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PRESENTATION

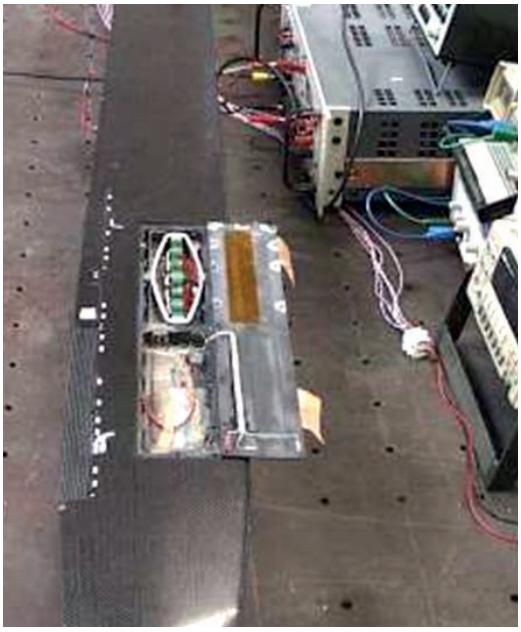
The development of the helicopters market is today limited because of its strong impact on environment: Their fuel consumption is high and produces a lot of emission; they generate a lot of noise both for the passengers (cabin noise) and for the people living close to the heliports (external noise).

Fig. 1: APA® is a registered mark by CEDRAT TECHNOLOGIES

Numerous projects involving CEDRAT TECHNOLOGIES like DTP RPA (ABC), Cleansky PPSMPAB, IMESCON...show the wish to reduce these nuisance by **reducing vibration, noise and power consumption using piezo flap mechanisms**.
CEDRAT TECHNOLOGIES's piezo actuators and mechanisms, benefiting from their air and space qualification and their high output energy density, are increasingly used in aircraft applications. Actuators and electronics have already been supplied for various experimental equipment to BOEING, DLR, SANDIA LAB, ONERA...

CEDRAT TECHNOLOGIES' PIEZO ACTUATORS TECHNOLOGY

Cedrat Technologies's APA® (Amplified Piezoelectric Actuators) cover a large range of displacements and forces while needing low electrical power. They have been developed initially for positioning space optics but **they are spreading widely in engineering fields such as the active damping and the control of shapes in aircraft**.



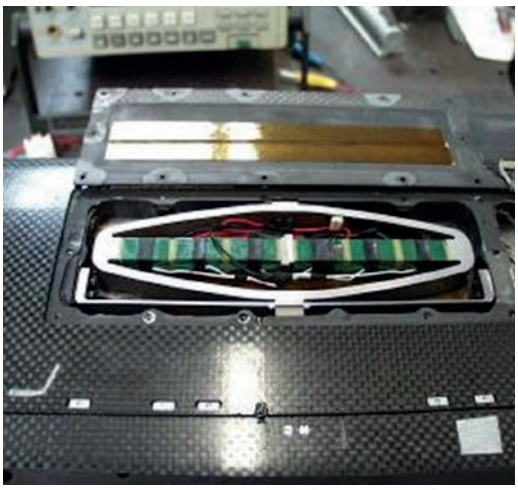


Fig. 2: Helicopter Scale-1 blade with active flap including APA1000XL from CEDRAT TECHNOLOGIES

The main features of APA® are:

- high force and large displacement in compact sizes
- high resolution within the nanometre range,
- very short response time below 1 ms
- life time greater than 1010 cycles,
- low voltage supply below 150V DC, no backlash and no play
- low power consumption when static
- severe environment compatibility (vacuum, cryogenic, high temp...).

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SOME PROJECTS

> ABC PROJECT-ACTIVE BLADE CONCEPT

CEDRAT TECHNOLOGIES provided several **APA® and linear amplifiers LA75C to ONERA and DLR**. The results obtained have been quite satisfactory even if some improvements still have to be done. Functional performance of the flap mechanism included a 10° tilt motion with a bandwidth of more than 200Hz. The flap mechanisms were separately tested under centrifugal and aerodynamic loads. A good behaviour under centrifugal loads was noticed from tests on Bravo Test Rig. Although the actuators were standard one, they survive the 2000g acceleration. Performance under aerodynamic loads was fully satisfactory at low Mach numbers.

