CASE STUDY

Brüel & Kjær
BEYOND MEASURE

# EXTERIOR NOISE CERTIFICATION OF THE AIRBUS A330 MRTT

The military version of Airbus's A330 needs to use civilian airports, where noise restrictions apply. After converting it into the military A330 MRTT, aerodynamic changes required new measurements of noise at approach to update the noise certification. With the support of Brüel & Kjær, Spain's INTA conducted the measurements and analysis required.

## CHALLENGE

Perform noise certification measurements on the Airbus A330 MRTT, capturing highly accurate data the first time and processing it for noise certification

## SOLUTION

With the assistance of Brüel & Kjær's staff, PULSE data acquisition and analysis systems, and microphones, INTA successfully gathered and processed the data

## RESULTS

Successful noise certification, giving clear guidelines for the maximum take-off weight for certain noise levels, with minimal wasted capacity due to the margin for error

*The Morón de la Frontera military base where the tests took place*

## BACKGROUND

The A330 is a civil aircraft acoustically certified according to JAR36. The variant for military use, the A330 MRTT (Multi-Role Transport Tanker) developed by Airbus Military Spain (AIM), has been very well accepted in the aerospace industry. One of the main reasons for its success is that it can operate in civil airports, a feature that is extremely important, for example, for international human aid operations.

The aerodynamic modifications from the basic A330 into the A330 MRTT aircraft were important enough to need new noise certification. Any new noise source caused by the aerodynamic modifications would probably be perceived on the ground during an approach as it would not be masked by the much lower engine noise. Therefore, the approach phase was the main issue for the A330 MRTT certification.

Airbus selected the National Institute of Aerospace Technology (INTA) to perform the noise certification.
Pascual Rodriguez, Head of Performance at AIM explains, "We knew the noise measurement capabilities of INTA so we asked if they could work together for the approach flight certification." Gonzalo Mosquera, Propulsion Manager at INTA says, "Acting as a technical advisor and providing services to public and technological companies are key activities for INTA, so it was natural that we accepted this difficult job." Jose Luis Navarro, Lab Manager at INTA adds, "We have the right background, the right people and the right instrumentation, so we felt that we were ready for this new responsibility."

INTA conducted the certification measurements, under the observation of the European Aviation Safety Agency (EASA).

## CHALLENGE

Noise certification is a measurement and calculation process in which you have to

### INTA

The National Institute of Aerospace Technology (INTA) is a public research body, a non-profit organization specializing in aeronautic and space research and technological development. The institute is located in Torrejón de Ardoz, Madrid, and provides technical assessment to administration authorities in the aerospace field. Its activities include R&D activities of defence interest, R&D activities in the civilian sector, and activities such as testing, experimentation, certifying and technical assistance.

INTA has an environmental laboratory LIMA (Laboratorio de Impacto Ambiental). The INTA-LIMA engineers are renowned for their background in aero- and vibroacoustics and INTA's laboratory has its own quality management system covering both procedures and calibration according to ISO 70354.

*Brüel & Kjær's PULSE data acquisition and analysis hardware platform*

determine three Effective Perceived Noise Level (EPNL) values corresponding to the approach, take-off and flyover operations. This is then converted into a Maximum Take-off Weight-EPNL curve, which operators of the aircraft follow in order to ensure they stay within the noise limits of the airport.

**Measurement accuracy = money**
Noise certification measurements result in the maximum weight an aircraft can take, while remaining within set noise level limits. To ensure the plane remains within the noise limits, a small confidence margin is added – to offset any possible measurement errors. Since confidence margins are directly related to the measurement quality, accuracy is of paramount importance.

**Short time in the restricted runway zone**
Noise certification measurements are not a simple task. EASA requires periodic electrical noise checks on each measuring channel during measurement. But access to the area where the microphones are located is restricted and only available for a few minutes. Special permission is required to access the measuring zone, more than 200 m away from the PULSE system. The microphones are then replaced by equivalent capacitors in order to inject an electrical noise signal to the microphone preamplifier.

