

# CASE STUDY

Denmark

Aerospace

## Terma A/S, Ørsted DTU, Engineering College of Århus Investigating Active Noise Reduction

PULSE, HATS, Transducers

*Terma A/S, Ørsted DTU (Technical University of Denmark) and the Engineering College of Århus (ECA) have started a joint research project in the field of active noise reduction. Terma specialises in the development and production of systems for Electronic Warfare Integration and Control, Tactical Reconnaissance, and Environmental Surveillance.*

*Brüel & Kjær's PULSE™ multi-analyzer platform and HATS (Head and Torso Simulator) were chosen to determine noise inside the pilot's helmet and in the cockpit.*



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## Terma A/S

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Terma A/S is the leading defence contractor in Denmark with a host of related applications, including:

- Army air defence
- Naval command and control
- Airborne electronic warfare
- Airborne tactical reconnaissance
- Aerial surveillance
- Ground-based communication, and many more

Terma is also a main partner in a number of aerospace co-production programs and has been involved in a large number of onboard systems for the F-16 aircraft.

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## HATS and PULSE Take to the Air

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*Fig. 1  
HATS, complete  
with its customised  
"bone-dome", is  
installed in the rear  
seat of the F-16*



With a Brüel & Kjær PULSE system and Head and Torso Simulator (HATS) strapped into the rear seat of an F-16/B, the goal of this airborne mission was to measure the noise that an F-16 pilot is exposed to during typical flight scenarios, and to determine the noise reduction provided by his helmet. Terma A/S, together with Ørsted DTU (Technical University of Denmark), and the Engineering College of Århus (ECA) have started a joint research project in the field of active noise reduction.

Terma is involved in designing the next generation of pilot helmets, also referred to as Joint Helmet Mounted Cuing Systems, including 3D-Audio.

Existing helmets provide insufficient low-frequency attenuation, exposing pilots to a low-frequency, residual sound pressure, which typically totals 85 dB(A). Therefore, in order to improve the pilot's situational awareness, there is a demand for additional noise countermeasures.

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## Total Solution

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*Fig. 2  
The test setup  
comprising HATS,  
PULSE Multi-  
analyzer and  
SONY® DAT  
recorder*



Senior Research Engineer Torsten H. Leth Elmkjær is in charge of the project. To make his measurement, he chose a PULSE system to test sound inside the helmet ear-cups and in the cockpit. His choice of setup was an interesting one that probably not been tried before. It consisted of PULSE operating on standard Notebook PC but with solid state hard drives and flash memory cards for ruggedness. In fact, apart from a SONY® DAT recorder to be used as back-up, all the equipment was provided by Brüel & Kjær – HATS Type 4128 C, PULSE Type 3560 C (6/1-channel Input/Output Module Type 3032 A and LAN Interface Module Type 7533), and four external Pressure-field ½-inch Microphones Type 4192 L.

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## Fully Prepared

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After choosing the equipment, the next step was to design and manufacture a dedicated frame for the rear seat equipment. It was decided to implement a frame that could use the existing torso harness. The HATS was then provided with a genuine, tailor-made helmet. Flying helmets are always made to fit the individual for personal convenience and to provide optimal noise reduction. Fitted out with its own F-16 helmet including oxygen mask, and with the setup already decided upon, the HATS was ready for take-off.

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## Testing Before Take-off

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But before putting HATS into the air, Torsten decided to make a few test-runs on the ground as there would only be one opportunity to make valid measurements in the F-16. So, strapping the Brüel & Kjær system into his car, Torsten took advantage of his journeys driving to work by making practice measurements with the car radio or an alternative noise source – there were strange glances from bemused drivers!

