Aviation and Railway Accident Investigation Board
Report No. ARAIB/UAR0903

Ultralight Vehicle Accident Report

Unmanned Rotorcraft Collision with Pilot
Osu Agricultural Cooperative
RMAX L17, S7044
Imsil-gun, Jeollabuk-do, Republic of Korea
3 August 2009

31 December 2010

Aviation and Railway Accident Investigation Board
Ministry of Land, Transport and Maritime Affairs
Republic of Korea

According to the provisions of the Chapter 4, Article 30 of the Aviation and Railway Accident Investigation Act of the Republic of Korea, it is stipulated;

The Accident investigation shall be conducted separately from any judicial, administrative disposition or administrative lawsuit proceedings associated with civil or criminal liability.

And in Annex 13 to the Convention on International Civil Aviation, Paragraph 3.1 and Paragraph 5.4.1, it is stipulated and recommended as follows;

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents, and it is not the purpose of the activity to apportion blame or liability. Any judicial or administrative proceedings to apportion blame or liability should be separated from any investigation conducted under the provisions of this Annex

Thus, this accident investigation report issued as the result of the investigation on the basis of the Aviation and Railway Accident Investigation Act of the Republic of Korea and the Annex 13 to the Convention on International Civil Aviation, shall not be used for any other purpose than to improve aviation safety.

In case of divergent interpretation of this report between the Korean and English languages, the Korean text shall prevail.

Ultralight Vehicle Accident Report

Aviation and Railway Accident Investigation Board, unmanned rotorcraft collision with pilot, Osu Agricultural Cooperative, RMAX L17, S-7044, Imsil-gun Jeollabuk-do, 3 August 2009, Ultralight Vehicle Accident Report ARAIB/UAR0903, Seoul, Republic of Korea.

The Aviation and Railway Accident Investigation Board (ARAIB), Republic of Korea, is a government organization established for the independent investigation of aviation and railway accident, and the ARAIB conducts accident investigation in accordance with the provisions of the Aviation and Railway Accident Investigation Act of the Republic of Korea and Annex 13 to the Convention on International Civil Aviation.

The objective of the investigation by the ARAIB is not to apportion blame or liability but to determine the cause and prevent further accidents and incidents.

The main office of the ARAIB is located near Gimpo International Airport.

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Contents

Unmanned Rotorcraft Collision with Pilot

- ○ Operator: Osu Agricultural Cooperative
- ○ Manufacturer: Yamaha Motor Company, Japan
- ○ Type of Device: Unmanned rotorcraft (RMAX L17, Ultralight vehicle)
- ○ Registration number: S7044
- ○ Date of occurrence: 3 August 2009, 14:30 (Korea Standard Time[1])
- ○ Place: Rice paddy at Imsil-gun, Joeollabuk-do, Republic of Korea

Synopsis

An unmanned rotorcraft RMAX L17 (hereinafter referred to as "S7044") for aerial spray, operated by the Osu Agricultural Cooperative (hereinafter to be referred to as "Osu AC"), collided with the pilot and crashed into terrain during backward moving after a hovering takeoff for aerial spray on the rice paddies located at Imsil-gun, Jeollabuk-do, Republic of Korea.

Due to this accident, the pilot (male, age 46) was killed, and the S7044 was substantially damaged.

The Aviation and Railway Accident Investigation Board (hereinafter referred to as "ARAIB") instituted an accident investigation in accordance with the Aviation and Railway Accident Investigation Act, and notified the occurrence to the Japan Transport Safety Board(JTSB) which is the investigation authority of the State of manufacture, in accordance with the provisions of the ICAO Annex 13. The JTSB appointed[2] an

1) Unless otherwise indicated, all times in this report are Korean Standard Time based on 24 hours.
2) An unmanned rotorcraft is not included in the accident investigation objects as specified by Japan aviation law, but for cooperation between government agencies of the two countries, the Japan Transport Safety Board appointed an accredited representative.

accredited representative to this investigation.

As a result of the investigation, the ARAIB derived findings out of the factual information and analysis of the S7044 accident. And based on these findings, the ARAIB developed 4 (four) safety recommendations to the Osu AC and 4 (four) safety recommendations to the Yamaha Motor Company of Japan.

1. Factual Information

1.1 History of Flight

On 3 August 2009, around 08:10, the pilot (male, age 46) and the aerial spray team leader (male, age 56) arrived at the Osu AC building to prepare for the aerial spray mission. Because the other pilot of the Osu AC who was eligible for operating the S7044 was on vacation at the day of accident, the Executive Director in charge of guidance and economy (male, age 51, hereinafter referred to as "Guidance Executive") who had come to work earlier, volunteered to join the aerial spray team to act as a co-pilot.

