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# THE DRONE AVIATION NAVIGATION SYSTEMS

**Masaru Tanaka*, Takao Okubo**, Shunya Yamada***, Genki Idei***, Masanori Takase***, Reika Hosomi*****
***Nagoya University, **Institute Information of Security, ***Kyoto Institute of Technology**

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## Abstract

*In this paper, we would like to examine about the drone aviation navigation systems, collision avoidance of small manned aircrafts, air-intake avoidance technology to the jet engines of large aircrafts, the mid-air collision avoidance technology of drones each other.*
*Performance of drone has been improved as same as a small aircraft, and mid-air collision with small aircrafts is becoming a possible problem.*
*However, the current drone does not have the traffic alert and collision avoidance system between aircrafts, and the separate technology against large-sized aircraft is not sufficient.*
*If we do not make rules now, low altitude airspace could become a lawless zone of the drones that expand explosively.*
*So, we consider the possibility of a navigation system that uses existing radio waves of the mobile phone.*
*Mobile phone antenna in Japan is arranged to cover a small area, and its population coverage is 99%.*
*It is a system that prevents a mid-air collision and attempts to grasp the position of the drones flying by sending and receiving information between the antenna of the mobile phone and the drone and limiting the number of drones flying such as one or two drones only within the area coverage of one antenna (about radius 500m).*
*In this study, we will consider the information and the method that drones should be transmitted and received via a mobile phone antenna and the specifications that server require to control the drone, and also describe the difference in the safety of the current drones.*
*Also, we consider if it induces to increase electric power consumption and the flight performance decrement in the case of having this control system.*

## 1 Current Air Traffic Control System

In September 2015, drone regulation bill was enacted.[1] Under the bill, subject drones are defined as “out of aircrafts, rotorcrafts, gliders, and airships, flying objects that humans cannot board due to their structure but whose flight can be controlled remotely or on autopilot (ones weigh less than 200g [sum of the body weight and its batteries] are excluded).”

The functions of drones are rapidly enhanced and flight in high altitude that are equivalent of those of small aircrafts became possible, which has heightened the risk that the use of drones affects the taking off and landing of passenger planes. However, the lack of autorotation function which is equipped by helicopters is one major shortcoming of the drones now in use. When the crafts loses its power source, this function provides helicopters with dynamic lift as the rotor is turned by upward natural wind pressure caused due to the free-fall of the body.

The next issue is that drones are not subject to the traffic control system used for manned aircrafts (passenger aircrafts) and that there is no proper method to transmit their information to the traffic controller, and that drones are not equipped with a system that can provide information required by the traffic controller. Therefore, incorporating drone control to the existing air traffic control network is not possible. The reason lies on the side of the flying object, drones, rather than on the side of the air traffic control system. If we are to add the control of drones to the existing air traffic control system, drones also must be able to transmit their altitude, location, speed, and airframe number to the air traffic controller. These are generally thought available by using GPS; however, the altitude of aircrafts is measured by the barometric altitude. Thus, what the air traffic controller would recognize as the altitude of a drone should be the “barometric altitude.” Since the barometric altitude is the only altitude measurement used throughout the system, we cannot expect proper distance from other aircrafts or sound instructions from the air traffic controller when using precision-lacking GPS information. Thus, this study was launched for the purpose of the development of drones that can provide their own information to the current air traffic control network and of the examination of the triggers of risk judgment and threshold at which drones go into a stall and cannot regain buoyancy.

