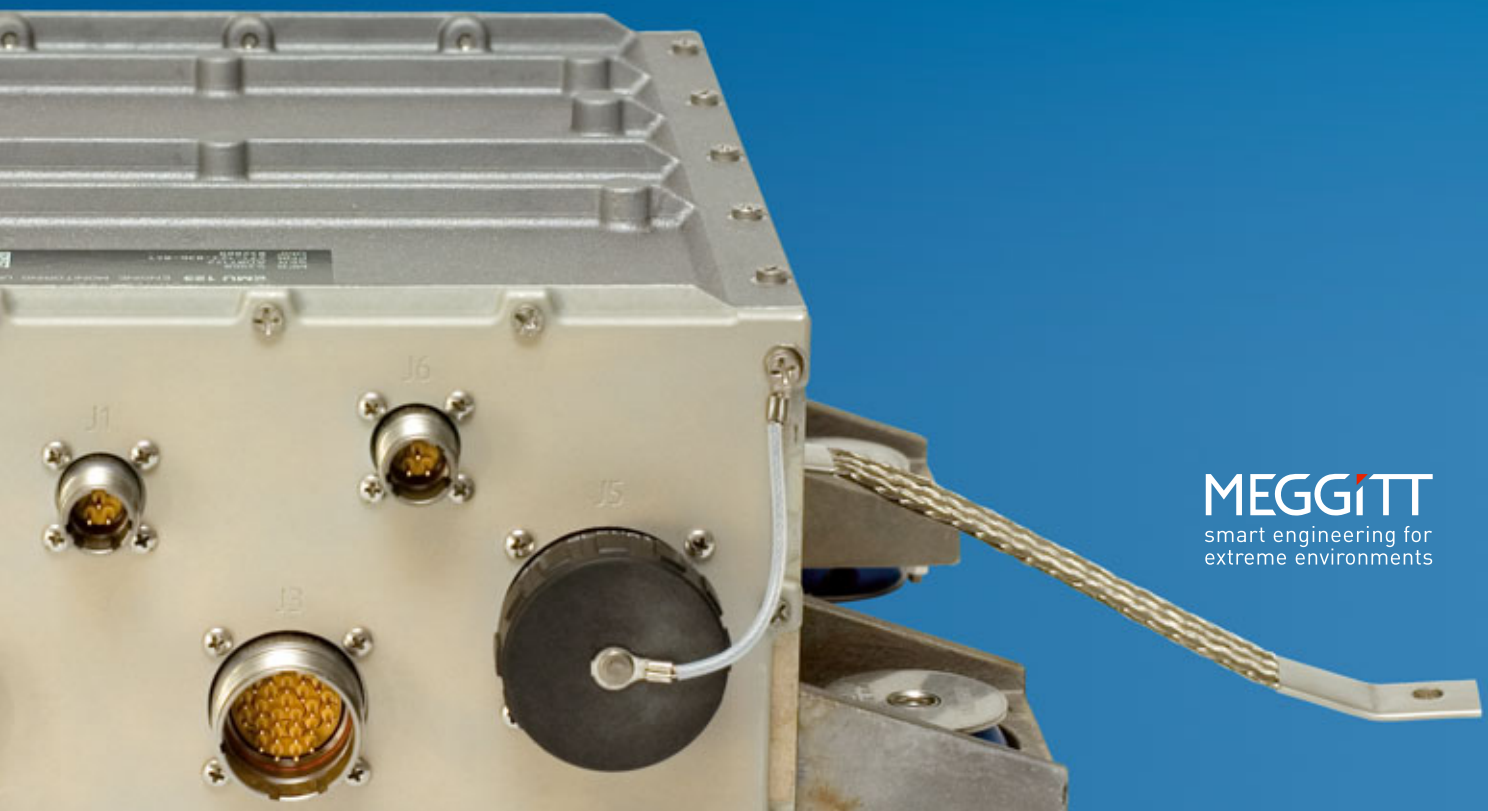
Vibro-Meter

Engine vibration and health monitoring systems



MEGGiTT
smart engineering for
extreme environments

Engine Vibration Monitoring Systems

EVM System benefits

Engine Vibration Monitoring (EVM) Systems measure rotor out of balance with high indication reliability, and they also provide further functionality that brings large operational and commercial advantages:

- Significant reduction of engine balancing costs through the storage of in-flight data for “multi-plane cold trim balance”.
- Lower ownership costs via the introduction of digital algorithms to dramatically improve indication reliability.
- Use of vibration trending techniques (outside the EVM) to allow condition based maintenance.
- Reduction in spares holding costs to airlines with Vibro-Meter’s “universal” EVM.