The team departed the Osu AC around 09:00 and arrived at the morning work aerial spray site[3] around 09:40. The team carried out aerial spray work on the paddies of about 4 hectares from around 10:40 to 12:10. After finishing the morning aerial spray work, they planned to do aerial spray work on the owner's another paddy which was located close to the morning aerial spray site.

After having lunch at a restaurant nearby, the aerial spray team and the paddy owner arrived at the aerial spray work site shown in [Photo 1]

3) About 500 m northeast of the accident site

for the afternoon aerial spray. According to the statements of witnesses, the aerial spray team made preparations until aerial spray work, such as identification of obstacles in the area scheduled for the afternoon aerial spray, dilution of agricultural pesticide, work briefing and visual check of S7044, and the aerial spray work was planned to be conducted by flying to the left and right from southwest to northeast as shown in [Photo 2].

After starting the engine, the pilot and the other aerial spray team members moved away about 15 meters from the S7044. The pilot increased the engine RPM to make the S7044 take off.

After confirming that the S7044 took off, the aerial spray team leader and the Guidance Executive started to move to the locations[4] from where the signals to be sent to inform the pilot the boundary of the aerial spray area.

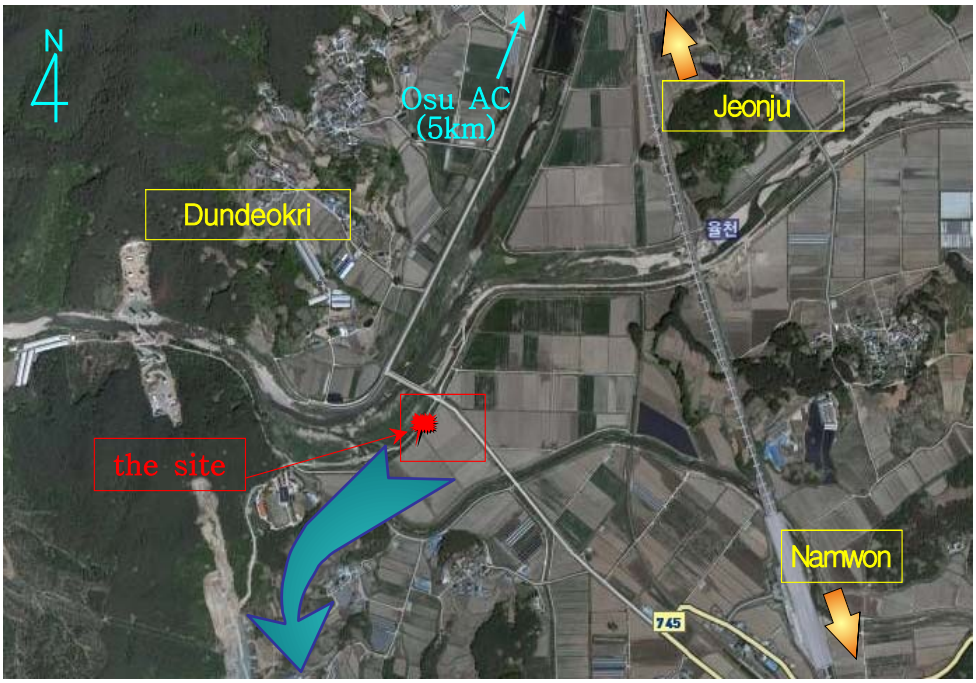


Photo 1. Location of accident

4) The signal position of the aerial spray team leader and the Guidance Executive as marked by a red flag in [Photo 2].

