

CASE STUDY

AERMACCHI S.p.A.
Ground and Flight Test Instrumentation
Aerospace Development and Flight Testing

Italy
Aerospace
Transducers

The long history of Aeronautica Macchi parallels the story of man's progress in the field of aviation. Founded in 1913, throughout its existence the company has been a leader in the development of heavier-than-air machines. Now a part of the Finmeccanica Group, today the name of Aermacchi is synonymous with pilot training, and over 1000 jet trainers of two generations are currently in service in sixteen countries, and with tens of thousand of civil and military pilots trained on its aircraft.

The company's relationship with Brüel & Kjær goes back over many years – a wide range of transducers are specified for ground and flight testing of Aermacchi aircraft. In addition, Brüel & Kjær sensors are extensively used in the testing of airframe components and engine nacelles related to Aermacchi's numerous collaboration programs with aerospace companies throughout the world.

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First Flight of AERMACCHI M-346



The Aermacchi M-346 next-generation advanced/lift military trainer flew for the first time on 15th July, 2004. The aircraft took off from Aermacchi's Venegono airfield at 0730 GMT and returned 55 minutes later. The flight was controlled in real-time by Aermacchi's flight test team operating from the company telemetry facilities. The maiden flight pilot was Olinto Ceconello, Aermacchi's Experimental Chief Test Pilot.

Fig. 1

The Aermacchi M-346 took off from the company's Venegono airfield at 0730 GMT on 15th July, 2004

The M-346 was chased by two Aermacchi MB-339CD aircraft, piloted by Capt. Alessandro Sciaburri of the Italian Air Force Flight Test Centre, and by Maurizio Cheli, Alenia Aeronautica's Chief Test Pilot for combat aircraft.



The M-346 integrates technologies, systems and competencies of several Finmeccanica companies. The aircraft exploits features and advanced technologies including a digital fly-by-wire control system, allowing full controllability up to 40° angle of attack. The two Honeywell/Avio F-124 turbofans provide the M-346 with a one-to-one thrust to weight ratio and optimum energy management capabilities.

This first flight sets a milestone in the development effort by the M-346 Integrated Product Team led by Massimo Lucchesini, M-346 Program Director, and marks the beginning of a comprehensive test campaign consisting of 700 flights based on three instrumented aircraft for full flight envelope assessment and for Type Certification.

Pioneers in Aviation

Fig. 2

The MB-339FD is the latest Full Digital (FD) cockpit variant of the classic Aermacchi basic/advanced/lead-in fighter trainer and light attack aircraft. Various MB-339 versions have flown more than 500000 flying hours and are in service with nine airforces throughout the world

Aeronautica Macchi was founded in the northern Italian city of Varese in 1913, only ten years after the Wright Brother's first flight at Kitty Hawk. Throughout its existence, the company has been a pioneer in the aviation industry, developing state-of-the-art technology in aircraft design, development and construction.



Training Aircraft

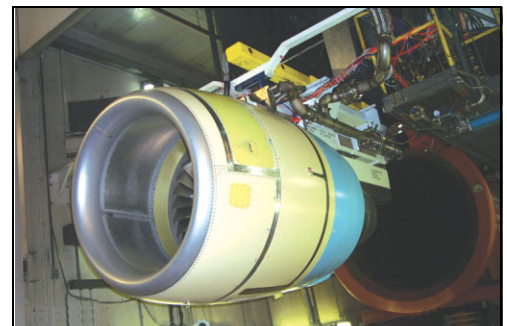
Today, the Aermacchi name is synonymous with a range of advanced training aircraft for military and civilian organisations throughout the world and over 1000 jet trainers of two generations are currently in service in sixteen countries. A high level of flexibility enables the military variants to also be used in operational roles. The advanced fly-by-wire M-346 is Aermacchi's latest aircraft following this tradition of excellence.

Production Facilities

Fig. 3

Aermacchi, teamed with Hurel-Hispano, builds the complete engine nacelle for the General Electric CF34-8 engines installed in Dornier 728 and Embraer 170 aircraft

Aermacchi's production facilities are located in the main plant at Venegono, near Milan where it manufactures its own aircraft, and other joint venture products, sub-assemblies and components for aerospace companies throughout the world. A highly skilled work force, combined with cutting-edge technologies, ensures that Aermacchi remains a leader in its markets.



