A Promising Tool for In-Flight Flow Measurements: - Particle Image Velocimetry -

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Abstract

Nowadays, advanced optical measurement methods for wind tunnel or laboratory applications become more and more sophisticated and relatively easy to employ, even in complex and severe experimental environments. Hence, the European research project *AIM (Advanced In-flight Measurement Techniques)* intended to transfer the present experiences of optical deformation and flow visualisation tools to flight tests in order to measure at real aircraft and flight Reynolds numbers.

A commonly used and very mature flow measurement method for a wide variety of flow phenomena in wind tunnel applications is the Particle Image Velocimetry (PIV). PIV is based on imaging tracer particles (i.e. seeding) which are added to the flow and illuminated two times subsequently by a strong light source i.e. laser. The scattered light of the particles from one observation area is captured by two cameras in a stereoscopic mode. During the evaluation process each pair of the recorded images are cross-correlated in small interrogation windows to determine the local velocity vectors based on the particles displacement. Integrating such a PIV system inside an aircraft will pose several problems which have to be resolved in order to receive the permission to flight and carry out the flight test itself as save and efficient as possible. The main challenges of this particular flight test were the installation of the high energy laser system and the identification of natural aerosols / cloud droplets as seeding for PIV.

Within three flight tests, launched at the German airport Braunschweig-Wolfsburg in 2009, several flap settings, velocities and altitudes (i.e. cloud layers) were flown and PIV recordings have been acquired with the help of the installed PIV system. The size of the observed flow field was approximately 68 x 90 mm² and it was located right behind the aircraft wing (aligned parallel to the fuselage of the aircraft – Figure 1). A highly disturbed flow field was recorded which was mainly influenced by the propeller slipstream, the fuselage boundary layer and the flap downwash (Figure 2).

However, this feasibility study proved the applicability of this optical flow measurement tool for flight testing. In this regard, the main advantages of the PIV technique are its non-intrusive nature as well as the capability of providing information with high spatial resolution of a flow field. This ability ensures the affordable determination of valuable instantaneous velocity vector field data during flight tests, whereas on the other side external probes or intrusive sensors could only enable to obtain discrete single point values of the desired parameters. Nevertheless, a number of significant challenges for the application of in-flight PIV to future flight tests still remain related to the aircraft operation and certification. Hence, further developments and improvements of this in-flight measurement technique will be discussed in the full paper and the presentation for the symposium.

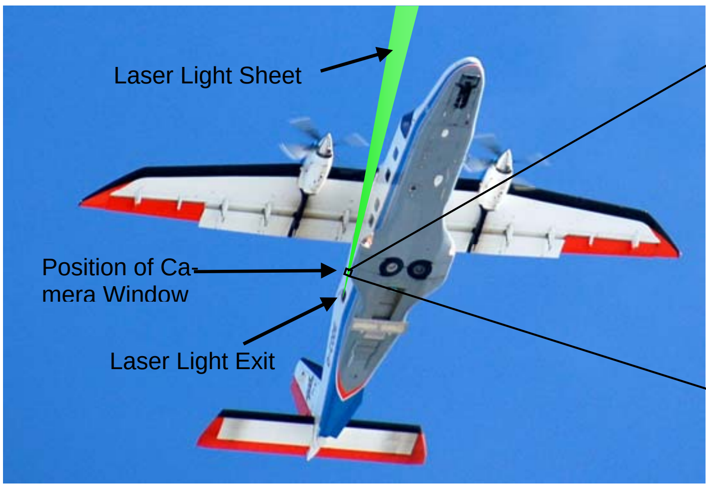

Figure 1: Research aircraft Dornier Do 228 – 101 with sketched laser light sheet during flight

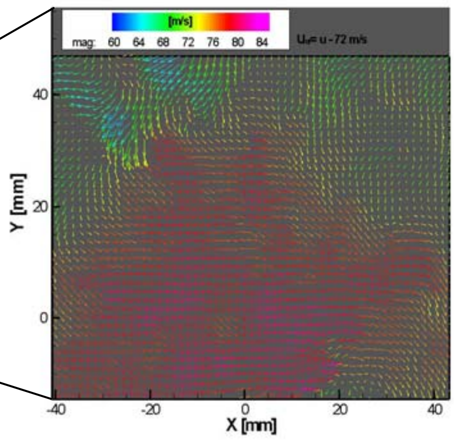

Figure 2: Sample of instantaneous velocity field

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