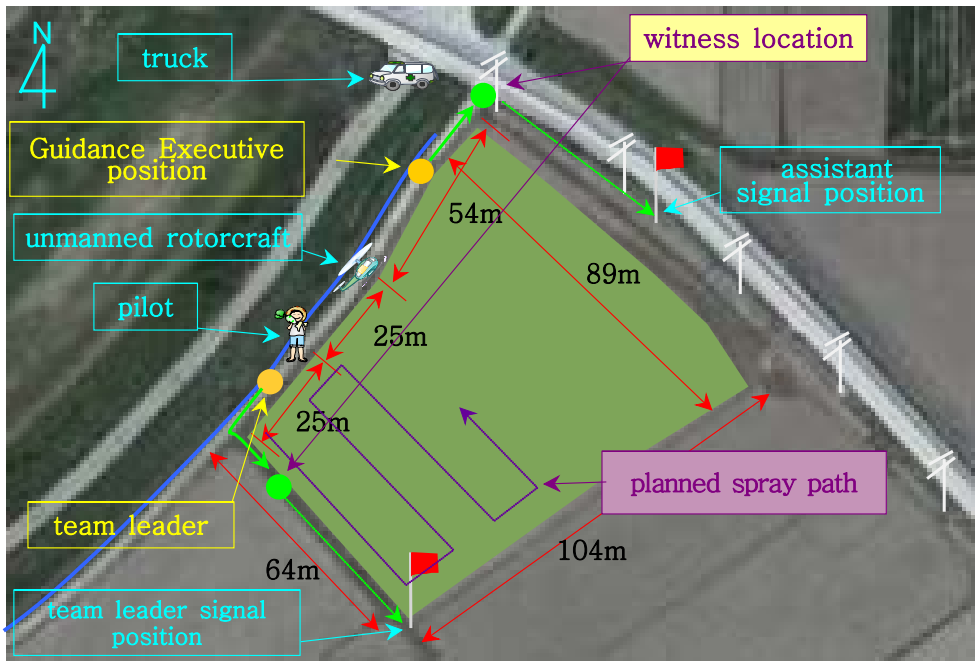


Photo 2. Aerial spray site

While moving to the assistant signal position, the Guidance Executive turned around two times to watch the pilot and the flying of S7044. The Guidance Executive stated that when he turned around for the second time to look at the pilot, he saw the S7044 approaching fast with its tail toward the pilot and the pilot falling down after making few backward steps.

The aerial spray team leader also turned around to watch the pilot occasionally while he was moving to his position at which signals were to be sent, but he did not see the moment of accident and saw only the pilot fallen down immediately after the accident.

The pilot died immediately after collision with the S7044 on a farm road about 18 m away from the takeoff place of the S7044.

1.2 Injuries to Persons

One person (the pilot) was fatally injured due to this accident.

1.3 Damage to the Unmanned Rotorcraft

1.3.1 Main Rotor

The main rotor comprises two blades made of composite material and a balancing stick of metal material.

The middle portion of the main rotor blades were broken by ground impact as shown in [Photo 3]. But the balancing stick and the pitch control stick of the hub portion were not damaged.

Photo 3. Main rotor damaged

1.3.2 Skid

The skid of the S7044 was bent and damaged by ground impact as shown in [Photo 4].

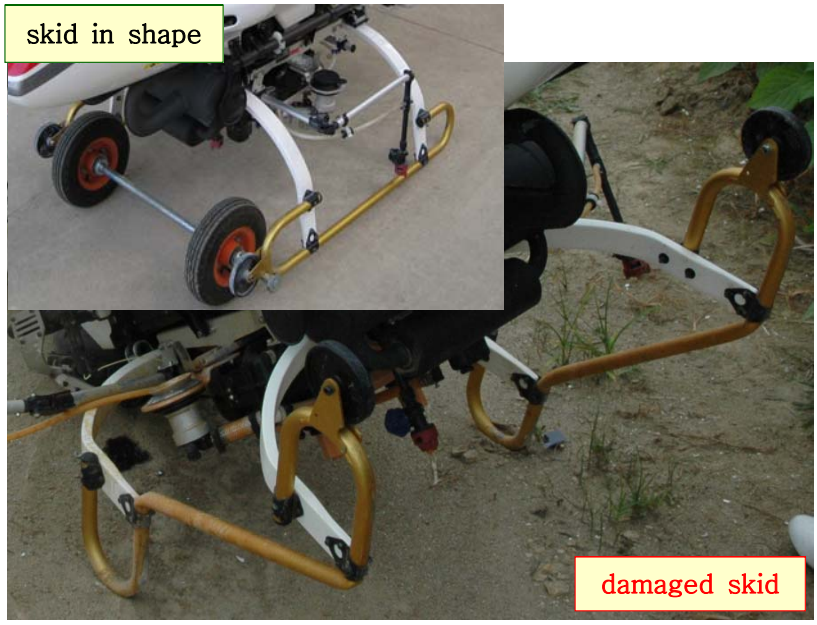


Photo 4. Skid damaged

1.3.3 Tail Boom

The tail boom was broken at the joint of the forward fuselage and aft fuselage by ground impact as shown in [Photo 5].

Photo 5. Tail boom damaged

1.3.4 Radio Control Box

The front and rear case of the radio control box were broken as shown in the [Photo 6], and the inside circuit board was partially damaged due to the collision with rotor blades.

Photo 6. damaged radio control box found at the site

1.4 Other Damage

There was no other damage occurred in this accident.