*INTA-LIMA Aeroacoustic Engineer Eduardo Mezquida*

**Right the first time during expensive flight tests**
Repeated flight approach operations are expensive due to fuel costs. Also, a high number of people are involved during a practical test session. Therefore, reducing measuring time is imperative in order to lower the testing costs. The only way to fulfill this essential requirement is to perfectly coordinate all the people involved and to make sure that the instrumentation records all the tests at the first run.

**Detailed flight test measurements**
During an approach test, several measurements need to be performed. All data must be registered as a function of UTC+2 provided through GPS clocks. Time label precision is expected to be better than milliseconds. The main parameters are aircraft position (measured by a GPS system) and flight parameters (airborne recordings). The aircraft trajectory, measured through a GPS system, and the aircraft parameters, recorded by the airborne installation, are then processed by the AIM flight test department.

The following values are extracted – UTC time, position X, Y and Z, glide path angle, calibrated airspeed, GPS ground speed, weight and engine power setting. Coordinates are expressed in the same reference system as the one used for defining the flight path.

All parameters relative to reference flight path were provided by the performance department from EADS. For flyover before cut-back and sideline, reference flight path is defined by points associated to timescale. For flyover after cutback, engine correction curve for sideline noise and approach, reference flight path is defined by a section of a straight line which pass with a given slope (–3°) in a given point (x = 2000 m, y = 0, z = 121.2 m) at a given Vc airspeed.

## SOLUTION

INTA's laboratory developed and integrated a complete noise measuring test plan for the AIM MRTT noise flight campaign, in accordance with the approach method in International Civil Aviation Organization (ICAO) Annex 16.


*Dr. María Concepción Parrondo and Dr. José Antonio Adame, from INTA preparing the Vaisala Digicora sounding system and meteorological balloon*

Aeroacoustic engineers at INTA's LIMA, Eduardo Mezquida, and Ernesto Ibáñez studied ICAO's Annex 16 in detail and using it as background came up with a number of measurement requirements. Miriam Parra, the PULSE operator at INTA's laboratory built a PULSE project with the assistance of Brüel & Kjær. In order to check the project and procedures, and to fine-tune the general coordination, a number of real preliminary test sessions were done at the Airbus site at Getafe (Madrid, Spain), using different aircraft.

**Pre-flight test equipment validation**

INTA owns a multitude of Brüel & Kjær products including a 30-channel PULSE system and a 6-channel LAN-XI system, sound level meters, acoustic calibrators, reference sound sources, acoustic analyzers, acoustic impedance measuring systems, ISO sound power systems, sound intensity probes and calibrators, multi-channel analyzers and GPS time generators.

One of the first steps was to check whether Brüel & Kjær's PULSE data acquisition and analysis platform fulfilled the comprehensive demands of ICAO's Annex 16. All tests were performed at Brüel & Kjær headquarters in

**Meteorological impact on noise**

INTA provided the following data – temperature, relative humidity, pressure and wind direction and speed. They were measured and recorded at three different locations:

- 10m above the ground near the mobile laboratory
- At ground level, on the house lab
- Meteorological balloon position

Dr María Concepción Parrondo and Dr José Antonio Adame, research scientists from the Atmospheric Research and Instrumentation Branch at INTA were in charge of the vertical profiles of temperature, pressure, humidity and winds using a Vaisala Digicora sounding system. The radiosonde is attached to a meteorological balloon inflated with helium to provide data from the ground up to 12 km with a vertical resolution of about 10 m. An initial profile was performed to ensure that measurements were done according to ICAO Annex 16 (data valid within the ±30 minutes time interval around the time of launch).

Temperature and relative humidity were interpolated every 20 m (in height) in the radio soundings for the time of the test flights.

The absorption in dB/100 m for the 8000 Hz 1/3-octave band was calculated for each altitude data according with ICAO Annex 16.

The absorption in dB/100 m for the 3150 Hz 1/3-octave band was calculated every 20 m as well as the difference in absorption along the noise propagation with the absorption at a height of 10 m.