Total system responsibility: Sensing – Signal transmission – Processing

Vibro-Meter is in a unique position to provide the total system capability from one source and thus ensure that the complete system is well integrated and functions correctly and reliably.

Sensing:

Vibration sensors capable of operating up to 650°C with MTBFs upward of 250’000 flight hours. Vibro-Meter is one of the few companies worldwide that has the know how to develop and manufacture such technology. The issue of “where and how to integrate” the sensors on the engine is a specialized expertise.

Signal transmission:

Range of high performance, low noise engine- and airframe- mounted cable assemblies. We work closely with engine and aircraft manufacturers to optimise architecture decisions involving parameters such as: weight, routing and signal quality.

Processing:

EVMs provide vibration indication, allow airlines to trend vibration data and perform condition based maintenance decision making. They also record data continuously during normal flights, allowing to balance engines in a matter of minutes. Instructions are given in plain-language: correction location and weight.

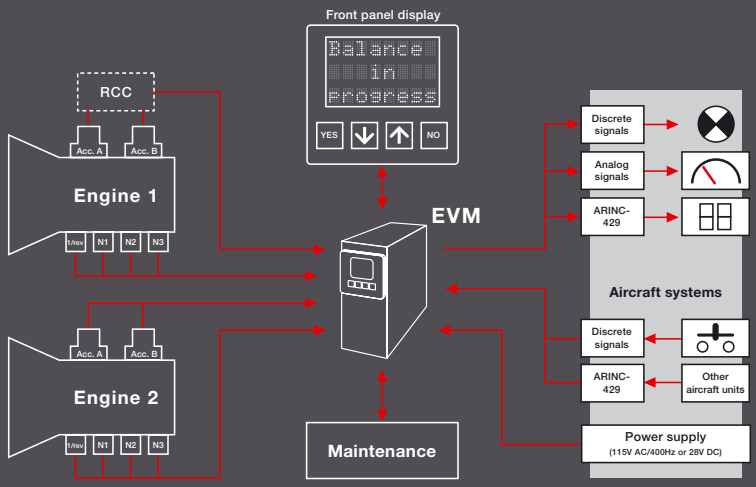
Vibro-Meter works hand-in-hand with engine OEMs to tailor cost-effective solutions to each individual application. The optimal engineering of sensing, transmission and processing elements is primordial especially as one moves towards engine condition and health management systems.

More than 40 years experience

Vibro-Meter has been designing, supplying and supporting EVM Systems for airborne applications from the beginning of the 60’s, with all major engine and airframe OEMs relying on us today.

EVM System Architecture

A typical system architecture, similar to that used on all Boeing aircraft is shown here: Two engine mounted piezo-electric sensors, one mounted on the fan bearing and one mounted on the turbine casing, monitor the vibration from each engine. A front panel display on the EVM allows operators to easily access system BITE messages, measured vibration values, FAN and LPT balancing results amongst others. A front panel maintenance connector provides raw signals for engine troubleshooting and also allows the up- and download of operational software. The EVM unit provides digital processing and FFT analysis for the trending of vibration parameters and for cold trim balancing. Engine vibration levels are transmitted to aircraft systems and cockpit display.