1.5 Pilot Information

The pilot was hired by the Osu AC in May 2003 and has been worked at the Rice Processing Center (RPC)of the Osu AC. As the Osu AC decided to employ an unmanned rotorcraft for aerial spray as a part of farming support project for the AC members, he was selected as the pilot of unmanned rotorcraft along with another pilot.

He completed the initial training course provided by the importer from 11 to 29 February 2008 in accordance with the project plan of the Osu AC, and obtained a skill certificate (certification number 2008-47) in July 2008 from the Korea Agricultural Unmanned Helicopter Association[5].

5) A private association organized by agricultural unmanned helicopter pilots for evaluating and certifying the qualifications of agricultural unmanned helicopter pilots since there are no provisions for the qualifications of unmanned rotorcraft pilots in the current Aviation Act.

The pilot used to work at the RPC at normal times, and in the summer which is a season for aerial spray, he has been doing work of unmanned rotorcraft aerial spray for the sake of supporting the member farmers of the Osu AC.

The unmanned rotorcraft with which the pilot had flight training to obtain the skill certificate was of the same type as the S7044, and the pilot has been operating the same type of unmanned rotorcraft since his obtaining of the skill certificate.

However the pilot's total flight time could not be identified since he did not maintain his flight log in which he was supposed to record his flight time for each flight.

1.6 Unmanned Rotorcraft Information

The S7044 is an unmanned rotorcraft, model of RMAX L17 type, manufactured for aerial spray by the Yamaha Motor Company of Japan in May 2008, and it was introduced to Korea on 20 July 2008.

The maximum takeoff weight of the S7044 is 94 kg, and the length of the airframe is 3.63 m and the height is 1.08 m. About 18 ℓ of pesticide can be loaded for one time spray on the area of 2 hectares.

As of September 2009, a total of 75 units of RMAX L17 were introduced and in operation in Korea, and most of them, excluding those for pilot training, are being operated by the agricultural cooperatives or farming corporations for the purpose of aerial spray of pesticide.

1.6.1 Configuration and Major Functions of RMAX L17

The configuration and major functions of RMAX L17 are as follows;

- Composition
  - Airframe: lift generation device, engine, power transmission device, skid, spraying device, control panel and warning lights, radio receiver
  - Radio Control System: radio control box, pesticide spray radio controller
  - Others: battery set, radio interference detector, walkie-talkies

- Major functions
  - Automatic hovering function: With GPS in connection, hovering is automatically conducted when control signal cuts off.
  - GPS interfaced control function: With GPS interfaced, the unmanned rotorcraft maintains constant airspeed proportionately responding to pilot's control stick input. If GPS switch is not turned on, the acceleration is not controlled. Therefore a pilot should make an additional neutralizing control stick motion in order to control the acceleration of the unmanned rotorcraft.
  - Automatic descent function: With GPS in connection, when radio interference occurs or control signal cuts off, the unmanned rotorcraft descends to the ground automatically.

1.6.2 Operation of Radio Control Box and Movement of Unmanned Rotorcraft

The unmanned rotorcraft ascends or descends when the throttle control stick on the left front of the radio control box is moved up or down. When the throttle control stick is moved to the left or right, the

heading accordingly changes to the left or right. When the control stick on the right front of the radio control box is moved to the left or right, the unmanned rotorcraft banks to the left or right. When this control stick is pulled down, the swashplate[6] of the unmanned rotorcraft activates so that the rotorcraft moves rearward, and vice versa. The operation of the control stick and the movement of the unmanned rotorcraft is shown in Fig. 1 below;

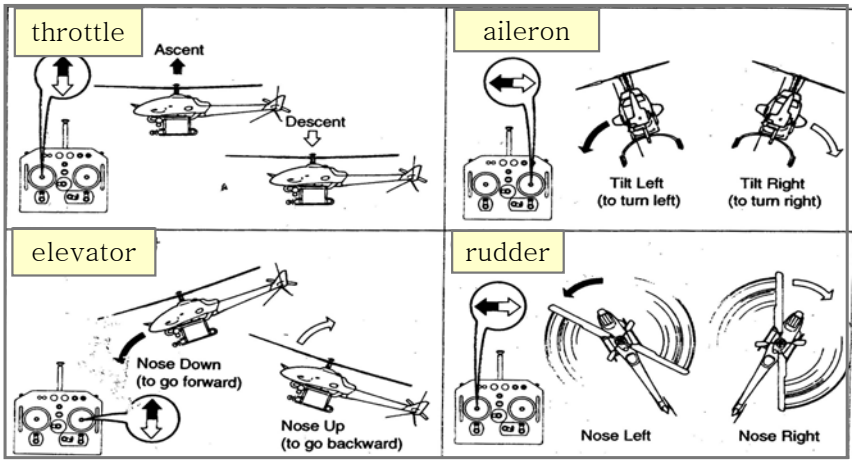


Fig. 1. Movement of control stick and the unmanned rotorcraft

1.6.3 Specifications of the Radio Control Box

- Frequency: 72 Mhz
- Coverage(effective/maximum): 150 ~ 200 m / 600 m (confirmed through test flight performed in the optimum circumstances)

The radio control box has a throttle, rudder, pitch and aileron trim switches for the sake of pilot's convenience in controlling the unmanned rotorcraft. The locations of these trim switches are as shown in [Photo 7].

