Airload Simulation on the Airbus A380

- Testing the Airbus A380's slat and flap control system
- Simulating real airloads
- Multiprocessor system of DS1005 PPC Boards

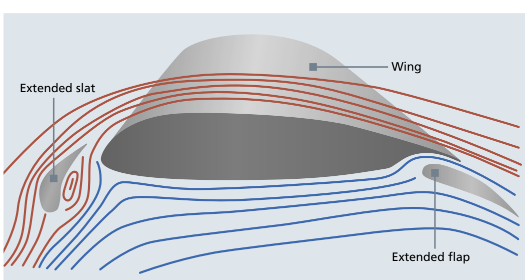
A system of movable slats and flaps enables commercial aircraft to increase the lift acting on their wings as required. This allows them to fly extremely slowly and especially facilitates take-off and landing. The largest passenger aircraft in the world, the Airbus A380, has a particularly complex system of slats and flaps. The Airbus test bench for this "high-lift" system uses a multiprocessor system consisting of DS1005 PPC Boards.

High Lift at Low Speed

A high-lift system consists of deflectable slats at the front of an aircraft wing and flaps at the back. The slats and flaps increase the curvature of the wings, which in turn increases lift. An aircraft with its flaps deployed can fly far more slowly at the same lift, which greatly reduces the length of take-off and landing runs.

The High-Lift Test Bench

The testing facility for the A380's high-lift components is Airbus's largest at its Bremen location. The entire system of slats and flaps, with all their drives, has been constructed in actual size. The control system for the facility was implemented by engineers from Ingenieurgemeinschaft IgH in Essen, Germany, who are experts in developing special test systems. The core task is precise control of the hydraulic and pneumatic cylinders that represent the varying aerodynamic airloads.



▲ *Schematic of the flow profile with deflected slats and flaps. Increasing the curvature also increases lift.*

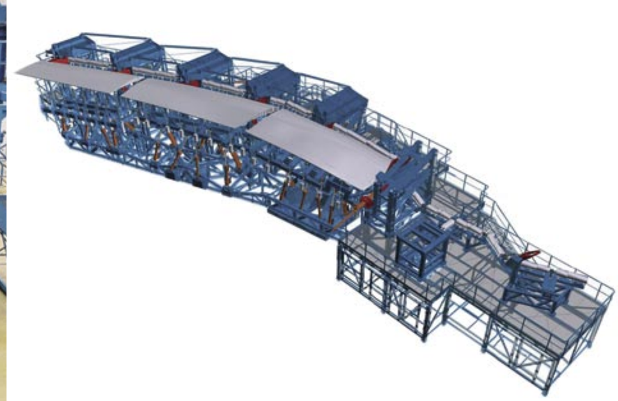
In the slat test facility, a central hydraulic motor (5000 PSI) moves the slats via cardan shafts and drives. To simulate the airloads of a real aircraft, hydraulic cylinders on the drives generate the necessary compressive and tractive forces. The facility can exert forces of up to 600 kN (per wing half) on the slat system. The steel structure of the slat testing facility has dimensions to match: length 60 m, height 3.9 m, depth 4.5 m, weight around 50 tonnes.

▲ *The Airbus A380 during landing: Movable flaps and slaps on the wings increase lift and allow the aircraft to fly extremely slowly.*

The flap test facility also uses original components. A total of 46 pneumatic cylinders are in action, distributed across the surfaces. The facility can exert forces of up to 800 kN (per wing half) on the flap system. Again, the dimensions are impressive: length 34.8 m, height 7.2 m, depth 8 m, and weight around 155 tonnes.

Airload Simulation

In test runs, the flap positions are set by an original control from the actual cockpit of the A380. The flap/slat position determined via proximity switches is used to compute the flight phase and the highly dynamic current load situation that has to be controlled by the control system.



▲ *The high-lift test bench for testing the slat and flap system. The airloads of a real aircraft are simulated by hydraulic cylinders.*

The control system simulates the signal from the cockpit control in long-term trials. To do so, it includes a programmable sequence generator that enables various test cycles to be performed in any desired number of iterations.

> *"We're glad we used dSPACE in conjunction with MATLAB/Simulink. They give us the testing flexibility we need and enable us to adapt to new test scenarios in a minimum of time."*
> *Christian Tillmann, member of Airbus staff in the High Lift Test department (Bremen)*

The airloads are inserted via load value tables. These are provided in comma separated lists and transferred to the running system via a Python script that communicates with the dSPACE Real-Time Library (RTLib).

The Challenge of Complexity

The greatest challenge to implementing the control system is the structural complexity of the system to be controlled. More than 750 digital and analog input and output signals have to be processed, with clock rates of 500 or 1000 Hz. Some of these signals are wired directly, others are transported via PROFIBUS. The PROFIBUS is additionally used to continuously supply all the relevant data to an external logging system and to ensure continuous synchronization. The control system has other tasks to perform apart from simulating airloads:
It also regulates the supply of mineral oil to the test facility and the supply of hydraulic oil (Skydrol) to the drives on the aircraft side. All the functions of the control system are controlled via a graphical user interface that was set up in ControlDesk. The user interface was designed to provide the greatest possible flexibility in testing and give users all the information they need at any time and in a clearly structured form. The entire control system is based on two DS1005 PPC Boards, six DS2003 Multi-Channel A/D Boards, and two DS2001 High-Speed A/D Boards, which have to stand up to continuous operation.

Proven Under Load

The modular dSPACE hardware has proven very successful, as it has been in continuous operation for two years and up to the present moment shown no weaknesses. Developing control functions via MATLAB®/Simulink® has also proven useful. Finally, the competent support given should be emphasized, as it has been a great help, particularly for performing difficult subtasks.

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