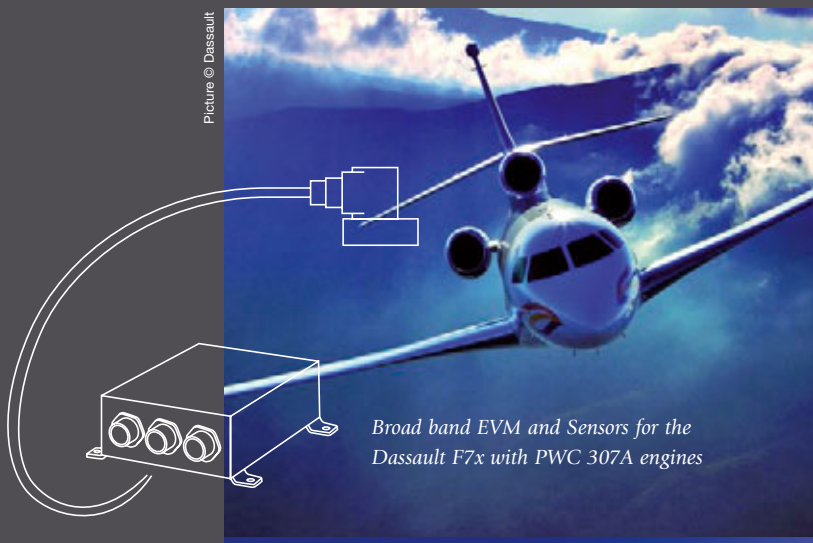


EVM System Applications

Our engineers work closely with the OEMs to develop optimised system architectures. The success of this cooperation is evidenced by the Vibro-Meter range of system architectures in service today.

Broad Band EVM Systems for Business Jets

Broad band systems are well adapted to business jet applications.
Multi-channel broad band processing meets the minimum regulatory requirements for vibration monitoring with full engine-to-engine segregation, very high reliability, light weight and low cost. The concept allows easy adaptation to single, twin or triple engine vibration processing in one single EVM unit.
Broad band EVM systems on: Dassault F7x and 2000 Ex, Gulfstream 150 and 200, Learjet 45 and 60,...

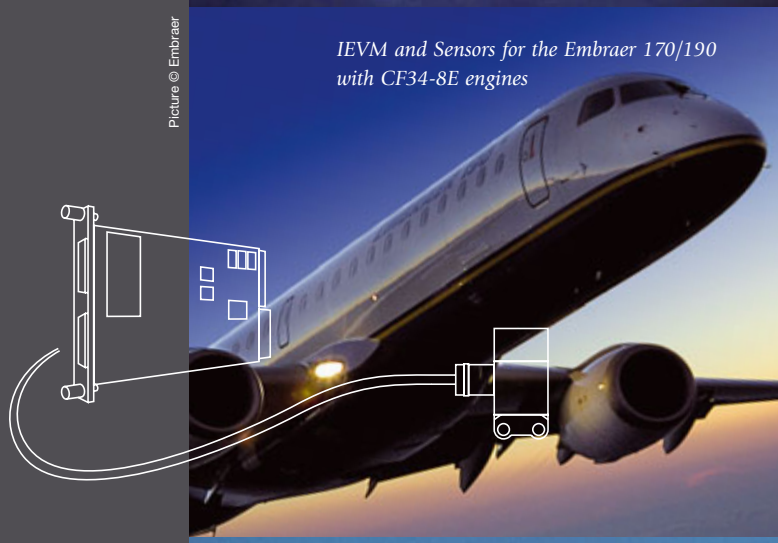


Picture © Dassault

Broad band EVM and Sensors for the Dassault F7x with PWC 307A engines

Integrated EVM Systems for Regional Jets and Business Jets

Recently, Vibro-Meter has integrated the whole functionality required for airborne vibration monitoring onto a single plug-in board called IEVM (Integrated EVM). Compact and easy to replace, such IEVM modules are used today on a number of business/commuter aircraft applications. Initial variants have been engineered for the Honeywell EPIC system and certified on the Embraer 170 and 190 family.
IEVM systems on: Embraer 170 and 190,
Hawker Beechcraft 4000, Gulfstream 350, 450 and 650...