6) A system for regulating the direction of main rotor and the quantity of thrust of rotor blade by regulating the pitch and tilt direction of rotor blade

Photo 7. Various trim switches of the radio control box

1.6.4 Certification of Safety and History of Maintenance

The S7044 was maintained in accordance with the methods specified in the manufacturer's maintenance manual since its introduction and was certified its safety on 15 May 2009 by the Korea Transportation Safety Authority.

No defect was recorded in the「Pre-flight and Post-flight check items」of the 2009「Flight Check Log」maintained by the Osu AC pilots.

According to the testimony of witnesses, the S7044 had no signs which could be judged as abnormal condition of the airframe or radio control box such as a noise, vibration of the airframe or abnormal response to the control signal of radio control box during the morning aerial spray flight.

1.6.5 History of Accident

The S7044 was caught in an electric wire and crashed during its inauguration aerial spray flight on 17 August 2008. The inauguration flight, which was ended in a crash, was carried out by the pilot of this accident.

The S7044 was repaired on 17 August 2008, the day of accident, by the Moosung Aviation. After repaired,[7] it returned to normal operation again.

1.7 Meteorological Information

The weather on the day of accident, as stated by the witnesses, was mostly cloudy and not windy with the temperature of about 30 degrees Celsius. Meanwhile, according to the official weather data of the Imsil Weather Office[8], which is the nearest one from the accident site, the weather around 14:00 and 15:00 were as follows;

14:00 - wind: easterly wind 1.7 m/s[9], temperature: 23.6 degrees Celsius, humidity: 74 percent

15:00 - Wind: southwesterly wind 1.2 m/s, temperature: 24.1 degrees Celsius, hu12midity: 72 percent

1.8 Aids to Navigation

Navigation aids are not a factor of this accident.

1.9 Communication

Communication is not a factor of this accident.

1.10 Takeoff Area Information

- Location and surface condition of takeoff area

7) 23 items including the clutch and housing assembly were replaced
8) Located 13 km north of the accident site
9) Meters per second

The takeoff area is located about 5 km south of the Osu-myeon Office. It is a concrete paved farm road[10] with the average width of 3.3 m, which lies in parallel with the embankment road south of the Dundeok Bridge as shown in [Photo 8]. Its surface was paved with cement concrete, and was partially covered with soil and sands.