Engine Nacelles

The manufacture of engine nacelles has become an Aermacchi speciality and five production lines have been established at its Venegono and Latina production plants. This strong commitment stresses Aermacchi's diversification into civil aviation.

In partnership with the French aerospace company, Hurel-Hispano, Aermacchi designs and builds the entire engine nacelle for the General Electric CF34-8 engines for the Dornier 728 and Embraer 170.

For the Pratt & Whitney PW 6000 nacelles for the Airbus A 318, Aermacchi is also responsible for the design, development, manufacture, testing and product support for the nacelle inlet and all related parts.

Aermacchi is also extensively engaged in a number of joint programs with aerospace companies throughout the world. These programs focus on the manufacture of special airframe components and assemblies. Examples include the inlet for the Pratt & Whitney Canada PWC 307 and parts of the thrust reverser for the Rolls-Royce Trent 900, to be installed on the Airbus A380.

Testing Expertise

Fig. 4

From left to right:
Massimo Paolorosso,
Flight Test
Instrumentation
Engineer
Francesco Bojeri,
Executive Manager,
Experimental and
Flight Test
Ermanno Brughera,
Flight Test
Instrumentation
Engineer



Francesco Bojeri is Executive Manager, Experimental and Flight Test. He has worked in testing at Aermacchi for over thirty years and has total responsibility for all testing functions – structural ground testing, flight testing and experimental flight line.

Massimo Paolorosso is a Flight Test Instrumentation Engineer and is in charge of testing instrumentation on engine nacelles and components in Aermacchi's civil programs.

Ermanno Brughera is also a Flight Test Instrumentation Engineer. He has responsibility for flight test instrumentation of Aermacchi's military program including the M-346.

Long Relationship

Fig. 5

Miniature DeltaTron[®]
Accelerometers Types
4507 and 4508 consist
of a ThetaShear[®]
accelerometer and a
DeltaTron preamplifier
in a lightweight
titanium housing with
integrated 10–32 UNF
connectors. Types
4507 C and 4508 C are
similar to the DeltaTron
accelerometers but
come as a charge
version



Aermacchi's relationship with Brüel & Kjær goes back over many years. Ermanno Brughera says, "Our partnership extends to more than just Brüel & Kjær providing the transducers – it includes the provision of technical advice regarding the design and implementation of sound and vibration measurement and analysis of our ground and flight test instrumentation requirements."

Francesco Bojeri adds, "The support we get from Carmine Salzano, Brüel & Kjær's Key Account Manager, Aerospace and Defence, is excellent. His experience is

very valuable – we consider him a member of our team, and involve him in our discussions concerning the suitability of different sensors. We see it as a major advantage to have one overall contact point for noise and vibration applications".

Brüel & Kjær has supplied all the transducers for the ground vibration testing (GVT) that was carried out on the M-346 before its first flight. The order, placed at the beginning of 2004, included 117 Miniature DeltaTron[®] Accelerometers Type 4508 and eight 16-channel DeltaTron[®] Conditioning Amplifiers Type 2694. Brüel & Kjær also supplied all the necessary cables and accessories.

Francesco Bojeri adds, "Type 4508 combines high sensitivity, low mass and small physical dimensions. This makes it ideal for applications such as ground vibration testing (GVT) of airframes using modal analysis techniques to obtain FRFs".

For flight testing, Aermacchi specified a range of Brüel & Kjær transducers including pressure sensors and some twenty miniature Model 7258 triaxial accelerometers, designed specially for flight testing applications. Ermanno Brughera comments, “Model 7258 has good range, high sensitivity and high level output. It is very conveniently powered with 28 VDC which comes straight off the aircraft supply and we can record data without any external conditioning. This one transducer can satisfy many flight test parameters. We are very pleased”.

Each fully instrumented M-346 prototype will be equipped with six Model 7258 transducers.

Flight Testing

Fig. 6
Aermacchi's state-of-the-art flight test telemetry control room. It is located in the control tower at Venegono airfield

Francesco Bojeri says, “We are responsible for the complete flight testing programs of all Aermacchi aircraft. This includes specifying the flight test program, data acquisition, the telemetry, the ground station and post-processing of the huge amount of test data. We use DAT recorders inside the aircraft. Other data is transmitted by telemetry and we have a very powerful data acquisition system with some 800 analog channels”.



