

Title of Invention

VERTICAL TAKE OFF AND LANDING UNMANNED AERIAL VEHICLE WITH
TWIN YAW CONTROL SYSTEM

5 1. Aspects and Purpose of the Invention

This invention is an unmanned aircraft or Vertical Take Off and Landing Unmanned Aerial Vehicle (VTOL UAV) with Twin Yaw Control System (TYCS) for military and civilian operations. VTOL UAV is part a complex system with a piston engine or jet engine as a prime mover. The power is transferred through a toothed belt to a reduction gearbox to change
10 the movement into a transverse direction in order to drive the main rotor blades and therefore causing a lift to the aircraft to move upward and downward. Apart from this, VTOL UAV is equipped with additional equipment for serving military operation or other mission as required. VTOL UAV with TYCS is controlled by means of radio signal or an electronic device called "Flight Control System" which is capable of controlling the aircraft to take-off and
15 land automatically as well as to fly on pre-determined routes and therefore not only is it easy-to-use, it is also very highly safe to fly.

The purpose of this invention is to develop an unmanned aircraft or Vertical Take Off and Landing Unmanned Aerial Vehicle with Twin Yaw Control System for use in military and civilian operations. The aircraft can take off and land vertically without resorting to an airfield.
20 For flexibility and operational safety, it is possible to choose a manual flight control mode operated by an external pilot using radio signal, as well as an automatic or semi-automatic flight control system.

2. Technologies Involved in Invention

Mechanical Engineering (aircraft structure, power transmission, and engine)

25 Aeromechanical Engineering (main rotor, tail rotor, and helicopter aircraft design)

3. Art or Technology Background

Concept of the use of UAV in security related operations has occurred in many countries worldwide. UAVs have been developed for supporting various missions successfully, both military and civilian. UAV or Unmanned Aerial Vehicle has been defined as "an aircraft with
30 engine and blades which can propel by itself. Such an aircraft will have no pilot onboard while in the air and can fly by itself using an onboard automatic flight control system or a remote flight

control specially designed for flying the aircraft back and forth and can be reused”. However, this definition does not cover any craft which is lighter than air such as balloon, blimp, Zeppelins, or airship and does not include missiles which does not use aerodynamic force for
5 lifting the craft body afloat in the air. This also does not include any guided weapons, ballistic ammunitions, and RC airplanes which are built and control from external flight controller pilot. Even though the RC airplane has no pilot onboard, it is to be controlled by external flight control pilot at all time.

3.1 UAV can be divided roughly into 4 types as follows: (from “The Royal Thai Air
10 Force Journal”, volume 8, by Wg.Cdr.Nattapol Niyomthai)

3.1.1 Endurance UAVs—designed for high altitude-, long distance- and high endurance-flight, they are high performance UAVs and are always found flying above the horizon and beyond the Line of Sight, the flight control and sensors of which are linked to satellite network.

3.1.2 Tactical UAVs—designed for medium altitude-, and within the Line of Sight of
15 the ground control station, they must be capable of operating for a long time and often use Line of Sight links for controlling the aircraft and detecting the received signal.

3.1.3 Small UAVs—movable by human and designed for a-few-kilometers flight around ground control station using Line of Sight communication, in general is capable of carrying out 2-3 hours of operation.

20 3.1.4 Micro UAVs—very portable, with averaged size no bigger than 6 inches which makes them more difficult to be detected and therefore can be controlled to access small areas such as opening windows of a building that are impossible to do so by bigger aircrafts.

Another type of aircraft which is similar to a UAV is a Remotely Piloted Vehicle (RPV). RPV is the aircraft without any onboard pilot but can be remotely controlled via
25 a communication network. An RPV is normally designed to be recoverable and was originally a large-scale version of a remotely controlled aircraft. RPVs have been used in the military are such as the remotely piloted drone, tested aircraft, and surveillance aircraft for many years.

3.2 VTOL UAV can be divided into 2 main types as follows:

3.2.1 Conventional Helicopter

This is the modification of conventional helicopter so that it can fly by itself using an automatic flight control. Here, only the VTOL UAVs which are already developed and commercialized at the present time will be discussed, such as:

- Yamaha R-MAX is the most advanced commercial helicopter (VTOL UAV) ever built today. Yamaha Company started developing an unmanned helicopter in 1983 after receiving research requirement from the Forestry and Fisheries Department, Japanese Ministry of Agriculture, for use in the strewing of fertilizers to plantations such as rice field fertilizer strewing and pesticide strewing in place of human labor.

Specifications of Yamaha R-MAX

Main Rotor Diameter	3.115 m
Engine Power	21 hp, two-stroke engine
Empty Weight	58 kg
Payload Weight	30 kg
Cruise Speed	11 knots
Operation ceiling	300 ft
Maximum Operation Radius	30 nautical miles
Maximum Endurance	1 hr
Prices - Base model for agriculture - Research model with manual control - Aerial photography - Full package (two airframes, a four-camera system, one ground station)	US\$ 86,000 US\$ 120,000 US\$ 150,000 – 230,000 US\$ 1,000,000
Operational Cost	10% of that for an unmanned helicopter

- Schiebel CAMCOPTER S-100 is a medium operational range and medium endurance VTOL UAV with main uses in the military. Its specifications are as shown in Table 2.