A special application calculates the sound attenuation above the ground by means of the temperature and relative humidity corrected values obtained from the ground meteorological station and meteorological balloons. It also defines the processing to be applied to the noise measurements – homogeneous or layered atmosphere.

Denmark in the presence of AIM, INTA and EASA authorities. As Eduardo Mezquida says, "The certification process requires not only measurements and calculations, but also the elaboration of very detailed and comprehensive documentation describing all the steps for the measuring and calculation process – from the microphone frequency response to the final noise index result. Brüel & Kjær was capable of providing this information and explaining all processes inside PULSE." As a result, PULSE became a valid system for aircraft noise certification, complying to the technical standards of ICAO Annex 16, Volume 1, Fourth Edition, Appendix 2.

**Special software**

The INTA and EADS teams designed computer software to assess noise emissions index for noise certification purposes, namely Effective Perceived Noise Level (EPNL). This program complies with ICAO Annex 16 Environmental Protection, Volume 1: Aircraft Noise, 4th Edition (2005), and follows the indications given on ICAO document 9501 3rd Edition: Environmental Technical Manual on the Use of Procedures in the Noise certification of Aircraft.

There are two methods to compute the EPNL in the reference conditions:

- The 'simplified' transposition method
- The 'integrated' transposition method

The first was selected for the calculation. Two corrections are determined using this simplified method:

$\Delta 1$: The level correction established on the basis of propagation and attenuation differences.
$\Delta 2$: The duration correction due to the differences in flight paths and speeds.
The effective reference noise level for noise certification is equal to:
EPNL = EPNL measured + $\Delta 1$ + $\Delta 2$

**Flight test**

Once all details were tested and validated, both the system and the team were ready for the actual measurements which took place at the military NATO airbase of Morón de la Frontera, in Seville (Spain). INTA transported a mobile laboratory to the airbase. INTA has a mobile laboratory for making measurements in the field and a workshop for maintenance and construction of small parts and mock-ups.

Brüel & Kjær engineers Flemming Larsen, Flemming Nielsen and Mario Menéndez attended the tests and helped INTA and EADS during operations. They also acted as advisors, helping INTA by answering many technical questions from EASA during the tests.

With the PULSE system you can listen to the microphone signals coming from the microphones either in real-time or after the measurements are completed. This is very useful for diagnosing strange shapes in the spectra, for example crickets, and avoiding the rejection of valid measurements.

Portable, battery-operated PULSE front-ends including generators were used to generate the electrical noise as quickly as possible, so the operator could leave the zone as quickly as possible. Ernesto Ibáñez says, "One of the reasons to choose Brüel & Kjær for this complex test is the extreme flexibility of the

*The microphones located in the restricted access measuring zone*

*INTA-LIMA Aeroacoustic Engineer Ernesto Ibáñez*

From a total of 33 approach flights, four were not valid due to large deviations from the expected path.

**Data recording and preparation**
Brüel & Kjær's PULSE system recorded the complete raw acoustic signals and, at the same time, processed a 3D spectrum (1/3-octave) of each run with a 0.5 second time interval in real-time. The raw signal recordings are kept in digital format for later verification, re-analysis, audio playback, identification of extraneous noises, etc.

The data was transferred to the noise calculation software to compute noise levels, corrections to the reference conditions and the certification noise levels. Taking into account noise recording starting time, flight path data, aircraft parameters and meteorological conditions, the files are then cropped in order to select the data for each flight test run.

PULSE system. In addition to an Acoustic Calibrator Type 4231, we also borrowed additional portable PULSE units from Brüel & Kjær to generate electrical noise signals for in situ verifications.

