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Tiltrotor UAV Development: Ground and Flight Tests

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Abstract
Full-scale tiltrotor UAV(5-m span), called Smart UAV(SUAV) has been developed since 2002 and ground and flight tests are in progress(Fig 1). This paper will present the special ground test articles used in the tiltrotor UAV development to mitigate the risks. It will also describe early features of the SUAV flight test.

The SUAV development program was launched in July 2002 as one of the '21st Century frontier R&D programs' planned for 10 years by the Korean government. Its objectives are not only to develop a VTOL UAV system with payloads, but to explore and implement innovative technologies to be used in future UAV systems. The smart technologies under study include automatic take-off and landing, collision avoidance, fault diagnosis and reconfiguration.

Conceptual study led to select a tiltrotor configuration as a platform at early stage. Wind tunnel tests and various performance simulations were made, and key technologies were explored and validated. Control algorithms were verified using 40%-scale flying models. A total unmanned system was manufactured, ground tested and flight test is under way.

Ground testing for the SUAV adopted unusual methods in the rotorcraft development community. Ironbird test, 4-degree-of-freedom rig test and tethered flight test were included in the tests. These ground testing methods were developed during early development of the small-scale tiltrotor UAV, which were verified to reduce risks in development of the unfamiliar, unconventional rotorcraft.

The ironbird as shown in Fig 2 was developed to test a power plant system of the tiltrotor in cost-effective manner. Turbo-shaft engine, drive train and rotors were connected and tested together unlike the conventional method in rotorcraft development community, where the rotor and transmission are tested separately using whirl tower and drive test rig. The ironbird enabled to test major components of the power system in a building block concept. The engine was tested with dynamometer connected first and a center gear box was connected additionally and tested. Then two pylon gear boxes and drive shafts were added and tested. Finally the rotor system was added to form a complete ironbird system. The ironbird was also used in verification of the flight control software and computer.

The 4-dof test rig was developed to allow dynamic testing of the vehicle where the rig supports the vehicle in limited degree of freedom (Fig 3). The vehicle was supported in such a way that it is free to heave, rotate around three axes over a limited range of motion. The 4-dof test rig was also used to tune the control gain in development of the flight control system in a rough way.

A tethered flight test as shown in Fig 4 was conducted to verify soundness of the total UAV system including the platform, data link and ground control system. The vehicle was tethered from the top unlike conventional rotorcraft tethered flight. Tower crane originally for building construction was modified to fit the tiltrotor tethered test. The tethered test experience from previous small-scale test was well reflected in the full-scale test. The flight control gain in the control software was also tuned during this tethered flight test.

The SUAV flight test is being performed at KARI flight test center in Goheung Korea as shown in Fig 1.

Fig 1　Full-scale tiltrotor UAV in helicopter mode flight

Fig 2　Ironbird test rig for full-scale tiltrotor UAV

Fig 3　4-degree-of-freedom test rig for for full-scale tiltrotor UAV

Fig 4　Tether flight test rig for full-scale tiltrotor UAV