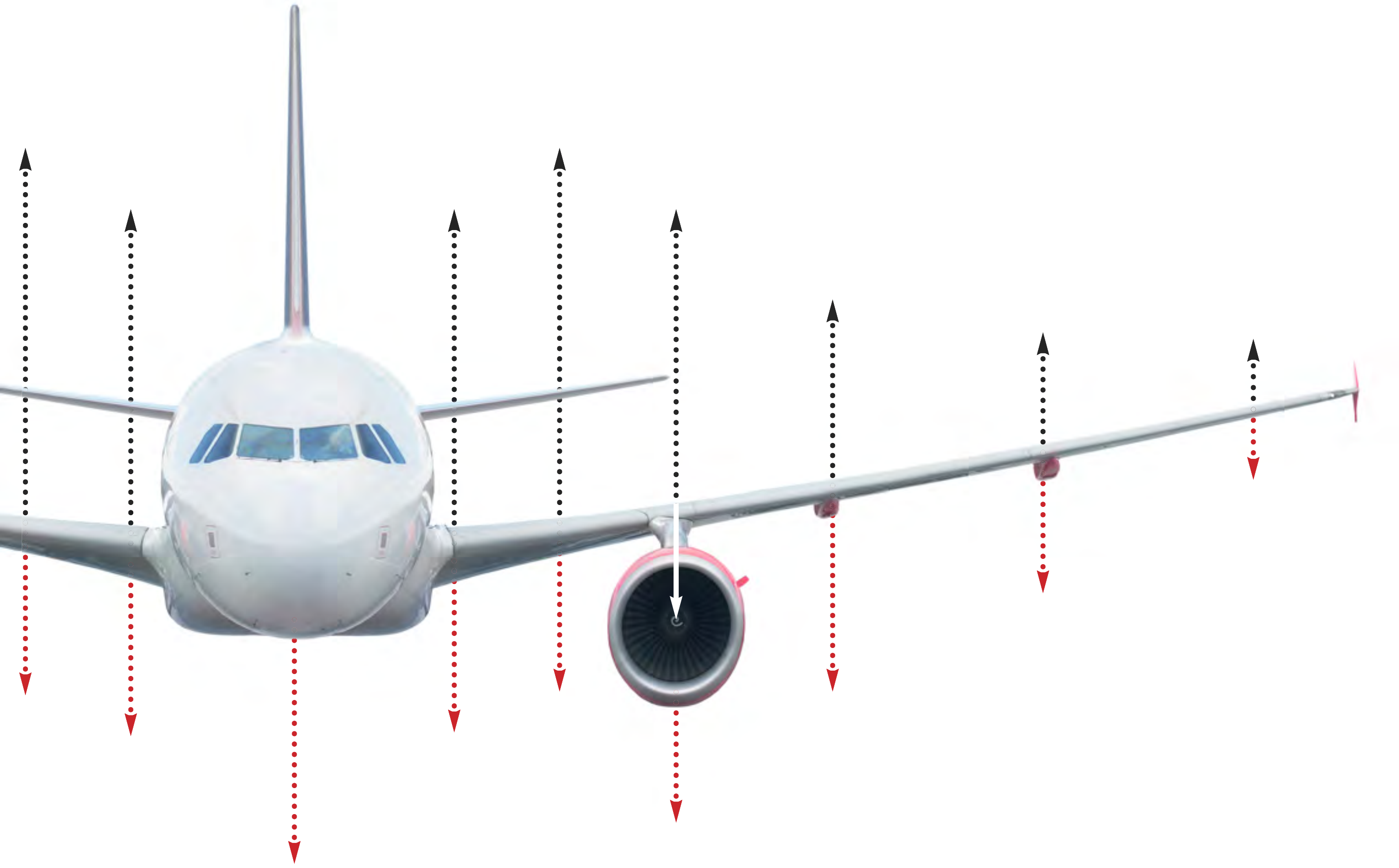
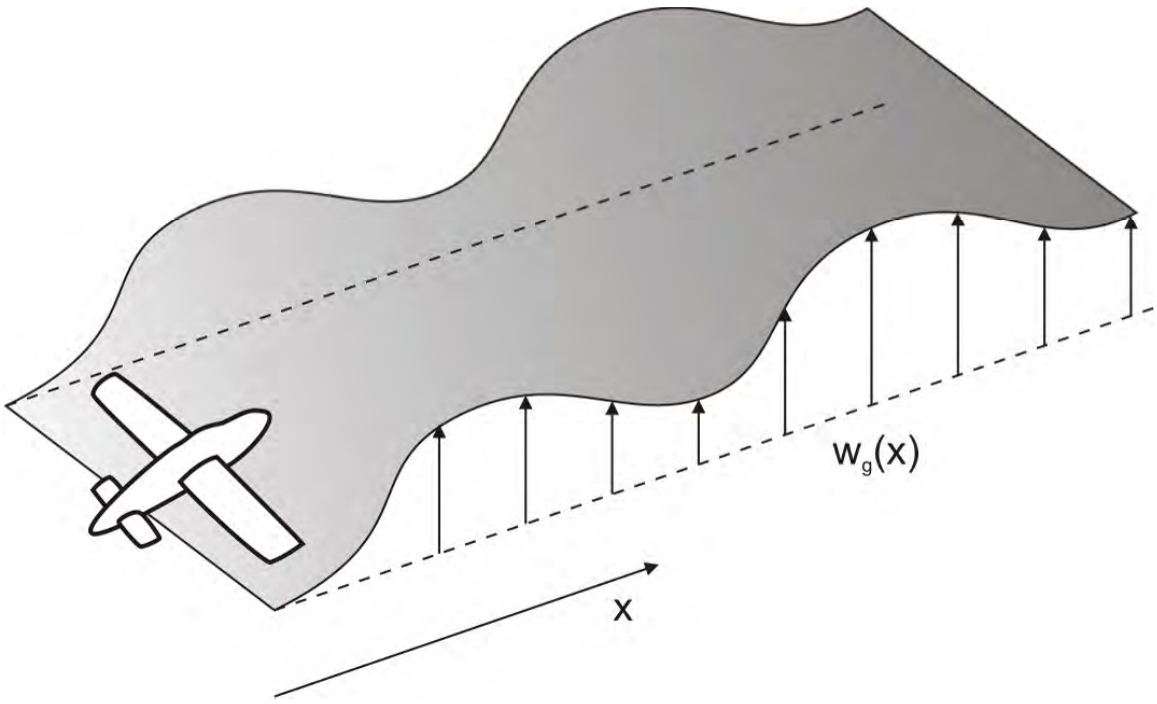
Aerodynamic Lift Distribution



