Chapter 2
AIM: An Introduction to the Project

Fritz Boden

Abstract The European Specific Targeted Research Project (STReP) AIM—Advanced In-Flight Measurement Techniques was launched on the 1st of November 2006 and was finished by the 30th of April 2010. This project intended to make advanced, non-intrusive measurement techniques applicable for time and cost effective industrial flight testing as well as in-flight testing for research. In the AIM consortium, eleven Partners from aircraft industries, airport services and research organisations coming from seven countries were working closely together. AIM was coordinated by DLR in Göttingen. The purpose of the AIM program was to further develop measurement techniques in such a way that they can be routinely applied to flight tests, hence providing comprehensive planar information on various important parameters such as wing and propeller deformation, thermal loads on the structures of helicopters, the surface pressure distribution on a wing, density gradients of strong vortices generated by airplanes and helicopters and velocity flow fields near airplanes and helicopters. The chapter will provide a brief overview on the activities within AIM and the project itself.

2.1 Introduction

At the 1st of November 2006 the European Specific Targeted Research Project (STReP) AIM—Advanced In-Flight Measurement Techniques was launched within the 6th European research framework programme. The goal of the project was to make highly sophisticated optical measurement techniques applicable to industrial flight tests.

Within the AIM consortium, eleven Partners from aircraft industries, airport services and research organisations from seven countries worked closely together.

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Fig. 2.1 The participants of the AIM Kick-Off meeting at Göttingen (from *left* to *right*: 1*st row* L. Girard, K. Kindler, R. Denos, F. Klinge, M. Morkus; 2*nd row* H. Jentink, C. Besson, O. Dieterich, K. Garry, P. Ruzicka, B. Rinkevichyus; 3*rd row* C. Petit, J. Meyer, H. Veerman, Y. Egami, F. Boden, C. Lanari)

These partners were: Piaggio Aero Industries (I), Eurocopter France (F), Eurocopter Deutschland (D), Airbus France (F), DLR (D), ONERA (F), NLR (NL), EVEKTOR (CZ), Flughafen Braunschweig Wolfsburg GmbH (D), Cranfield University (UK), MPEI-Technical University (RUS). AIM was managed by the DLR in Göttingen, where Fritz Boden acted as the coordinator of this STReP. The kick-off meeting took place at Göttingen the 21st and 22nd of November 2006. This meeting was organized by Falk Klinge, the coordinator of the AIM proposal and its initial project phase (see Fig. 2.1).

The project was split into 7 work packages (WP) and further subdivided into several tasks:

- WP0—management activities,
- WP1—wing deformation studies,
- WP2—propeller deformation studies,
- WP3—helicopter studies,
- WP4—surface flow measurements,
- WP5—high lift flow structures,
- WP6—industrial flight testing.

In what follows, the main content of all these work packages is briefly presented.

2.2 WP0: Management Activities

WP0 was the main work package for all project management aspects like the co-ordination of the work package activities, the management of any contractual, financial and administrative issues, as well as the communication with the EC. Furthermore the coordinator provided a communication platform for the partners and an official website. The knowledge gained with AIM concerning these kind of websites was later applied to the website of the follow up project AIM^2, which can be found under "http://aim2.dlr.de". Beside the communication between the partners and the information of the public about the general project results, another important task of WP0 was the exploitation of the results and the dissemination of the gathered knowledge.

2.3 WP1: Wing Deformation Studies

This work package mainly dealt with the in-flight measurement of wing deformation by means of the Image Pattern Correlation Technique (IPCT). DLR and NLR used WP1 to further develop their IPCT methods and to apply them in the scope of research testing on the Fairchild Metro II and on the Piaggio P 180. Whilst the NLR test on the Metro II was mostly for static wing deformation measurements with a one-camera IPCT approach, the DLR test on the P 180 was focused on ground vibration measurements with a stereoscopic IPCT setup. Figure 2.2 shows some pictures of the WP1