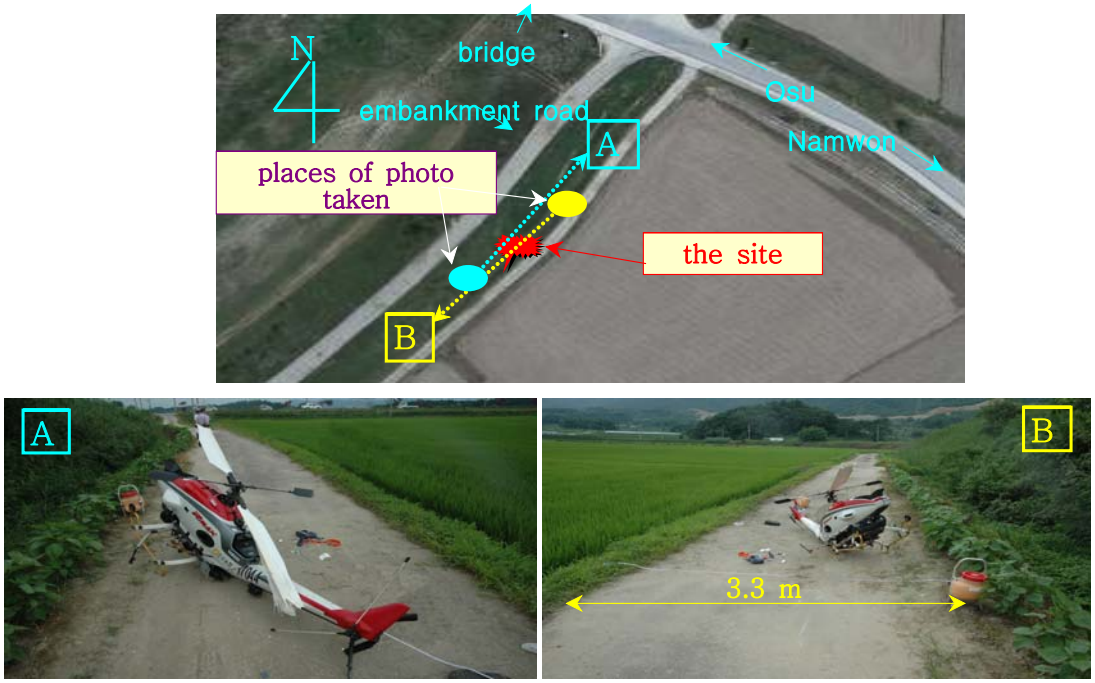


Photo 8. General view of the accident site

- Ambience of the accident site

The embankment road, located parallel to the farm road used as the takeoff area, is about 3 m higher than the farm road, and a waterway with a width of about 1 m lies between the embankment road and farm road.

1.11 Flight Data Recorder

1.11.1 General Information

The S7044 has a flight data recorder[11] installed. This flight data

10) The direction of the farm road is formed from southwest to northeast.
11) Type: R-MAX Type Ⅱ (first recorded first deleted method), manufacturer: YAMAHA Co. recording time: 100 seconds (record starts at engine RPM 3,000 ~ ends at engine RPM 1,500)

recorder, as installed in the S7044, was detained in the ARAIB.

The ARAIB downloaded the whole flight record data by using the flight data output equipment owned by the Moosung Aviation, the importer of the unmanned rotorcraft, in the presence of a representative[12] of Yamaha Motor Company, the unmanned rotorcraft manufacturer.

The ARAIB conducted precision analysis[13] of the downloaded flight record data at the Yamaha Motor Company of Japan from 7 to 10 September 2009.

The flight record data contained a total of 18 items[14] and 60 parameters. The ARAIB verified the circumstances immediately before the accident and flight situation at the time of accident by using these data.

1.11.2 The Results of FDR Analysis

The result of the precision analysis of the flight record data showed no evidence of troubles or malfunction of the S7044, and other analysis results are as follows;

In the graph of [Fig. 2], the red solid line at the top shows engine RPM[15] and the green solid line at the bottom shows the swashplate angle[16].

12) An instructor of the Moosung Aviation, Ltd.
13) Joint works in the presence of experts from Korea and Japan (ARAIB: 2, JTSB:1, Yamaha: 5)
14) Total 18 items: 3 for attitude, 2 for altitude, 2 for engine, 2 for communication, 5 for servo control, 4 for position.
15) Engine RPM is the number resulted from multiplying by 10 the numeral shown by the red line located on the left in the graph.
16) The swashplate angle of pitch direction refers to the green index on the right in the graph. The positive value is pitch up and the negative value is pitch down.