Inertia Distribution



A sustainable transport strategy for Europe

M F Warrender, Open Access Government, highlights EU Commissioner Violeta Bulc's innovative plan to finance sustainable transport and infrastructure projects

February 2017 marked the launch of the European Commission's new and innovative proposal to finance transport and infrastructure projects in Europe. This proposal will seek to combine €1 billion of grants to help achieve the "twin objectives boosting investment to fund innovative, sustainable transport infrastructure upgrades, while supporting jobs needed to put that infrastructure in place."

European Commissioner for Mobility and Transport, Violeta Bulc, commented on the proposal, stating that: "Achieving our vision for seamless, intelligent and sustainable mobility in Europe requires investments that public funds alone cannot provide. That is why we are launching an innovative solution to make the best of our resources, and unlock untapped private investments, with particular focus on Cohesion countries. Today's action is a sign of solidarity on the move."

This investment highlights the importance of transport innovations through Europe, while also supporting the upcoming road mobility initiatives to be launched later this year.

Roads

Road transport provides jobs for 10.6 million people across Europe, and carries more passengers than all other methods of transport combined. The 2017 Road Transport Strategy outlines 4 main initiatives:

- A well-functioning internal market (A more cost-efficient road transport network will make EU firms more competitive globally, thus encouraging job creation).
- Fair competition and workers' rights (Simplifying rules and improving cooperation between member states will ensure better working conditions for transport workers and operators through ensuring enforcement of social rules).
- Decarbonisation (CO_2 emissions from heavy goods vehicles represent around 30% of all road transport emissions. With renewed political momentum following the Paris COP21 agreement, road transport will begin to play its part in fighting climate change. Encouraging new charging solutions, with the possibility of providing additional value-added services will cut costs for businesses and people, while better controlling emissions and optimising the use of energy and infrastructure).
- Digital technologies (Facilitating the use of digital technologies by proposing common standards and platforms will contribute to improving road safety, the enforcement of road transport rules, and ensure digital technologies will be used to their full potential).

Bulc, who has been a European Commissioner since November 2014, commented that "We need the sector to be more competitive and, at the same time, socially and environmentally responsible."

Aviation

Another transport sector that is undergoing immense improvement and renovation is Air; in December 2015 the European Commission launched an Aviation Strategy for Europe, allowing all elements of the aviation ecosystem to come together.

In her speech in January last year, Time for Delivery, Bulc stated firmly that, "A competitive and sustainable air transport sector will allow Europe to maintain its global leadership position benefiting citizens, industry, and driving jobs and growth. In 2015, we outlined an ambitious vision for the aviation sector. In 2016, it is time for delivery."

This aviation strategy aims to contribute directly to the Commission priorities of jobs and growth, digital single market, energy union and the EU as a global actor through a series of proposals:

- An ambitious external aviation policy.
- Tackling limits to growth both in the air and on the ground.
- Maintaining high EU standards.
- Innovation, investments and digital technologies.

These proposals will boost Europe's overall economy, as global air transport over the long term is expected to grow by around 5% annually, until 2030 when there will be 16.9 million flights per year – despite the current economic crisis. The aviation sector also contributes €110 billion to EU GDP, it ensures that remote areas of the Union can stay connected, and benefit from industries such as tourism, which in some regions would be non-existent without aviation. Connectivity is also a core driver for jobs and growth. Innovation is a vital ingredient to maintaining high standards within Europe.

Violeta Bulc

The technology required is provided through the air traffic management research programme SESAR, (the joint initiative between the European Commission, Europe Control and the entire Aviation sector) which aims to modernise infrastructure and raise efficiency by optimising capacity – and so enable these innovations to become a reality.

Overall, the European transport systems are becoming more and more vital every day, and Bulc has recognised this. She said, "I am confident, that – together – with understanding, cooperation and collaboration, we will get to our destination – a Single European Transport Area that serves the needs of people, businesses (big and small) and our planet."

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