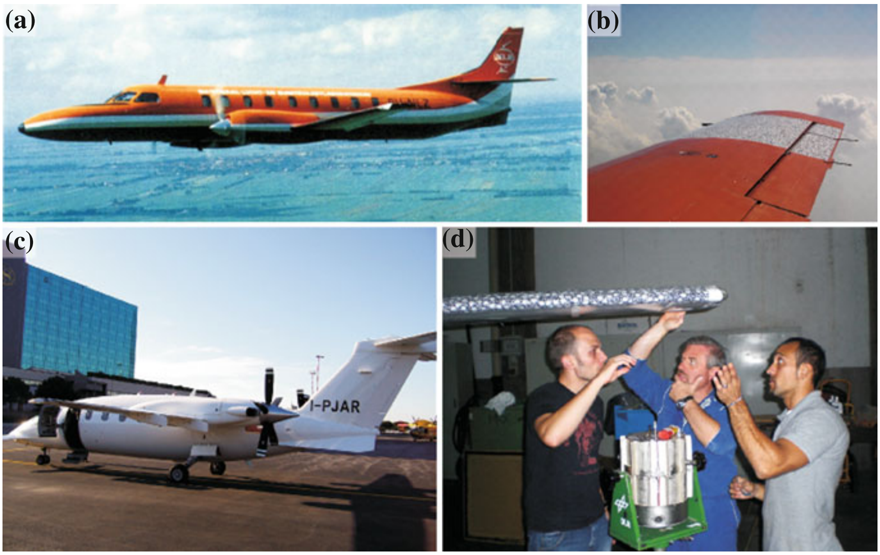

Fig. 2.2 The WP1 test aircraft (**a** NLR's Fairchild Metro II, **b** pattern on Metro II wing during flight, **c** Piaggio's P 180, **d** discussions on the P 180 shaker mounting)

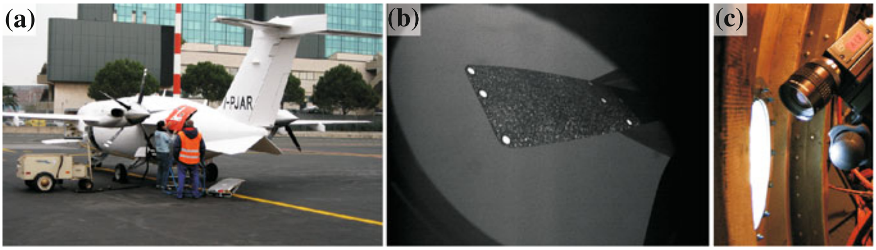

Fig. 2.3 The P 180 shortly before the propeller test flight (**a**), the propeller blade recorded during flight (**b**) and one of the cameras in the luggage compartment (**c**)

tests. Descriptions of both measurement campaigns as well as an assessment in the view of an aircraft manufacturer are presented in the respective chapters of this book.

2.4 WP2: Propeller Deformation Studies

In WP2 Piaggio Aero Industries and the DLR realised measurements of the P 180's propeller blade deformation by means of IPCT and QVT. One of the fast rotating propeller blades was covered with a sprayed dot pattern (see Fig. 2.3b) and observed by two cameras, installed in the luggage compartment and synchronized to the propeller by a special recording system—the videostroboscope. The description of a preliminary CFD study as well as the performed propeller deformation measurements are presented in two chapters of this book. In addition, an assessment of the IPCT for propeller deformation measurements was done by one aircraft manufacturer.

2.5 WP3: Helicopter Studies

The WP3 was the helicopter measurement work package. DLR, Eurocopter Deutschland and ONERA performed extensive research on measurements of:

- the main rotorblade deformation by means of stereo IPCT,
- the blade tip vortex trajectory by means of BOS,
- the flow field around the blade tip by means of PIV and LIDAR (see Fig. 2.4).

The main platforms for the research testing were the Eurocopter EC 135 for the blade deformation measurements and the MBB Bo 105 for the blade tip flow measurements. Both helicopters are located at the DLR in Braunschweig. For the main rotorblade deformation measurements Eurocopter Deutschland also provided their whirl tower in Donauwörth and manufactured a specially painted rotorblade equipped with strain gauges. Detailed descriptions of all these activities can be found in part IV of this book.