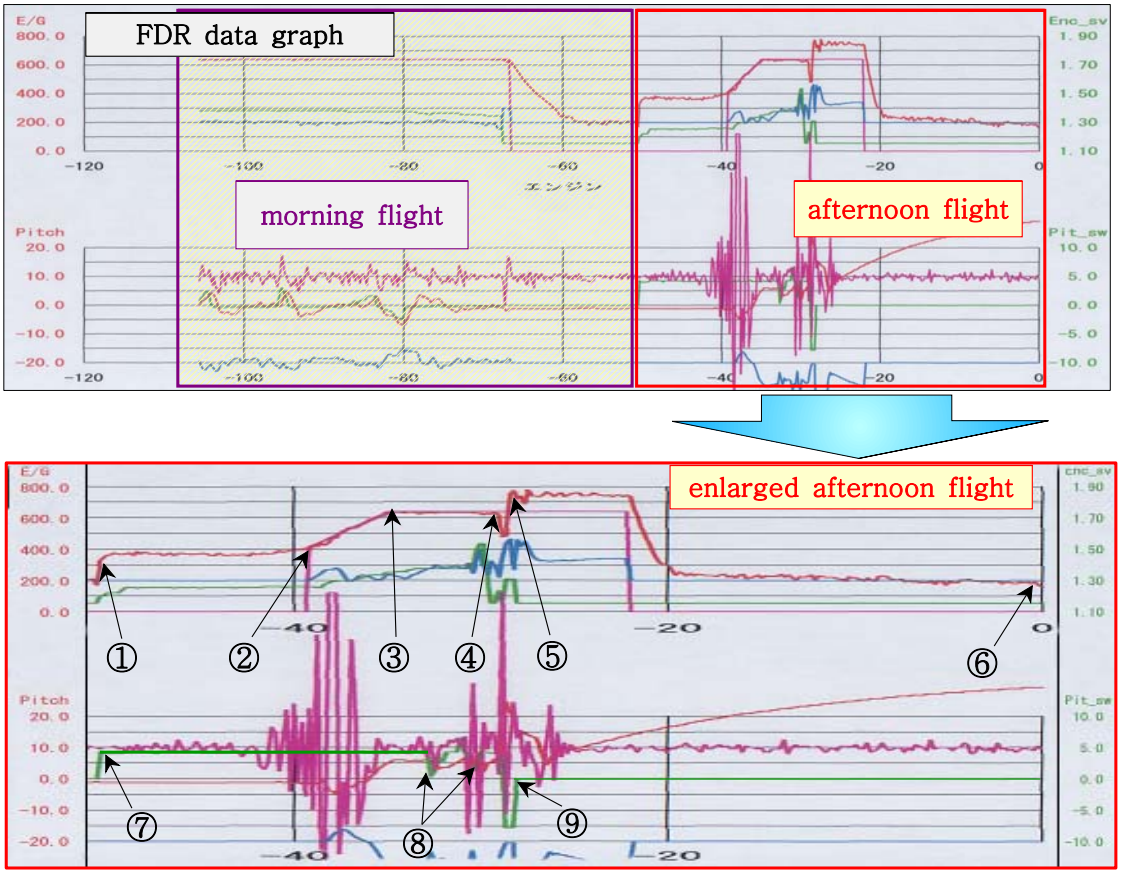


Fig. 2. Major event time verified with the flight record data

① : Time of starting data recording (engine RPM 3,250)

② : Engine RPM increases

③ : the S7044 takes off (engine RPM 6,150)

④ : Time at which the S7044 collides with the pilot

⑤ : Time at which main rotor blades are damaged (engine RPM increases)

⑥ : Engine stops operating (engine RPM decreases below 1,500)

⑦ : Point at which swashplate was pulled to pitch up: rearward flight operation

⑧ : Point at which swashplate was pushed to nose down (2 times): forward flight operation

⑨ : Time at which signal input of radio control cut off

a. Engine starting time was not identified from the FDR data. But considering that the recording started at or above engine RPM 3,000 and the time ① at which the recording of the flight data of afternoon aerial spray flight started is -50.4 second(engine RPM 3,250), the engine would have been started up before this time.

b. The swashplate at the position ⑦ on the graph showed that it was pulled backward (+4.8) already before takeoff.

c. The time of take off was estimated as -35.2 second, where the vibration of the S7044 was stabilized at the time ③ of engine RPM recorded 6,150.

d. Based on the vertical and horizontal acceleration and time, the flying altitude of S7044 was calculated as about 1~2 m high, and the flying distance until the time of collision was about 18 m .

e. The S7044 had the GPS switch "On" and "Off" two times before takeoff after engine start-up. After takeoff, it remained at "Off" position until crash. (-44.6, -40.6 time frame)

f. Before the S7044 collided with the pilot, the operation in which the swashplate was pushed forward for two times, was recorded ⑧.

g. The flight attitudes at the time when the S7044 eventually impacted the ground were pitch-up and right-banked, and the heading of S7044 from the time of engine start-up to crash remained in about 30 degrees of magnetic heading.

h. The time of -29.2 second was judged as the time at which the S7044 and the pilot collided each other, and is the point of time ④

where the engine RPM decreased suddenly to 4,800 RPM from the normal operation range of 6,300 RPM.

i. At the point of time ⑤ of -28.6 second, the engine RPM decreased to 4,800 RPM, and after 0.4 seconds it increased to 7,550 RPM again. This RPM jump could be explained that it was caused by partial breaking off of the main rotor blades due to the collision with pilot and ground.

k. The point of time ⑨ at which the signal of radio control to the S7044 was cut off, was -28.2 second.

1.12 Wreckage and Impact Information

No part of the S7044 was separated from the fuselage except that the main rotor blades were broken off. The pesticide canisters were separated from the airframe.

The radio control box was broken and lay between the pilot and the airframe.

1.13 Medical and Pathological Information

At the regular medical check-up[17] on 29 May 2009, the pilot was recommended that special care for the specific disease[18] was necessary.

17) Physical examination record of New Christian Hospital, Jeonju
18) A disease that could affect perception and motor ability

1.14 Fire

There was no fire occurred in this accident.

1.15 Survival Aspects

As soon as the accident occurred, the Guidance Executive and the aerial spray team leader ran to the pilot and gave an emergency treatment to the pilot. The Guidance Executive asked emergency rescue to the 119 Rescue Service using his mobile phone while he was giving the first aid.