## 2 Creation of Experimental Model

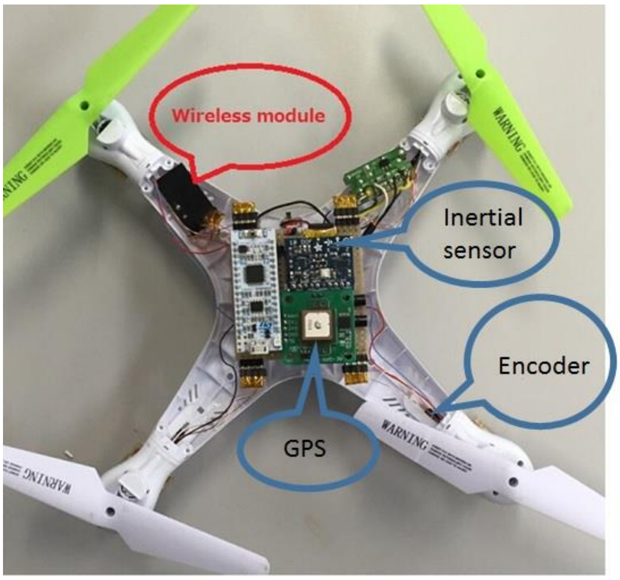



Fig:1

Fig:1 shows the measurement device used for the test flights in this study. This device was flyable, and its initial test flight was completed.
The device was equipped with a GPS sensor to detect flight position and flight duration of the body, an inertial sensor to detect environmental parameters and conditions of flight control of the object, an encoder to detect the rotational frequency of the rotor, and a wireless module to detect the communication state between the flying object and the controller and the communication contents. The inertial sensor was consisted of an air pressure sensor and temperature sensor to detect the absolute pressure and temperature at the flight position, a triaxial acceleration sensor and triaxial angular rate sensor to detect the flight attitude and angular velocity of the body, and a triaxial geomagnetism sensor to detect the heading direction of the body. The data obtained from these sensors were recorded to the microSD loaded on the measurement device. With the use of these data and the data link of multiple drones, we attempted to design a system which would enable the avoidance of mid-air collisions of the drones that travel at the same altitude and same collision course.

### 2.1 Flight Level

The flight level of aircrafts is defined by the altitude measured using an altitude measuring device. As such device, barometric altimeters which convert the pressure into altitude applying the fact that altitude elevation produces low pressure have been used. However, since pressure can be easily affected by the change in atmospheric environment including location and time, without pre-adjustment of the altitude measuring devices, multiple aircrafts departing from different locations may fly at the same altitude even though their altimeters show different altitudes. Hence, QNE setting was established to regulate altimeters’ setting on the basis of standard atmosphere, and the altitude obtained from this setting defines the flight level (FL) of aircrafts. In this study, we conducted test flights to examine whether the on-board system of our drone recognizes pressure altitude with the purpose of this study being the avoidance of airborne collision of drones by the use of this QNE setting for the air traffic control of drones. As for the difference in the accuracy of the altitude obtained from GPS, it is necessary for GPS receivers to capture radio waves from at least 3 satellites (at least 4 in case of actual operation) to measure GPS positioning; however, there is no guarantee that radio waves can be consistently captured since satellites are relatively constantly moving. This means that altitude information is available only intermittently, and therefore, it is desirable to capture the altitude of drones using barometric altimeters.

## 3 Test Flights

The first test flight was conducted on May 28, 2016 at Ishino Circuit in Toyota city. The items tested were data transmittance to PC on the ground via Bluetooth of the flying device in the air, the acquisition of the parameters, and the validity of the barometric altimeter.

The test result showed a successful data transmittance via Bluetooth from the air, and information from all sensors was successfully obtained. As shown in Fig:2, the air pressure dropped as the altitude elevated, which revealed that the use of a barometric altimeter for drones were as effective as for aircrafts.

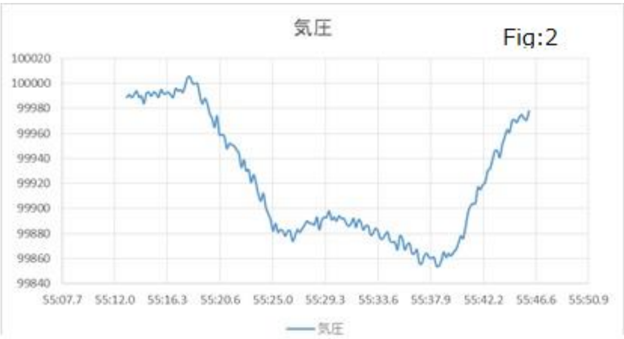


Fig:2

### 3.1 Impact of Wind Pressure of Rotors on Barometric Altimeter

To examine the impact of wind pressure of rotors on the barometric altimeter, we spun the rotors while maintaining the body on the ground. The output figures of the altimeter showed maximum pressure of 1000.17hpa and minimum pressure of 1000hpa. (Fig:3)