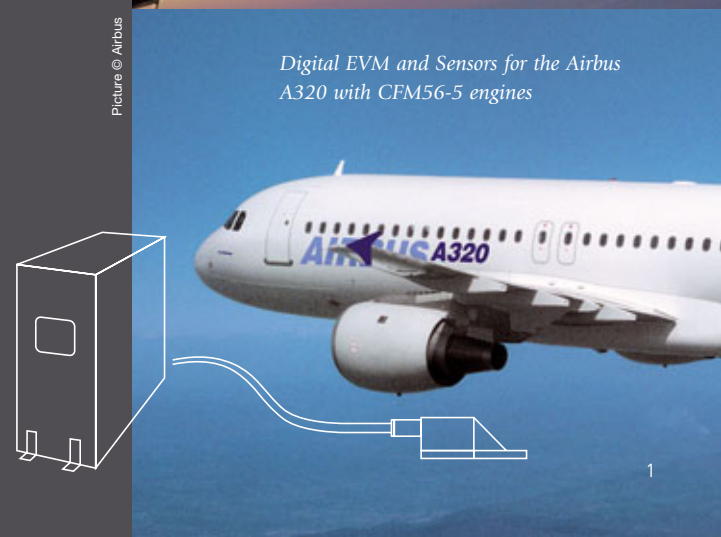


Picture © Embraer

IEVM and Sensors for the Embraer 170/190 with CF34-8E engines

Digital EVM Systems for large Civil Transport Aircraft

The majority of the large civil aircraft in service today utilise EVMs from this family.
The EVM units fitted to all Airbus A318/A319/A320/A321 have similar system architecture to that shown in the figure above, but they involve “menu-mode” communication with the MCDU system instead of the front panel display. Apart from meeting regulatory requirements, cost saving functionality usually involves **a)** Sophisticated BITE of the electronics and signal sensing/transmission chain, **b)** Outputs for trending engine vibration and **c)** Cold Trim Balance.



Picture © Airbus

Digital EVM and Sensors for the Airbus A320 with CFM56-5 engines

Engine Health Monitoring Systems

EHM System benefits

The rapid emergence of Engine Health Monitoring (EHM) Systems for civil aircraft has occurred during the introduction of a new generation of engine-aircraft projects, namely the Airbus A380 with RR and GE engines and the Boeing 787 with RR and Alliance engines. The main operational and commercial advantages linked to EHM are:

- Provides trending and use-age calculations
- Provides the data required to support “power-by-the-hour” commercial frameworks.
- Allows the use of generalised and engine specific diagnostic algorithms
- Supports the introduction of “condition based maintenance” concepts
- Lowers the cost and harmonises maintenance and repair logistics

Broad health monitoring experience from various domains

Health and Usage Monitoring Systems (HUMS) for helicopters with Vibro-Meter technology have been in service for over a decade. So too are Condition Monitoring Systems (CMS) for power generation machinery such as gas turbines, steam turbines, hydro turbines, etc. More recently, HUMS Systems are being specified for ESA and JAXA space vehicle engines.

Helicopters:

Our patented technology for Rotor Track and balance (ROTABS) together with vibration sensing/processing suites and signal acquisition processing cards are integrated into our customers HUMS. Vibro-Meter is a key supplier to Goodrich (Sikorsky) and Eurocopter, for most of their civil and military helicopters.

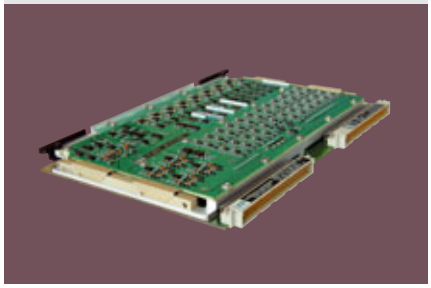
Electrical power generation:

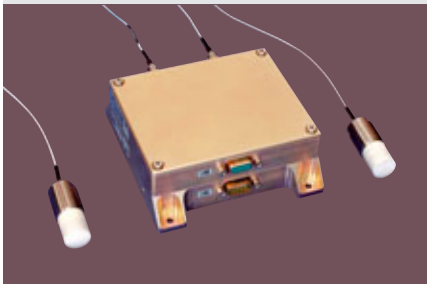
Our integrated systems protect and monitor thousands of high capital value rotating machines (gas turbines, steam turbines, generators...) worldwide. We have very close working relationships with major OEMs and our monitoring systems are fundamental to Plant Asset Management in the energy industry.

Space propulsion:

Vibro-Meter is a partner to CNES for the development of a system for health monitoring of the Vulcain and VINCI engines. Emphasis is being placed on extremely fast acquisition and diagnosis of anomalies in the LH2 and LOX systems followed by igniter and combustion chamber diagnosis.