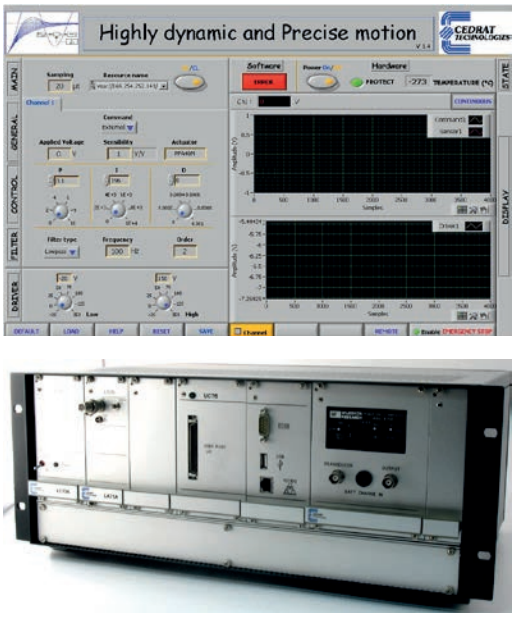

Fig. 5: Human Machine Interface with LabView® software and rack84F including a Unit Control UC75 based on Compact-RIO product

At higher speeds (mach 1), a small reduction of the 10° flap tilting stroke was recorded and later on attributed to the lack of stiffness of the gear mechanism transferring the linear motion from the APA® to the tilt motion of the flap. The main limitation of this piezo actuated trailing edge flaps was the added mass from the standard actuators. Therefore it was concluded by the RPA ABC project team that customized actuators with mass optimization would be beneficial. A R&D work of ONERA with Cedrat Technologies on customized light-weight APA® started at the end of the year 2009. One of the result of this activity is the composite shell-based APA® (see below).

> PPSMPAB - PIEZO POWER SUPPLY MODULE FOR PIEZO ACTUATOR BENCH

The Green Rotorcraft research Consortium of Clean Sky (CS-GRC) requests the development of a Piezo Power Supply module (PPS) and the associated Man Machine Interface (MMI).

CEDRAT TECHNOLOGIES (coordinator, SME) and UJF-G2ELAB (partner, lab from Grenoble Joseph Fourier University) form a consortium using their shared experience on piezoelectric actuators and energy recovery Switching Amplifiers (SA75) to meet the GRC request by the PPSMPAB project. The project aims at developing **2 PPS offering the highest required power (16kVA) with a high efficiency, for driving piezo actuators, accounting for further helicopter applications**.

Fig. 3: APA500L with standard shell & with S1 ceramic

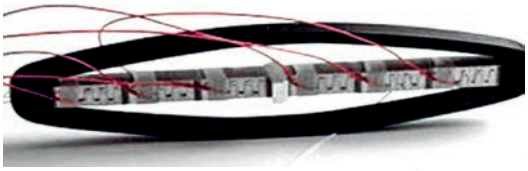

Fig. 4: APA500L with composite shell & with S1 ceramic

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IMESCON PROJECT – INNOVATIVE METHODS OF SEPARATED FLOW CONTROL IN AERONAUTICS

CEDRAT TECHNOLOGIES is involved in the **IMESCON project** which main objective deals with active flow separation control systems (AFCS) applied on **helicopter rotor blades**. IMESCON initial training network aims at providing the structured integrated and multidisciplinary training program for the future AFCS technology experts.

ONERA PROJECT ON COMPOSITE-SHELL APA®

Although the field of active rotor control has been widely covered in the literature, no application has reached today commercial success. The main reasons are the mass penalty implied by the actuators and the issue of temperature stability. In the framework of a project, CEDRAT TECHNOLOGIES and ONERA are testing composite shells to reduce the mass and to increase the energy density. Presently composite shell APA® have similar electro mechanical performances than steel shell APA® while being 35% lighter.

	STEEL SHELL	COMPOSITE SHELL
Height axis (mm)	50,09	56,43
Lenght (mm)	124,51	124,55
Thickness (mm)	20	20
Fr Blocked Free (Hz)	462	504
Fr Free Free (Hz)	1900	3770
Stiffness (N/µm)	1,22	1,19
Displacement (µm)	630	630
Blocked Force (N)	769	750
Shell Mass (g)	97	28
Total Mass (g)	200	131

Table 1: APA500L with composite shell, compared with standard APA500L.