Specifications of Schiebel CAMCOPTER

Main Rotor Diameter	3.4 m
Engine Power	55 hp, rotary engine
Empty Weight	97 kg
Payload Weight	50 kg
Cruise Speed	55 knots
Operation Ceiling	18,000 ft
Maximum Operation Radius	70 nautical miles
Maximum Endurance	6 hr
Prices	US\$ 2,000,000
- Full package (two airframes, payload, one ground station)	
Operational Cost	N/A

3.2.2 Other types of VTOL UAVs

5 So far, many VTOL UAVs have been designed with different concepts—some still in their development phases and others not officially commercialized, such as:

- Tail Rotor and Tail Body

10 This concept makes use of tilted rotor blades originally installed in conventional aircraft parallel to the earth surface so that their axis are perpendicular or nearly perpendicular to the earth surface. As a result, the aircraft will be able to take off and land vertically using very small distance. Once reaching certain height, the blades axis will return to their original orientations, parallel to the earth surface, to fly in Fixed-Wing or Rotary-Wing mode. In such design, the wings will be used as rotors to lift the fuselage up and down. After reaching certain height, the wings will stop rotating and turn into a Fixed-Wing aircraft.

- Tail Sitter

15 This design changes the orientation of the aircraft when parking from horizontally to vertically using the tail of the aircraft as a sitter instead of typical landing gears.

- Coaxial Rotor

20 This design makes use of two sets of rotors rotating in opposite directions in order to reduce the reaction torque occurred. Originally, a helicopter will use a small rotor blade at the end of the tail to perform this function. Once the two sets of rotors are used, this tail rotor therefore is no longer needed and results in a symmetrical aircraft body along the rotor shaft and high level of freedom for side-way movement. The research and

development of the Coaxial Rotor VTOL UAV in other countries set the origin of the research and development of all VTOL UAV from the past until present day. One has to look back to the time of WW I when the navy was the first organization to use
5 piloted aircraft in their surveillance operation, as can be seen in service in every battleship and cruiser of the British navy. These aircrafts were often seen taking off from the ship-base runway and many times were shot down by the gun turret of the enemy's ship.

Twenty years on, the aircraft launching system had been changed to a steam propulsion
10 system, which later became one of the standard systems onboard the aircraft carrier of that time. After the use of shipboard aircrafts for surveillance purposes had contributed to many successes of land battles and most of them were in short timeframes, sometimes later Drones had been considered as alternatives to manned aircraft in surveillance missions. Only the US navy was appeared to have an ability to develop and put
15 the Drones into service at that time. A helicopter had been modified for shipboard operation as it can take off and land vertically. The first VTOL UAV in service in the US navy which could carry out its mission in actual operational area was a Remotely Piloted Helicopter or Drone Helicopter model QH-50 DASH from Gyrodyne Rotorcycle Company used for an anti-submarine mission. Originally, QH-50 DASH had been
20 designed for the US navy for their need of a small helicopter which could carry 1 pilot for a short distance only. After QH-50 DASH was put in service since January 1963, they had equipped the surface battleships with anti-submarine ability by means of droppings of Torpedo. QH-50 DASH could take off and land by an external pilot on the ship deck. After taking off, it could be controlled by means of RADAR by an internal pilot working
25 in the ship's Combat Information Center (CIC) of a Destroyer ship. QH-50 DASH would monitor location of the enemy's submarine and dropped a MK-44 or a MK-46 Torpedo to destroy it. Once the mission had been carried out, it would return to the ship right away to avoid a crash due to major change of helicopter's body after Torpedo dropping. In fact, QH-50 DASH was also capable of carrying MK-57 Nuclear Depth Bomb, but there had
30 been no attempt to test the dropping of this type of the bomb due to the complexity of the control of the remotely piloted aircraft. It had been reported that more than 400 Drones had been lost during the operations due to electro-optic sensor problems. Sometimes later QH-50 DASH had been modified into another 4 sub-models and a total number of nearly 800 Drones were reported to be sent to the US navy during the years 1960 and 1969.

Afterwards, the remaining QH-50 DASH was decommissioned and the project was finally abandoned in January 1971. However, there had been some uses of QH-50 DASH as Unmanned Reconnaissance Drones in the Vietnam War and have been used until
5 today's at White Sands (White Sands Missile Range) in State of New Mexico for the US Army Strike Command. Apart from this, Germany's unmanned aircraft project called SEAMOS and Israel's unmanned aircraft project called HELISTAR have been developed based on QH-50 DASH structure.

- Ducted Fan

10 This type of UAV has made use of a cylindrical frame tube encircling a rotor blade. The movement of the UAV will be in the direction of the installation of such rotary tube.