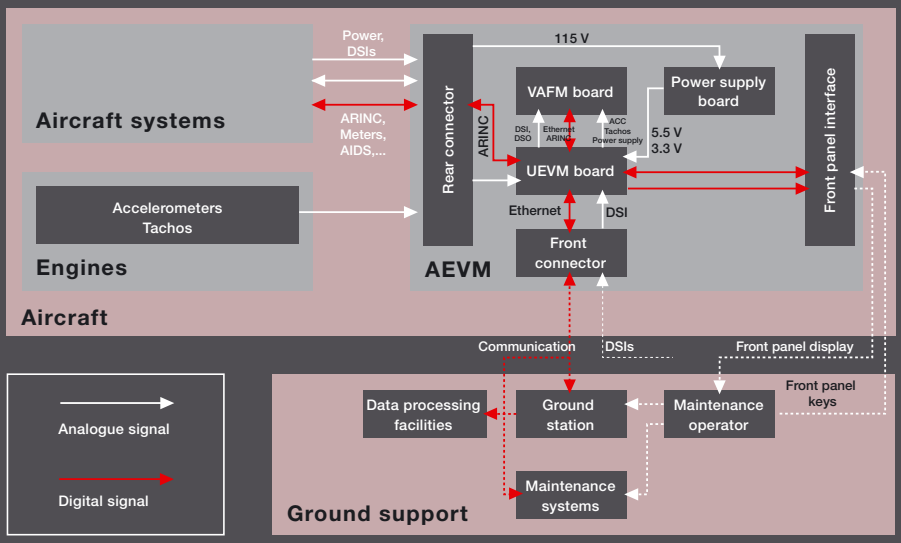
Health monitoring systems for civil fixed wing aircraft is based on experience gained in other high-tech domains, where Vibro-Meter is also a pioneer and a leader.





AAVM System Architecture

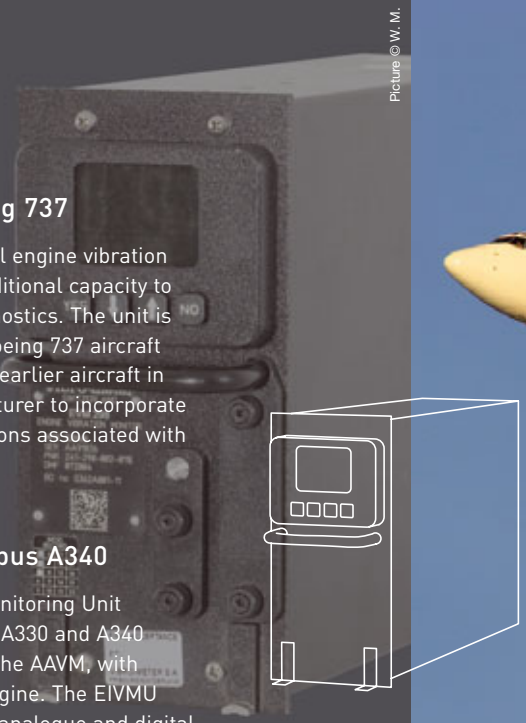
Vibro-Meter's Universal Engine Vibration Monitor (UEVM) provides engine vibration monitoring and cold trim balance functions with traditional system architecture. It contains the operational software of 4 aircraft and 9 engine types and can adapt to its aircraft/engine environment.
Based on the UEVM, the Advanced Airborne Vibration Monitor (AAVM) was developed with Boeing and CFMI to provide fault annunciation and diagnostic functions for the CFM56 engine.
The unit provides airborne fault prediction and diagnostics based on vibration measurement and analysis and is the first step towards the introduction of "condition based maintenance" practices in civil aviation.



Advanced EVM Applications: Pioneers in prognostics

Advanced AVM System for the Boeing 737

This Advanced AVM (AAVM) provides traditional engine vibration monitoring with cold trim balance and has additional capacity to provide number 3 and number 4 bearing diagnostics. The unit is supplied as standard fit on New Generation Boeing 737 aircraft and several hundreds have been retrofitted to earlier aircraft in service. The AAVM allows the engine manufacturer to incorporate a number of "value-adding" diagnostics functions associated with vibration analysis.



Picture © W. M.

