Preliminary In-Flight Biomechanic Tests on the BA-609 Fly-By-Wire Tiltrotor

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The paper presents the results of a preliminary test campaign made on the BA-609 tiltrotor for the in-flight measurement of the biodynamic response of the pilot. The objective of the test campaign was to verify the feasibility of this type of measures during flight tests, and to assess the quality of the results that can be obtained. The identification of the biodynamic response of the pilots can be especially useful for the design of Fly-By-Wire (FBW) rotorcraft where potentially adverse interactions between the aircraft dynamics and the pilot may appear.

In order to investigate the proneness of a new design to PAOs, it is necessary to build an appropriate model of the biomechanical response that takes into account the physiological dynamics of the neuro-muscular system of the pilot's limbs. These models are expected to be dependent upon: (a) the size of the pilot (weight, height), (b) the configuration of the haptic interfaces in the cockpit, (c) the posture of the pilot, (d) the pilot's skills and the control strategy adopted to accomplish the mission task, and (e) a set of elements correlated to the mental activity of the pilot and the level of workload required by the task, such as the cognitive state, level of awareness, fatigue, anxiety, and more. This broad class of dependencies is often hidden by the introduction of the concept of 'trigger', or initiation mechanism, which summarizes the external stimuli that may cause the occurrence of a PAO event.

The feasibility of measuring the motion of the pilot's limbs directly during flight tests is assessed in this work. Several miniature accelerometers with gyro-enhanced Attitude and Heading Reference Systems are applied to the pilots. Preliminary in-flight experimental tests have been performed with the following goals: (1) verify the compatibility of the test equipment with respect to electromagnetic interference; (2) verify the flight-worthiness of the set-up; (3) verify the freedom of movement of the pilots while performing flight tasks with the sensors attached to their limbs; (4) verify the quality of the measures; (5) identify possible pitfalls to be avoided in this kind of tests.

The tests have been performed on the BA-609 FBW tiltrotor prototype that is currently undergoing flight tests at the AgustaWestland test site in Cameri (NO, Italy). The required instrumentation was placed on the pilots during the execution of already scheduled flight tests that could present interesting features from a pilot's biomechanics point of view. Two MTi strapdown sensors, manufactured by XSens were used. They were applied to the left arm and forearm. The MTi are miniature devices which output the acceleration and the rate of turn along three orthogonal axes. Additionally, a built-in integration algorithm uses the output of a magnetic field sensor to produce the sensor orientation. One of the MTi sensors was placed close to the elbow and the other close to the wrist, using fabric hook-and-loop fasteners. The two MTi sensors were connected via USB ports to a laptop, based on an Intel Core2 CPU @ 1.66 MHz with Linux OS, dedicated to the biodynamic data recording. Additional signals were taken from the measurement instrumentation placed in the aircraft cockpit. The results obtained are encouraging and in line with those that can be found in the open literature. However, reliable results are expected to be obtained only when a dedicated biodynamic test campaign is designed and performed.