

# Ultra-Light Helicopter Flight Tests

Solution for data acquisition & analysis – applied by CURTI Costruzioni Meccaniche Spa



© Picture: CURTI

CURTI's two-seater helicopter is manufactured at Castel Bolognese, headquarters of the industrial group. The security system, validation and product launch phase of this project were co-financed by the EU, through a proposal within the "Fast-Track to Innovation" funding scheme of the Horizon 2020 program. Being the only Italian guided consortium that had made it into the winners list of 16 funded projects, it featured the only ultra-light helicopter in the world driven by a turbine engine – lighter, reliable, and with less vibration than traditional piston engines. Much of the planning was performed by Hypertec, an engineering company of the CURTI Group which operates in the aerospace industry and is also active in motor sports, oil and gas, energy and automation sector. The manufacture of flight parts completely checked and verified with control systems forms part of the know-how of the company -- located at Castel Bolognese – including the use of light-weight alloys, titanium and composites, thus reducing the weight upon take-off to below 450 kg.

## Introduction

This document briefly describes the application of the imc data acquisition system used during the flight test sessions of the ultra-light helicopter manufactured by **CURTI Costruzioni Meccaniche Spa. Hypertec Solution Sr** provided technical support in test design and experimentation. The COTS test instrumentation has been supplied by **imc-Italy** (represented by *Instrumentation Devices Srl*).



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## Testing the helicopter

The objective of the CURTI technicians for conducting the helicopter flight tests was to perform various kinds of measurements using analog sensors: e.g. *stress, temperature, vibrations, pressures, ...*

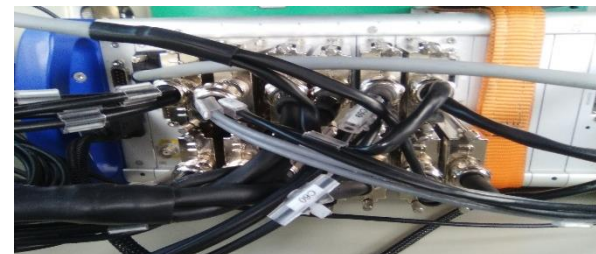
Some sensors were integrated into moving assemblies. In addition to collecting data from analog sensors, digital signals needed to be integrated, such as specific parameters originating from electronic control units (ECUs) and other systems integrated into the aircraft (*combustion engines, avionics, etc.*).

### Requirements on the measurement system

Apart from the appropriate sensors, a test and measurement system was needed that could provide extensive functionality:

- support telemetric sensor technology;
- condition and acquire analog sensor signals;

- interfacing to standard serial protocols, to acquire digital signals such as parameters from electronic control units;
- perform real-time mathematical calculations on measurement data and data logging for both acquired and calculated channels;
- monitor the test phases in real time.



Instrumented measurement system, © Photos: CURTI

The following is a brief description of the measurement devices supplied by imc Italy, which have enabled CURTI to meet the above mentioned requirements.

### Data acquisition system

The platform selected as the tool for signal conditioning, high speed data acquisition and data logging of signals originating from the sensors installed on the helicopter and from the on-board systems, is the **imc CRONOScompact 400-11**, produced by imc Meßsysteme GmbH.

The software that accompanies this device also permits real-time mathematical operations and the on-line display of acquired data, in addition to normal post-processing.

### Telemetric system

The blades of the helicopter have been instrumented with strain gauges in Wheatstone bridge configuration in order to perform of stress measurements.

Since the rotor is in rotation relative to the rest of the helicopter, these signals are acquired by using the “CTP8-Rotate” telemetry system produced by the German company, KMT Kraus Messtechnik GmbH.



### Vibrations measurements

The vibrations in certain parts of the helicopter structure have been recorded with the use of accelerometers.



Chosen sensors for this application were the MEMS-type triaxial accelerometers, model SDI 2476-50, produced by Silicon Designs Inc.

### Real-time data display

The installation of a graphics display of imc directly in the cockpit allows the real-time visualization of measurement data.



This permits the direct monitoring of test results and parameters during testing flights from on board the helicopter.

### Details of the instrumentation used

**imc CRONOScompact** is a modular data acquisition system, configurable with from 4 to 128 analog channels for various types of physical



sensors. It allows system sampling rates of up to 400kS/s, with 100 kHz per channel and A/D conversion to 24/16-bit.

It also supports the synchronous acquisition of digital signals (*event and pulse counting, on/off signals, tachometric signals, and incremental encoder*), parameters from digital bus protocols (CAN, ARINC, IENA, AFDX etc.) and GPS position.

imc CRONOScompact operates in stand-alone mode, with autonomous real-time processing of acquired data through **imc Online FAMOS**, for calculations of immediately available result parameters.