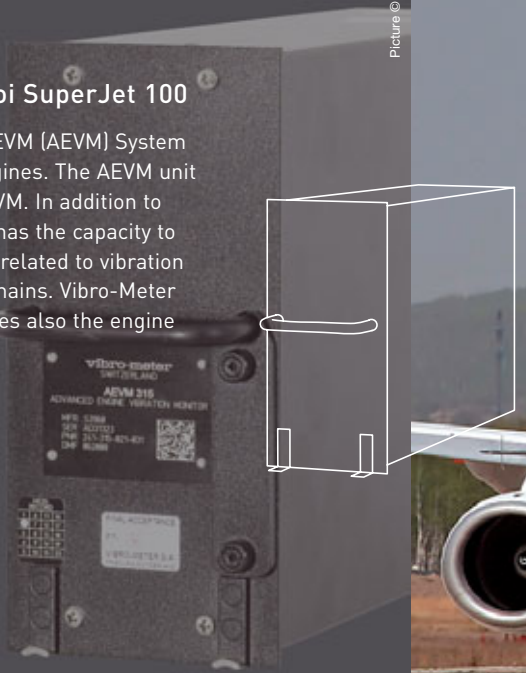
AAVM and Sensors for the Boeing 737 New Generation with CFM56 engines.

Advanced EIVMU System for the Airbus A340

The Advanced Engine Interface & Vibration Monitoring Unit (Advanced EIVMU) is standard fit on all Airbus A330 and A340 aircraft. It has similar diagnostic functions to the AAVM, with bearing diagnostic functions for the CFM56 engine. The EIVMU acts as a fundamental "gateway" for discrete, analogue and digital information flow between the engine equipment and aircraft equipment.

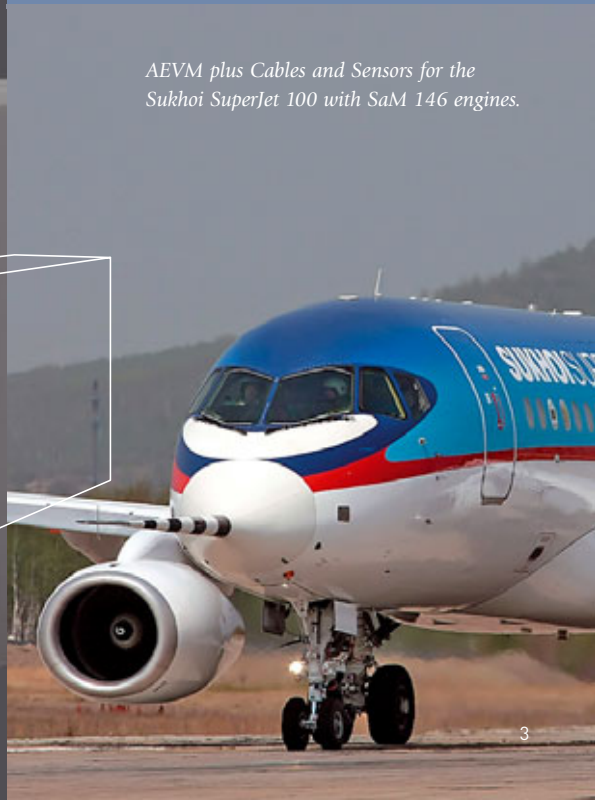
Advanced EVM System for the Sukhoi SuperJet 100

Vibro-Meter supplies the complete Advanced EVM (AEVM) System for the SuperJet 100 aircraft with SaM 146 engines. The AEVM unit is a second generation development of the AAVM. In addition to vibration monitoring and cold trim balance, it has the capacity to handle engine specific diagnostics algorithms related to vibration signal analysis in both time and frequency domains. Vibro-Meter has complete system responsibility and supplies also the engine sensor suite and cabling.



Picture © Sukhoi

AEVM plus Cables and Sensors for the Sukhoi SuperJet 100 with SaM 146 engines.



Engine Health Monitoring and Management Systems

On the most recently certified large civil aircraft, engine health monitoring is performed by a dedicated avionics unit fitted directly on the engine close to the sensor suite providing data for monitoring and diagnostics. Whilst such units operate in harsh environments, the short signal routing provides for maximum quality and reliability of data. In some cases it makes sense to provide the health monitoring and management functions in a less demanding environment (E.Bay) for architectural and commercial reasons.

Systems with E.Bay Mounted units

Vibro-Meter SA in cooperation with Abris Jsc in St. Petersburg and based on the technical requirements of Tupolev have developed a range of E.Bay mounted EHM units known as Generic Engine Monitoring Units (GEMU).

Tupolev 334 Aircraft with D-436-T1 Engines

The GEMU122 is a new generation engine monitoring and diagnostics/prognostics unit which is now standard fit on all new Tu-334 aircraft. The unit provides engine use-age, health monitoring and diagnostics/prognostics functions and the recording of related engine parameters in the case of “events”.