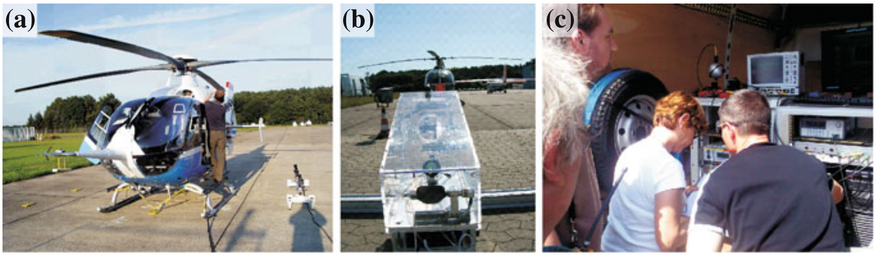

Fig. 2.4 The EC 135 prepared for the IPCT ground test (**a**), the LIDAR sensor aiming at the Bo 105 main rotor (**b**) and the ONERA team at Braunschweig (**c**)

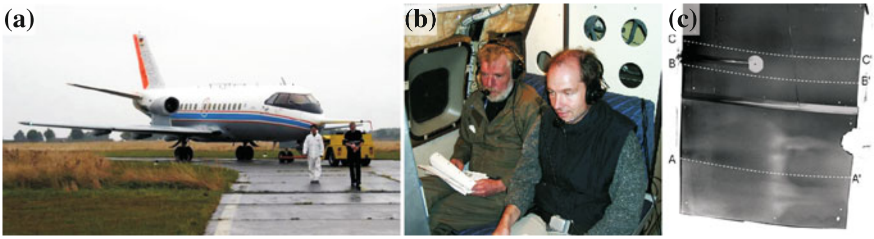

Fig. 2.5 DLR's VFW 614 ATTAS (**a**), scientists during flight test (**b**) and recorded PSP pressure distribution (**c**)

2.6 WP4: Surface Flow Measurements

In work package four the focus was on the in-flight application of PSP to measure the surface pressure distribution (see Fig. 2.5). Therefore, a suitable camera, an appropriate light source and the whole recording equipment were installed in the cabin of the VFW 614 ATTAS owned by DLR. The PSP itself and an electro-luminescence foil (EL foil) were applied to one of the engine pylons of the aircraft. Beside the PSP application also IRT was improved by DLR and Eurocopter France for in-flight temperature measurements. An interesting article about the PSP measurements is presented in Chap. 15.

2.7 WP5: High Lift Flow Structures

The WP5 was the work package with the most challenging tasks, as it intended to use the wind tunnel measurement techniques PIV and BOS in an outdoor environment. There were two areas of application—the ground based measurement of wake vortices of a landing aircraft and the in-flight flow field measurement. The measurement of landing aircraft's wake was prepared by DLR and Flughafen Braunschweig-Wolfsburg using a ground based BOS setup and a large outdoor PIV setup. As such

Fig. 2.6 The test crew after the first in-flight PIV flight (**a**) with droplets clouds as seeding particles (**b**) and pretest of soap bubbles as large scale PIV seeding (**c**)

a PIV setup was never realised outdoors before, first of all several pretests had to be performed. As the pretests caused some major delay, the real measurement of wakes on ground could not be performed during the AIM project.

A more successful outdoor application of PIV was the in-flight flow field measurement performed by DLR and Cranfield University on a Dornier Do 228 (see Fig. 2.6). This was the first time, that a PIV flight test installation was flown. Droplets in clouds were used as seeding particles and the observation area were the fuselage boundary layer and flap downwash. Several chapters dealing with the challenging application of PIV and BOS are included in this book.