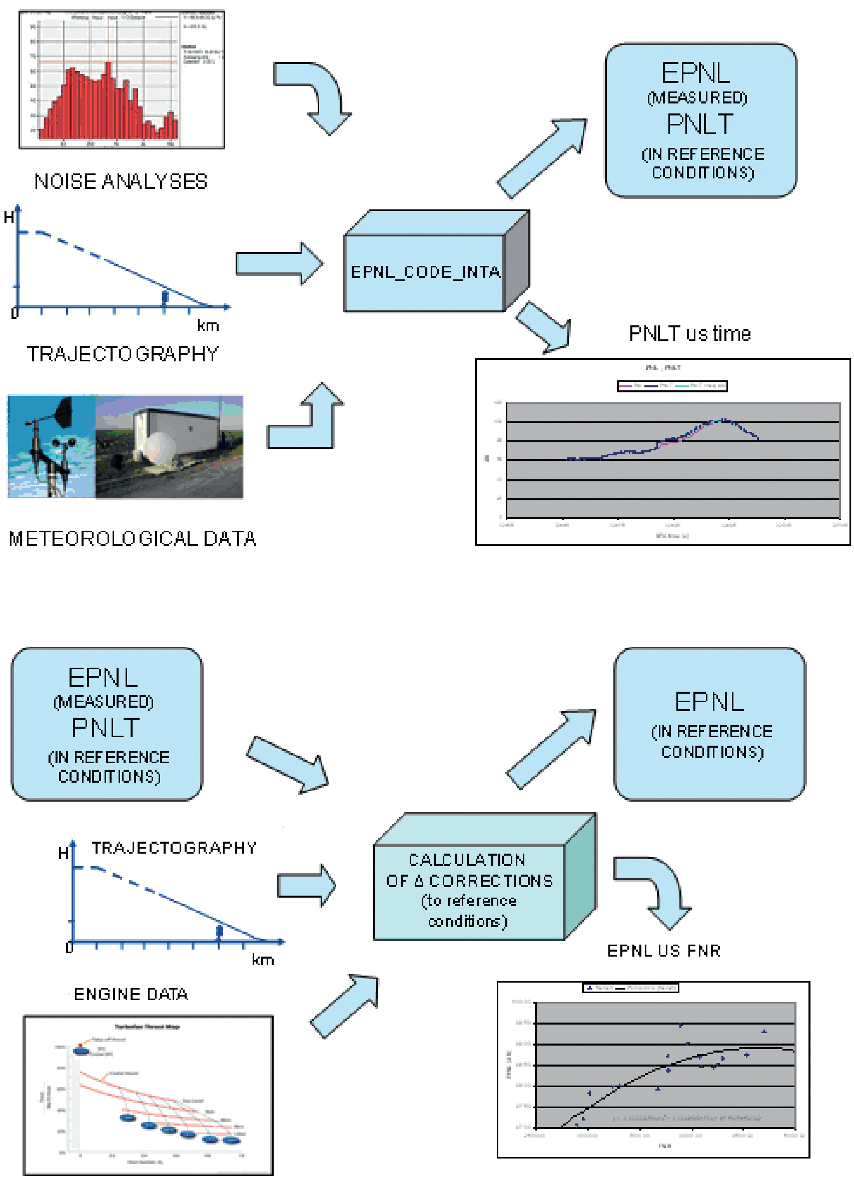
## RESULTS

**Flight test data capture**
The PULSE system accurately recorded and analysed 33 flight test runs. Each run was recorded and analysed simultaneously. Immediately after the flight pass, the acoustic data was inspected together with meteorological and trajectory data.

Ernesto Ibáñez says, "EASA authorities require continuous pink noise and acoustic calibration checks of all acoustic channels. In order to take into account the long extension cables, this task has to be performed at the far away microphone locations during the short time periods available between the flight passes. The portable PULSE unit, with its internal generator, is very light and easy to transport and works with internal batteries, making it very practical for this application." He adds, "We had just a few minutes to do these tests between the flight passes, and the assistance of Brüel & Kjær staff was vital for us."

This validation process took only four minutes. Taking into account that the plane needed seven minutes to turn back and be ready for another run, there were still three minutes left to prepare and activate the system for the next measurement.