On the contrary to the range of pressure change shown in Fig2, the pressure turned positive (it is not possible for flying objects to have higher pressure in the air than its surface air pressure). Moreover, the pressure fluctuation was within 1hpa. Together, it can be concluded that the impact of wind pressure of the rotors on the barometric altimeter is ignorable.

Fig:3

## 4 Measuring Wind Speed and Wind Direction

It is necessary for drones to get information of wind speed and wind direction for safe flight. Even though airplanes receive such information measured by wind profiler systems from base station, conventional drones don’t have such systems. Therefore, an anemometer is mounted on upper and center position of a drone to measure wind speed and wind direction (see Fig.4). There are various types of anemometers (windmill, ultrasonic, thermistor, etc.). In this study, thermistor type was selected considering a payload, tolerance of external noise, and a good sensitivity from low wind speed range to middle wind speed range. However, a thermistor anemometer alone cannot measure wind direction, this anemometer is attached to the anemoscope with dolphin design. By checking the angle of its rotation from encoder, wind direction can be measured.[2]

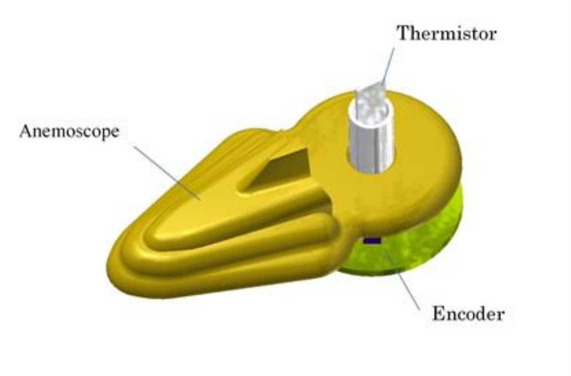
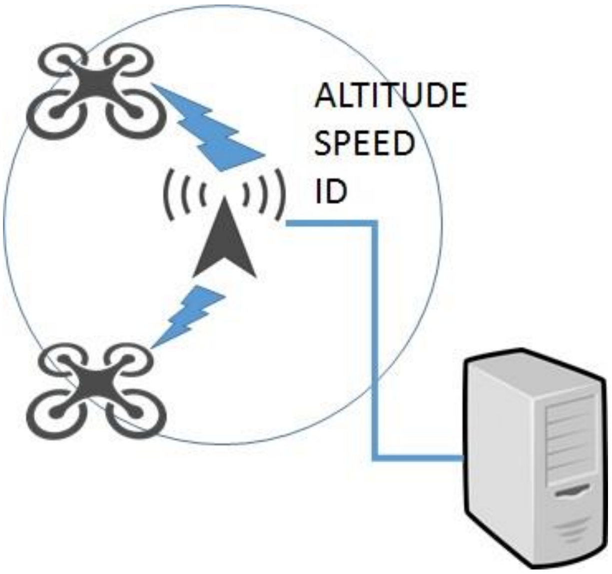



**Fig:4**

## 5 Ideas to Share Flight Information




Information transmission from aircrafts to the current air control network is mainly done by the transponder, and the air traffic controller receives their altitude, course, and airframe number. In this study, as a replacement of the transponder, we are planning to equip our drones with an information transmission unit which sends information to the air traffic controller via cellular network or which sends parameter information, to be available through this study, to the network control system for drones. We will conduct research and engage in the development of a system through which the air traffic controller or the network control system for drones can receive information from drones flying at the altitude of 150 meters or more by sending flight information from the drone body toward the antenna of the cellular phone.

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[1] http://www.mlit.go.jp/en/koku/uas.html

[2] http://www.facstaff.bucknell.edu/mastascu/eLessonsHTML/Sensors/TempR.html

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