During preparation for the flight, a number of pilots, both current and former, among Terma staff were asked to suggest possible noise sources. These were accordingly identified as:

- Engine – some dependency on the engine load is observed (10%)
- Environmental Control System (ECS) (70%)
- Oxygen mask – It is especially annoying to listen to the cockpit partner breathing. The noise is narrow banded. The noise level is dependent on possible pollution of the system leading to extra breathing (10%)
- Air noise – the noise due to air resistance will be heavily dependent on the velocity, altitude and the load of the aircraft (10%)

The percentage figures are, of course, subjective figures and the oxygen mask breathing problem could obviously not be verified by the HATS. The pilots were also asked to identify flight conditions that might lead to variations of the noise contributions listed above.

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## Flying High

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With the setup tried and tested, Torsten and two colleagues from Terma travelled to Skrydstrup Airbase in southern Jutland where they configured the F-16 with the microphones, PULSE and HATS. Before installation in the cockpit, the positions of the external microphones had to be determined. To do this, various positions of a 4192 L microphone were examined while the F-16 was on ground but with the environmental control system switched on. The noise scenarios for these positions were then stored by means of Time Capture Software Type 7705.

Torsten explains, “One of the main advantages of the PULSE system is the easy inspection of important signal characteristics in real-time”. He continues, “Because of this the noise picture could be identified quickly”.

The microphones were placed strategically in the cockpit – two within the HATS, two outside the helmet by the ear positions, one by the air-conditioning nozzle, and one placed 80 cm (31.5 inches) in front of the co-pilot position. The equipment was fixed to the home-made frame that, in turn, was carefully strapped to the rear seat using the torso harness. During the 70-minute flight, PULSE stored data on the Notebook PC using Data Recorder Type 7701.

**Fig. 3**  
Captain Casper B. Nielsen of the Danish Tactical Air Command checks that the HATS harness is securely fastened



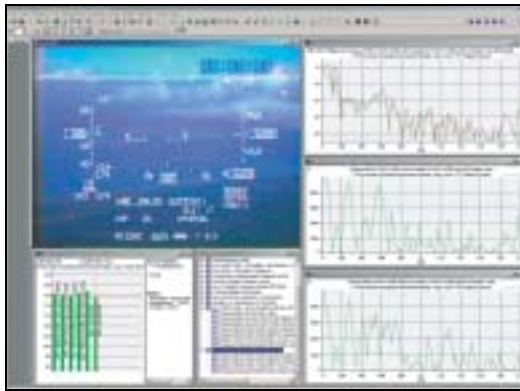
The flight took place over the North Sea and the flying manoeuvres carried out had been prearranged with the pilot, Captain Casper B. Nielsen of the Danish Tactical Air Command. A video of the flight, including the pilot's voice commands, was made and played simultaneously during post-processing, making it easy to synchronize the test points with the data recordings.

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## Future Plans

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**Fig. 4**  
The vast amount of data collected during the flight is being processed by Terma using PULSE software



The test was a success. The equipment survived the 3g manoeuvres, and no noticeable change was observed in the microphones' calibration measurement. The loudest sound source was confirmed as the air-conditioning nozzle, and the sound pressure level in the cockpit often exceeded 120 dB. The huge amount of data is being processed by Terma using PULSE software. This data provides Terma with information that can be used for further research into the noise reduction provided by their ANR solution for pilot helmets.

There are already plans for similar measurements on other aircraft including helicopters.

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## Key Facts

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- Terma A/S is the leading defence contractor in Denmark
- The company has been involved in a large number of onboard systems for the F-16 aircraft
- Terma A/S is involved in designing the next generation of pilot helmets
- Terma A/S, Ørsted DTU (Technical University of Denmark) and the Engineering College of Århus (ECA) have started a joint research project in the field of active noise reduction
- Brüel & Kjær's PULSE multi-analyzer platform and HATS (Head and Torso Simulator) were chosen to determine noise inside the pilot's helmet and in the cockpit
- Brüel & Kjær supplied the complete test system
- "One of the main advantages of the PULSE system is the easy inspection of important signal characteristics in real-time"
- The huge amount of stored data is being processed by Terma using PULSE software