4. Complete Disclosure of Invention

Pictures 1 and 2 show main components of the Vertical Take Off and Landing Unmanned Aerial Vehicle with Twin Yaw Control System (TYCS UAV Helicopter), which include a jet
15 engine- or a piston engine- prime mover, the power of which would be transferred through a toothed belt to a reduction gearbox to change the direction of rotation of the Main Rotor Head which further produces a vertical lift. The VTOL UAV is controlled by means of radio signal using a Flight Control System (FCS) which consists of an FCS box capable of sending and receiving control signals between VTOL UAV and the ground control station and acquiring
20 position of the VTOL UAV from an onboard GPS so that the VTOL UAV can fly by a manual radio control, automatic flight control system or semi-automatic flight control system, or by a mix of all three modes safely along the predetermined flight paths. The movement of the VTOL UAV in lateral (left-right) directions is performed by the Twin Yaw Control System (TYCS).

Descriptions of the design are as follows:

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- Distance between main rotor to center of TYCS's rotor blades when sitting vertically is 0.3 - 0.5 m.
 - Main rotor diameter is 2.0 – 2.4 m.
 - Height of VTOL UAV is 0.6 – 0.8 m.
 - Body width of VTOL UAV is 0.5 – 0.7 m.

30 Technical Specifications of Vertical Take Off and Landing Unmanned Aerial Vehicle (VTOL UAV) with Twin Yaw Control System (TYCS) are as follows:

- Main Rotor Diameter 2.2 m

- Fuselage 1.7 m
- Body Width 0.5 – 0.7 m
- Height 0.6 – 0.8 m
- 5 - Engine Power 15 hp
- Fuel Capacity 16 ltr
- Cruise Speed 70 km/hr
- Maximum Speed 100 km/hr
- Empty Weight less than 20 kg
- 10 - Operation Radius more than 50 km
- Maximum Ceiling more than 600 m
- Mission Endurance less than 3 hr
- Payload Weight less than 20 kg
- Day and Night Cameras Installation 1 system

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Claims

1. Vertical Take Off and Landing Unmanned Aerial Vehicle (VTOL UAV) with Twin Yaw
5 Control System (TYCS) consists of the following components:

Part 1 is the Prime Mover (1). A jet engine or a piston engine is chosen for the prime mover which transfers power through a toothed belt (2) to a gearbox (3) in order to transfer needed torque to the rotor head (4) which holds the two main rotor blades in place. The said gearbox (3) also transfers torque to the two auxiliary rotors of TYCS (6) and effectively causes both the main
10 rotor (5) and the auxiliary rotors (6) of TYCS to rotate at needed speed. When the main rotor (5) rotates to the speed where sufficient lift is produced in vertical axis, the VTOL UAV will be lifted afloat in the air and therefore the take-off and landing can be carried out without any runway or airfield. VTOL UAV body is equipped with landing skids (10) which support VTOL UAV body while parking on the airfield as well as bear VTOL body weigh during the take-off
15 and landing.

Part 2 is TYCS (6), consisting of auxiliary rotors connected to the tail boom (10) which receives rotating force from the gearbox (2). TYCS (6) will control the movement of VTOL UAV in the left-right directions and help reduce vertical torque caused by the rotation of the main rotor (5). Such torque, if occurs in a conventional helicopter which has only 1 tail rotor, will cause the
20 helicopter to tilt at a small angle with vertical axis during the flight. The invented TYCS (6) therefore will create a balance of torques around the vertical axis of the main rotor and help VTOL UAV to fly upright in parallel with the vertical axis without the need for an external pilot to try to trim the vehicle all the time. In the situation where any of the auxiliary rotors fails or is malfunctioned to the point where it cannot be used, VTOL UAV with TYCS (6) will not lose
25 balance completely until an external pilot or an Autopilot cannot control the direction of the vehicle, the vehicle loses the lift and spins down to the ground, but it will still be possible to control the orientation and fly back to the airfield with the remaining auxiliary rotor. The said Twin Yaw Control System (TYCS) (6) was designed such that the distance between the main rotor and centers of the auxiliary blades is 0.3 – 0.5 meters, diameter of the main rotor is 2.0 –
30 2.4 meters, and height and width of VTOL UAV are 0.6 – 0.8 meters and 0.5 – 0.7 meters respectively.

Part 3 is the Autopilot of VTOL UAV with TYCS. Radio signal is used for the control of VTOL UAV. The control can be carried out by an external pilot, automatic flight control system (8) or semi-automatic flight control system (external pilot and computer program). The automatic flight control system (8) and the data and video transmission system (9) consist of 6 radio transmission circuits capable of sending and receiving control signal up to 40 – 50 kilometers. VTOL UAV can fly forward and backward at equally fast pace in both directions. The balance of torque ensures no tilting angle of aircraft body is made with vertical axis during flight. This also makes VTOL UAV shorter in length and therefore reducing take-off and landing area. The parking area needed for VTOL UAV is only 30% of those required by conventional helicopter with the same engine size. The vibration is also reduced by 10-20% when compared to the vibration from convention helicopter with the same type and size of engine and this effectively prolongs lives of all components of the aircraft.

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