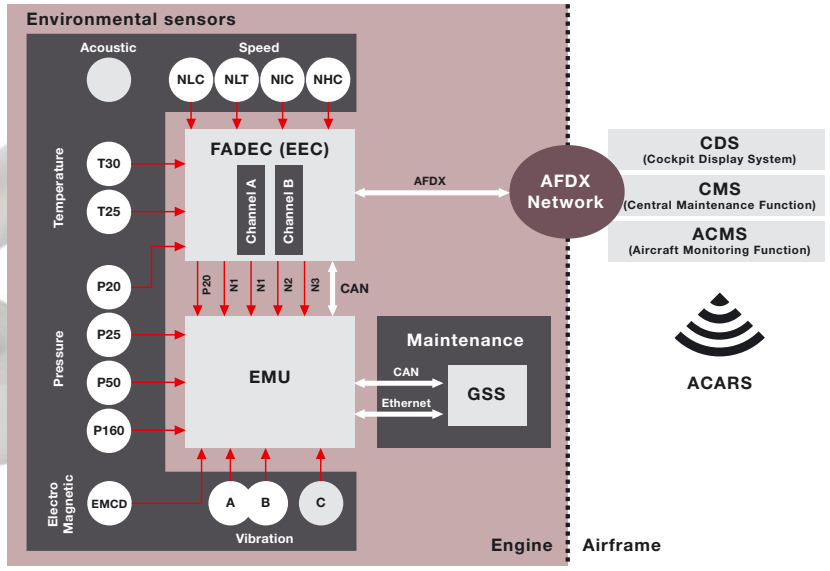
Tupolev 204 Aircraft with PS-90-A/A2 Engines

The GEMU122-5 replaces five avionic units previously fitted to the Tu-204 aircraft whilst providing additional engine and engine accessories diagnostics. Other advantages include lower weight by a factor of 6, better MTBF by a factor of 30 and lower power consumption by a factor of 10.

GEMU and Sensors for the Tupolev 204 with PS-90-A engines.

EMU Architecture

A typical Engine Monitoring Unit (EMU) System architecture is shown here: It provides vibration monitoring, engine performance, mechanical condition (health) and events data, together with various summaries via a bi-directional CAN bus to the FADEC which further communicates to external cockpit display (CDS), central maintenance (CMS) and aircraft monitoring (ACMS) systems. Detailed engine condition data is downloaded to platform maintenance Ground Support System (GSS) via an Ethernet bus. A compressed data downloader tool can be connected to the Ethernet port to access all internal memory data and for re-programming purposes.



Sensors Suite

Vibro-Meter together with other Meggitt companies, have the capability to supply all primary EMU Sensors.

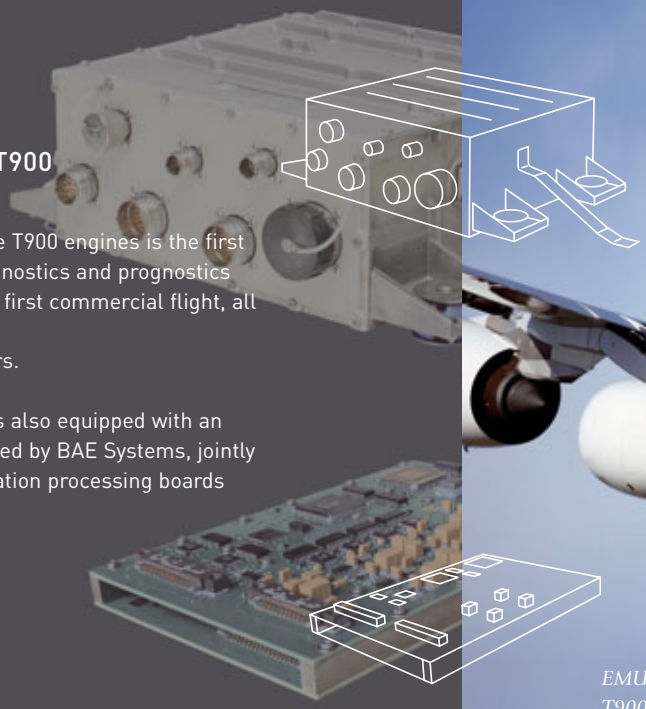
Systems with Engine Mounted units

The engine mounted EMU is part of Vibro-Meters' latest generation of health monitoring and management systems. EMUs are being certified for all major latest generation large civil aircraft. In all cases, the units have been developed in close co-operation with the engine OEMs who provide expertise in diagnostics and prognostics software.