*INTA's PULSE operator Miriam Parra*




*A330 MRTT noise certification level results from different approach configurations (different net thrust) and the noise level situation for different landing weights according to the ICAO Chapter 4 noise certification limits*

The recorded data was of such high quality that the team was able to provide the first EPNL estimates a few days after the measurements. After the measuring campaign, there were several meetings with EASA to validate the calculations and results. Some weeks later, INTA and AIM issued the complete test documentation and the A330 MRTT EASA administrative certification process started.

**Accurate noise certification level results**
The noise certification process was carried out by Airbus Military. Given the high resemblance between MRTT and the standard A330, Airbus contributed material from the A330 civil certification to give a base to AIM and to keep the coherence between the documentation of both aircraft. To obtain the certification from EASA authorities, AIM calculated the noise approach from INTA EPNL. For lateral and flyover noise, the main noise source comes from the engines and not from the aircraft aerodynamics, so AIM elaborated the new flight paths according to the MRTT performances, and Airbus transposed the A330's data into the A330-MRTT.

For the approach part, obtaining the levels was a matter of gathering the INTA acoustic and meteorological information, the AIM aircraft position and flight test data and to build the FNR-EPNL curve following a statistical method. This was then converted into a Maximum Take-off Weight-EPNL. The confidence margins of the constructed curve were very low, thanks to the accurate measurements.

There was also a lot of additional work to obtain EASA approval for both the measurement hardware and software employed.

Finally, the following information was sent to EASA by AIM in order to get the approval – detailed documentation for the test means used, flight test program flown, calculation assumptions documentation, measurements recorded and post-processed and methods used to obtain the final noise levels for approach, lateral and flyover conditions.

EASA studied all the information thoroughly. After a round of questions and answers, the process continued and a positive answer was received some time later.

INTA fulfilled the demands of both EASA (European Aviation Safety Agency) and the International Civil Aviation Organization's Annex 16 Environmental Protection, Volume 1: Aircraft Noise, 4th Edition (2005).

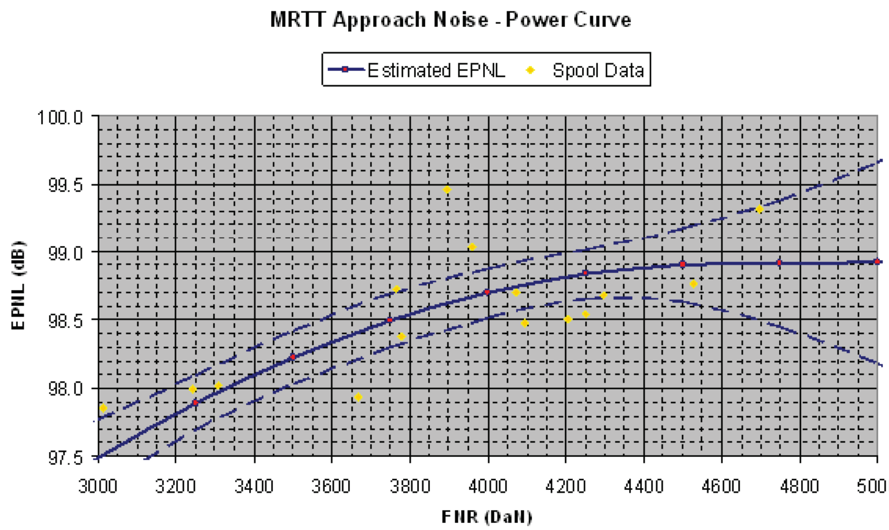
## CONCLUSION
The combination of advance preparation, good coordination and the use of reliable and stable instrumentation was a key factor for a successful and efficient measuring campaign.