“We can also record up to 4000 digital parameters, all simultaneously. We also use video telemetry with four video streams from on-board cameras or from the avionics display system of the aircraft being tested. Test data is recorded both in the aircraft and in the telemetry control room of the ground station. During final testing, some 1500 and 5000 digital parameters must be analysed.”

Ermanno Brughera adds, “Our aim is for real-time analysis of 200 vital parameters and for the computation of all other parameters in real time. The average test flight takes about two hours and the volume of data is immense. It is all archived in an digital data storage database. We are currently working on a project to put the complete flight test instrumentation process, including all flight test configuration details, on an Oracle-based digital database”.

The Test Process

Francesco Bojeri says, “When R&D activities start, we initially study the project and determine what is needed for the development and flight certification. We build up the test matrices, collect information from the specialist engineers, and discuss and agree on the testing methodology. We determine if sensors have to be installed during production if there are areas where sensors are to be located without physical access”.

“As the project develops, the test demands are refined. We determine where each sensor is to be installed. This process takes place for all the different types of testing to be performed on a new design or variant. These include flight testing, mechanical testing, specialist testing and safety.”

The choice of sensor is based on a number of factors including temperature, required sensitivity, measurement range, etc. Calibration of transducers is carried out in Aermacchi's flight test instrumentation laboratory. Some calibration is also made in the Metallurgical Department. Brüel & Kjær calibration systems are widely used.

Each test, either a ground or flight test, is defined in a test request document. The measurement procedure is defined and communicated to the ground staff and test pilot, as appropriate. Following a flight test, the pilot is debriefed by engineering specialists. The acquired test data is placed in a suitable format for examination by a specialist engineer. Final reports are

circulated both electronically and on paper and the test data and report are archived on a central database. A considerable amount of data comparison is made.

Airframes and Engines

Fig. 7

A Pratt & Whitney PW4168 nacelle for the Airbus A330 – Aermacchi not only designs, develops and manufactures the component but also carries out testing and provides product support

Massimo Paolorosso says, “We carry out both ground and flight testing for our engine nacelles during the development and certification phases. We determine the test program in close cooperation with the engine manufacturer. The next stage is to discuss the test plan with the airframe manufacturer and, where required, with the certification authority”.



He continues, “The same process applies to both ground and flight tests. Ground testing includes conventional vibration testing and modal analysis techniques. But it also extends to such aspects as the effects of bird strikes, icing and measurements in a wind tunnel. Our ultimate goal is to specify a full test program for flight test certification. Flight testing is expensive and time-consuming so it is important that we have full agreement with each of the partners to ensure that flight test activity is kept to a minimum but achieves the desired result”.

Aermacchi is in a rather unique situation with the components for engine nacelles for the Airbus A380. It is working with both the A380’s available engine options (Rolls-Royce Trent 900 and General Electric/Pratt & Whitney GP 7200), carrying out the design and production of the thrust reverser and fixed fan duct for Hurel-Hispano.

Brüel & Kjær is the major supplier of transducers for engine nacelle ground and flight testing. Typically specified are Piezoresistive Pressure Transducers Models 8511 and 8530, Charge Amplifier Model 2680 and Piezoelectric Accelerometers Models 2225 and 2248. Aermacchi also makes noise tests and uses Brüel & Kjær microphones.

Francesco Bojeri concludes, “For flight testing, Brüel & Kjær is our reference supplier. Their sensor solutions are world-class and they cover all areas of noise and vibration measurement”.

Key Facts

- The Aermacchi name is synonymous with a range of training aircraft (from basic to advanced) for military and civilian organisations throughout the world
- The highly advanced fly-by-wire M-346 is Aermacchi’s latest aircraft
- The manufacture of engine nacelles has become an Aermacchi speciality
- “Our partnership extends to more than just Brüel & Kjær providing the transducers – it includes the provision of technical advice regarding the design and implementation of sound and vibration measurement and analysis in our ground and flight test instrumentation requirements”
- “We see it as a major advantage to have one overall contact point for noise and vibration applications”
- “For flight testing, Brüel & Kjær is our reference supplier. Their sensor solutions are world-class and they cover all areas of noise and vibration measurement”

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