pellor's downwash while roll is controlled with the use of differential propellor thrust. A variety of approaches have been proposed for pitch control; most involve an additional thrust-producing device located near the tail.

(U) In contrast with the tilt-rotor air vehicle, tilt-wing aircraft produce essentially no download in hover since the wings are always aligned with the downwash from the propellors. Tilt-wing aircraft are also better suited to STOL operation because they have flaps and leading edge devices to improve flight transition, and because the wing can be tilted on the ground. Because of their higher disk loadings, tilt-wing aircraft cannot hover as efficiently as tilt-rotor aircraft; however, this is not a significant disadvantage if the aircraft is not intended to hover for long periods, or if it is intended primarily for STOL or STOVL operation.

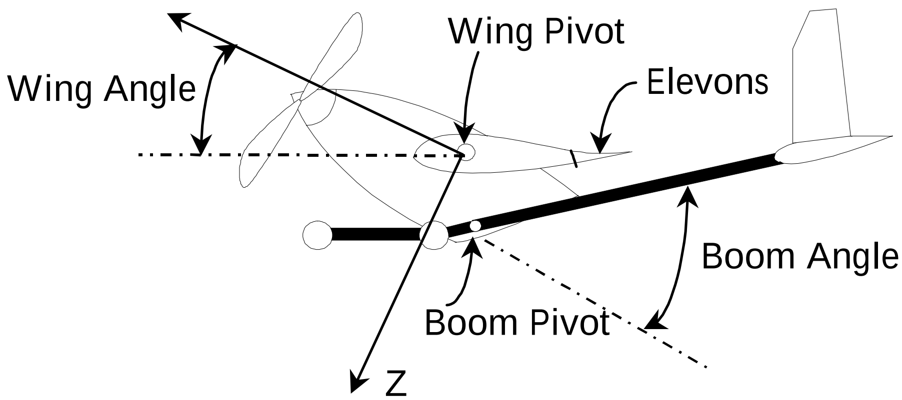
(U) Tilt-wing aircraft, on the other hand, do have higher downwash impingement effects on the ground and are much noisier. Another disadvantage of the tilt-wing is that the entire wing / engine / propellor assembly must be mounted on a large hinge mechanism with a weight penalty that is expected to be larger than the mechanisms required to tilt only the engine / rotor assemblies. Another argument in favor of the tilt-rotor is that by using the rotors for longitudinal control, that configuration does not suffer the power penalty and mechanical complexity of the additional thrust-producing device needed for the tilt-wing aircraft.

Tilt-body aircraft

(U) A relatively new kind of tilt-thrust vehicle, known as the tilt-body vehicle, has been developed for UAV applications by the Freewing Corporation (College Station, Texas). In the tilt-body UAV, the wing is hinged to the fuselage to allow free rotation of the wing in the pitch axes. This design largely decouples the pitch response of the wing from that of the fuselage, allowing a rapid wing response to gusting winds. As a result, the angle of the wing relative to the wind (i.e., angle of attack) is constant while the angle of the wing relative the fuselage (i.e., angle of incidence) is variable. Freewing claims that their design allows the wing to absorb energy that would otherwise be transmitted to the fuselage, yielding an inherently stable and lightweight platform.

Figure 57. Tilt-body concept[a]

Unclassified



a. Courtesy Freewing Corporation

(U) Rotating the tail boom assembly does not affect the wing angle of attack like a conventional tail elevator but acts instead to trim the fuselage, providing a thrust-vectoring capability without the weight or complexity of other concepts, such as the tilt-rotor or tilt-wing. By raising the nose of fuselage, the aircraft can fly as slowly as 20-percent of its untilted stall speed, which permits extremely short takeoffs and landings.

(U) In Freewing's Scorpion UAV models, only the wings have actual control surfaces. These control surfaces are used as ailerons when deflected differentially and as elevators when deflected together. In both cruise mode and tilt-body mode, all flight controls are achieved by activating these control surfaces, known as "elevons." According to Freewing, the tilt-body design is also relatively insensitive to changes in its center of gravity, allowing greater flexibility in its payload to accomodate changing requirements over time.

(U) Despite these purported advantages, the tilt-body concept is relatively immature, and much is still unknown about its specific aerodynamic performance. While wind tunnel testing on a 60% scale model and mathematical models have helped to define its operational envelope, only a flight test program will be able to define key operational parameters and its performance under a range of conditions, including its behavior in the “burble” following a naval ship. Last year, France-based Matra BAe Dynamics purchased the distribution rights for Freewing’s tilt-body UAV, which they have named the Marvel. Sea-based tests on the Marvel will hopefully provide much of this information.

Empty weight relationships for V/STOL vehicles

(U) Figure 58 displays the empty weight correlations for V/STOL vehicles.

Figure 58. Empty weight relationships for V/STOL UAVs

Unclassified