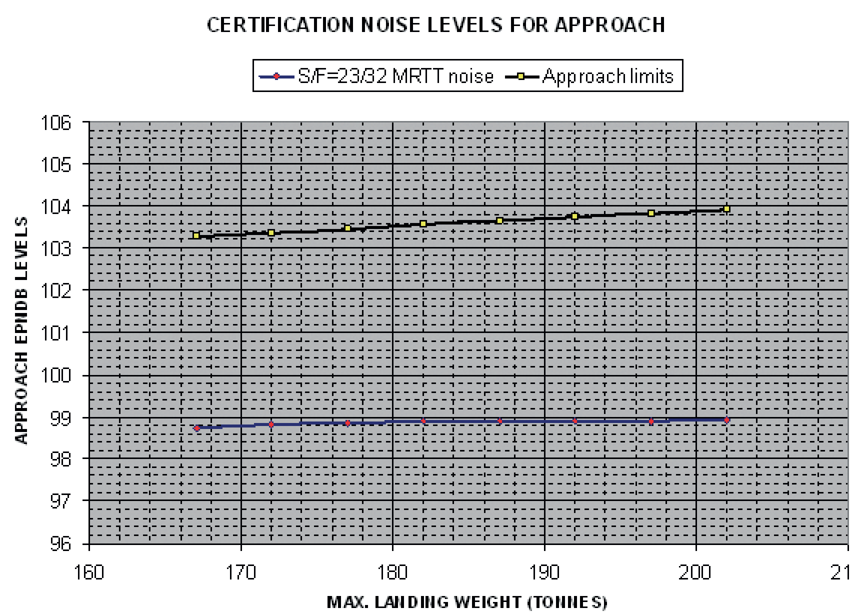
Ernesto Ibáñez, one of the INTA-LIMA aeroacoustic engineers says, "We knew it was going to be a long and complex process requiring a lot of initial tests and support. We have been working with Brüel & Kjær long enough to know that they not only sell great quality instruments but also provide first-class local support and fully understand our needs. The deep technical knowledge possessed by Brüel & Kjær and their continuous assessment were very important during the certification process."

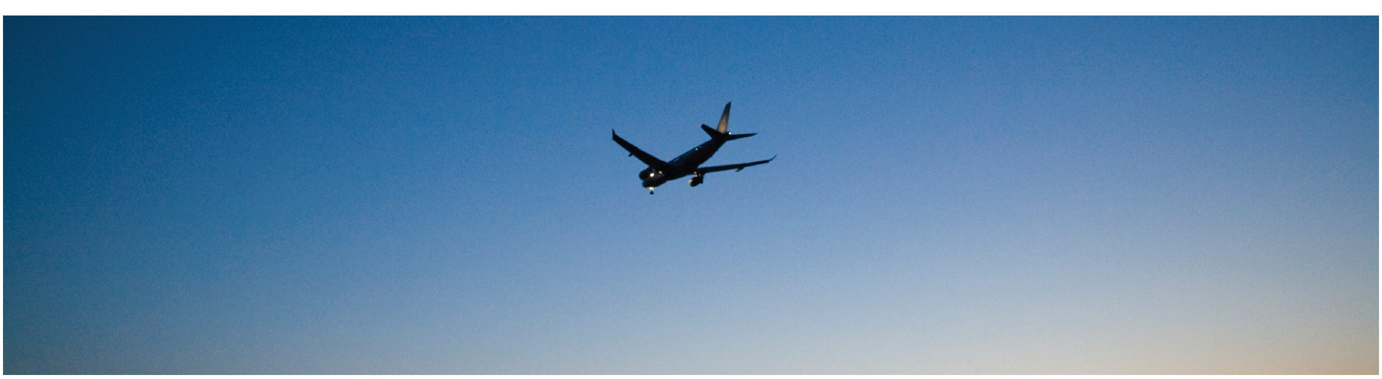
Pascual Rodriguez, Head of Performance at Airbus Military says, "Brüel & Kjær's assistance during measurements saved our skin at very critical moments, for example, when EASA authorities required us to perform some complex instrumentation verifications."

As Eduardo Mezquida says, "Brüel & Kjær's microphones, preamplifiers and the very long extension cables were perfect and stable during the measurements. We didn't have any downtime due to malfunctions or technical problems and this allowed us to focus entirely on the measuring process."

The A330 MRTT aircraft is now one more successful AIM aircraft fulfilling the CS-36 civil certification rules. Now the MRTT not only has the capabilities of a military aircraft, but also the potential to operate in civil airports in peacetime roles.



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BG 1910 – 11 2012-08

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