The storage of both raw and result data is assured on internal removable flash memory (CF card). In stand-alone mode, it may be combined with a graphic display, which permits the real-time visualization of acquired and calculated data. imc CRONOScompact may also be operated with direct connection to a single or multiple PCs via Ethernet (or WLAN), for on-line graphic and numerical display of test data and for the storage of data on a PC or Server.

**imc Online FAMOS**, thanks to **DSPs, integrated into the data acquisition equipment**, permits the real-time processing of analysis and result data from acquired channels without using a PC. More than **150 elementary functions** are available to be combined arbitrarily, in order to implement sophisticated and customized evaluation algorithms. It is possible to perform synchronized mathematical calculations on hundreds of “live” data channels originating from the acquisition.

**imc STUDIO** is an integrated and flexible modular software environment which can be used in conjunction with any data acquisition and measurement platform from imc.

Following the set-up of the hardware device, it permits the acquisition, processing and real-time display of any combination of analog and digital signals in tests lasting from seconds to an entire year.

Test and measurement procedures can be carried out as either a guided process, interacting with an operator or entirely automatic. Data visualization and customized GUI design is supported by creating display panels by simple drag&drop action.

In combination with the **imc FAMOS signal analysis software**, it is possible to automate data analysis, post-processing and generate test reports.

**imc FAMOS** is a powerful package for analysis of measurement data and visualization and documentation of results.

It includes hundreds of analytical functions and mathematics and features the most versatile and complete selection of graphical and numerical presentation tools.

To perform an operation upon a complete data set (e.g. time series), simply edit the corresponding mathematical expression in an explicit manner, i.e.:

New Parameter = Channel A + Channel B

The result is the new virtual parameter, which may be directly visualized or further processed.

Complex analytical algorithms may be organized in automatic sequences, right down to formatted report pages, ready to print, with charts, graphics and texts.

**CTP8-Rotate** is a telemetric system designed for installation on rotating assemblies, wheel rims and helicopter rotors.

Up to 8 measurement channels for strain gauge sensors in quarter, half and full bridge configuration, potentiometric, ICP/IEPE transducers, thermocouples and voltage signals. It offers a bandwidth of 12 kHz per channel with A/D converter resolution of 16-bit. Versions are available with up to 32 channels.



**SDI 2476** is a sturdy triaxial capacitive-type micro-machined accelerometer (MEMS), encapsulated in a small aluminium housing, complete with built-in electronics.

It requires a simple unregulated power supply between 8 and 32 VDC, and provides a low-noise analog voltage output

proportional to the measured acceleration.

It is available in the following measurement ranges:

$\pm 2, 5, 10, 25, 50, 100$  and  $200$  g full scale, with a frequency response from DC to 2 kHz.

It can be operated with temperatures between  $-55^{\circ}\text{C}$  e  $+125^{\circ}\text{C}$ .



## Further information

For over 25 years, **imc Meßsysteme GmbH** has been developing, manufacturing and selling hardware and software solutions worldwide in the field of physical measurement technology. Whether in a vehicle, on a test bench or monitoring plants and machinery – data acquisition with imc systems is considered productive, user-friendly and profitable. So whether needed in research, development, testing or commissioning, imc offers complete turn-key solutions, as well as standardized measurement devices and software products.

imc measurement systems work in mechanical and mechatronic applications offering up to 100 kHz per channel with most popular sensors for measuring physical quantities, such as pressure, force, speed, vibration, noise, temperature, voltage or current. The spectrum of imc measurement products and services ranges from simple data recording via integrated real-time calculations, to the integration of models and complete automation of test benches.

Founded in 1988 and headquartered in Berlin, imc Meßsysteme GmbH employs around 160 employees who are continuously working hard to further develop the product portfolio. Internationally, imc products are distributed and sold through our 25 partner companies, specializing in the distribution and local support of its solutions.

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**imc-Italy** is represented by

### Instrumentation Devices Srl.

Founded in 1991, imc Italy has acted as the Italian partner company to imc Meßsysteme since 1993. Active in the sectors of R&D, experimentation and scientific monitoring in the automotive, aerospace, naval energy production, structural sectors...

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**CURTI Costruzioni Meccaniche Spa**, with over 60 years of experience in mechanics, produces automated machines and complex sub-assemblies for various industrial applications.

Today, the company's added value is organized around various divisions, all orientated towards research and innovation in high technology-coefficient sectors.

**CURTI Aerospace**, for more than 40 years, has been manufacturing mechanical components for the defense and aerospace industry, providing client support covering the entire productive cycle, from the acquisition of the raw materials right down to quality control and non-destructive testing.

The division boasts consolidated experience in the design and manufacture of equipment for the production of parts and assemblies for helicopters, trainer aircraft and troop transport vehicles.

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