EMUs for the Airbus A380 with T900 and GP7200 engines

The Airbus A380, powered by Rolls-Royce T900 engines is the first aircraft to benefit from the extended diagnostics and prognostics capabilities offered by the EMU. Since its first commercial flight, all aircraft delivered are equipped with Vibro-Meter's EMUs and vibration sensors.

The GP7200 engine for the Airbus A380 is also equipped with an engine-mounted unit called VMU, produced by BAE Systems, jointly with Vibro-Meter manufacturing the vibration processing boards and providing sensors.

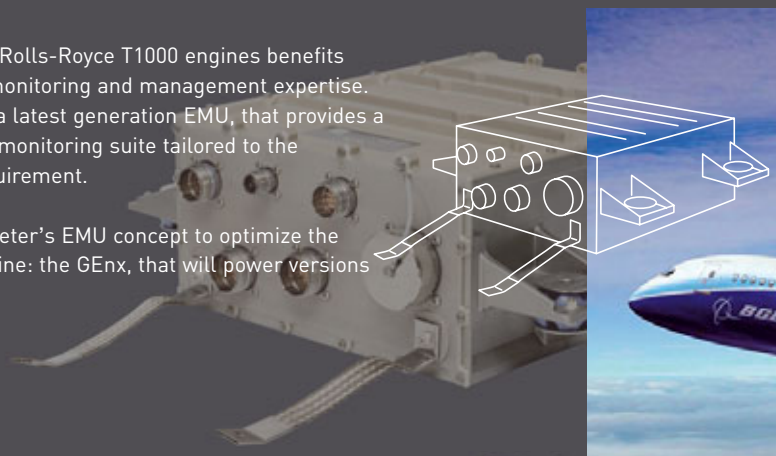


EMUs and Sensors for the Airbus A380 with T900 and GP7200 engines.

EMUs for the Boeing 787 with T1000 and GEnx engines

The Boeing 787 powered by Rolls-Royce T1000 engines benefits from Vibro-Meter's health monitoring and management expertise. The engine is monitored by a latest generation EMU, that provides a vibration and engine health monitoring suite tailored to the manufacturer's specific requirement.

GE has also chosen Vibro-Meter's EMU concept to optimize the operation of their latest engine: the GEnx, that will power versions of Boeing's B787.

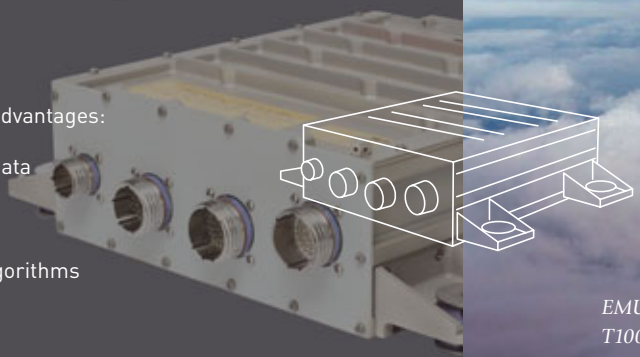


EMUs and Sensors for the Boeing 787 with T1000 and GEnx engines.

Diagnostics and prognostics

Typical EMU System functionalities and advantages:

- Engine vibration monitoring / cockpit data
- Cold Trim Balance computation
- Engine health computations
- Engine diagnostics and prognostics algorithms
- Engine performance calculations
- Monitor of de-rate/usage
- Engine novelty detection
- Propulsion system incident/event monitoring
- High level of storage capability
- High level of communication capability



Vibro-Meter

Since its foundation in 1952 in Fribourg, Switzerland, Vibro-Meter remains the leading supplier of reliable, high quality instrumentation systems to aerospace, marine and industrial customers world-wide, providing vibration, speed and dynamic pressure systems for civil and military applications.

The company's most significant asset is its ability to engineer reliable, high-quality, customer-oriented solutions. Vibro-Meter became a member of the Meggitt group of companies in 1998.

With our commitment to engineering expertise, comprehensive manufacturing resources, world-wide technical support, and full service repair capabilities, help is never far away.
Our international network of subsidiaries and distributors is always available.

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