2.8 WP6: Industrial Flight Testing

Finally, in WP6 an assessment of all advanced in-flight measurement techniques of the project was made. The most promising techniques IPCT and IRT were applied under real industrial boundary conditions (see Fig. 2.7). On the one hand, IPCT was applied to the P 180 industrial wing deformation measurements as well as on the Airbus A 380, which was quite challenging due to the enormous dimensions of this aircraft. The IRT on the other hand was applied to engine exhaust temperature

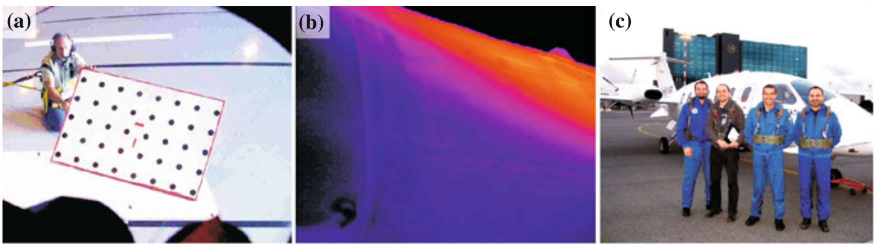

Fig. 2.7 Calibration of the IPCT camera system with a calibration plate on the A 380 wing (**a**), temperature distribution on the Superpuma helicopter engine exhaust measured with IRT (**b**) and happy flight test crew after successful P 180 wing deformation measurements (**c**)

Fig. 2.8 Participants of the AIM final workshop in Göttingen the 27th and 28th of October 2009 (from *left* to *right*: E. Popova, C. Klein, L. Girard, T. Wolf, J. Pons, D. Casella, K. Garry, C. Herbepin, N. Skornykova, M. Weber, C. Politz, F. Boden, P. Girard, R. Rudnik, C. Petit, H. Jentink, N. Lawson, A. Pätzold, R. Denos, J. Meyer, A. Kucaba-Pietal, D. Obst, J. Bakunowicz, M. Valla, M. Sitzmann, B. Stasicki, H. Veerman, T. Kirmse, P. Ruzicka, C. Rosenstock, M. Josefik, I. Micknaus)

measurements on an EC 225 Superpuma Helicopter by Eurocopter SAS in Marignane. Reports of these measurements can be found in the wing deformation measurement section and the helicopter section of this book.

2.9 Conclusion

The AIM project constituted a first step to establish advanced measurement techniques for industrial flight testing. Within the three years and six months of the duration of the project, the AIM consortium consisting of eleven partners—mainly developers of image based measurement techniques at European research organisations and the European aerospace industry as potential user of these optical measurement techniques—prepared the basis for further developments in the field of advanced in-flight measurement techniques by identifying the industrial needs and the research potentials.

All AIM partners devoted themselves to a successful accomplishment of a great number of feasibility studies including full-scale ground and flight tests. In total more than twelve flight and ground test campaigns had been performed by the AIM consortium within the 42 months project duration. There had been in-flight wing deformation measurements on small aircraft, like a Fairchild Metro II and a

Piaggio P 180, using IPCT, ground vibration measurements on the P 180 also using IPCT, QVT/IPCT propeller and rotor deformation measurements on the P 180 and on an EC 135 helicopter, three campaigns on a Bo 105 to measure blade tip vortices using BOS, PIV and LIDAR, temperature distribution measurements with IRT on an EC 225, pressure distribution measurements using PSP and IRT on the VfW 614 ATTAS, the first application of in-flight PIV on a Do 228 and, finally, also a wing deformation measurement campaign on an A 380 using IPCT. After three years of intense research and testing, a public final workshop took place in October 2009 at the DLR site in Göttingen. Over two days, divided into six main sessions, about 50 participants (some of them to be seen in Fig. 2.8) shared their experiences and results of several measurement campaigns. This workshop gave the opportunity to present a synopsis of the main results achieved. It also provided a forum to discuss the needs and possible means of further flight testing activities. The proceedings of the workshop as well as a lot of further background information are compiled as "stand alone chapters" in this book. Therefore, some unavoidable duplications occur and also one additional chapter presented at the workshop with no relation to the project is included.

As AIM presented the possibilities of image based measurement techniques, it also identified major challenges to be coped with before the demonstrated advanced optical measurement techniques will leave the research and development level and become state-of-the-art measurement techniques for industrial use. Therefore, the follow-up project AIM^2 started in November 2010. Whereas AIM proved the principal feasibility of using modern optical wind tunnel measurement techniques for in-flight measurements, AIM^2 focuses on developing reliable and easy to use dedicated measurement systems and on defining design and application rules for these new in-flight measurement techniques. Current information about the project AIM^2 can be found at the project website "http://aim2.dlr.de".