The 119 Rescue Service received the phone call around 14:34, arrived at the site at 14:51, gave the first aid to the pilot, and transported him by ambulanceto the Namwon Hospital located in Namwon City. .

The 119 Rescue Service examined him at the site and found that the pilot was died. The cause of the pilot's death was determined as a hypovolemic shock caused by left femoral open fracture by the doctor of the Namwon Hospital.

1.16 Examination of the Radio Control Box

According to the FDR data[19], it was verified that the position of the swashplate was already in the pitch-up attitude[20] from the time of engine start until the crash.

In order to verify whether such position of swashplate was made by

19) At ⑦ in the lower portion of the graph of Fig. 2, the green line that appears until ⑧ proceeds in a certain waveform at +4.8.

20) The swashplate pitch-up attitude is set when the pilot pulled down the pitch control stick or the pitch trim switch is at a negative (-) position.

the signal from the operation of the pitch control switch or the pitch trim switch of the radio control box, the ARAIB conducted a flight test in an open area near Pyeongtaek city on 15 September 2009 using the same type of unmanned rotorcraft of in the presence of related personnel.

Through the flight test aimed at finding out the pitch trim switch position that identically matches the pattern of signal appeared in the FDR, the position of pitch trim switch was estimated as positioned at the pitch-up 3 unit until the time of the crash. This estimation was made on the basis of the followings;

a. As shown in the graph of [Figure 3], there was a prominent difference[21]in the wave pattern between the one(in the red rectangle) made by the pitch control switch and the other one(in the blue rectangle) made by the pitch trim switch. Considering the flat wave pattern, the S7044′s swashplate pitch up attitude is judged as the result of operation by the signal made from the pitch trim switch rather than from the pitch control switch.

b. The swashplate pitch up attitude of +4.8 recorded in the S7044′s FDR was reproduced when the pitch trim switch was at the pitch up 3 unit.

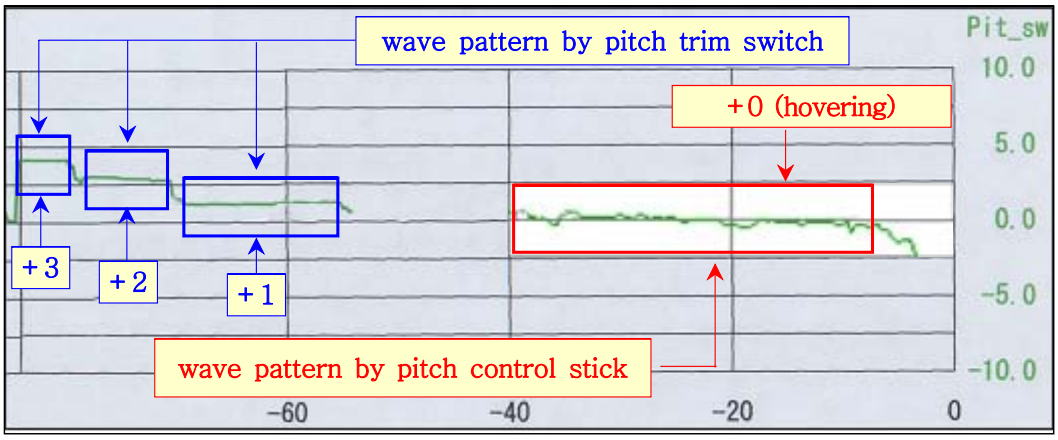


Figure 3. Flight test result pitch signal displacement graph

21) By pilot's manual control, the graph wave pattern showed high amplitude and dense frequency, whereas the wave pattern by trim switch appeared flat.

But the position of pitch trim switch of the radio control box photographed right after the accident was at the pitch-up 1.5 unit, so it did not agree with the result of flight test which indicated 3 unit.

So ARAIB conducted an examination[22] at the radio control box manufacturer's factory[23] from 20 through 22 October 2009 to verify the possibility of radio control box malfunction.

The examination results showed no defects in the functions of the radio control box. If the radio control box was operating normally, +4.8 position of the swashplate should have been resulted from the setting of the pitch trim switch at the pitch up 3 unit, and the pitch up 1.5 unit is estimated to be the result of the pitch trim switch position distortion caused by impact, etc.

The other results of the examination for the radio control box are as follows;

a. The radio control box had the left portion of the outer case broken by the collision with main rotor blades.

b. Damage to the circuit board was caused by a strong contact with the metal switch shaft inside.

1.17 Organizational and Management Information

1.17.1 Organization, Flight Management and Supervision of Aerial Spray Team

22) Joint investigation in which total 8 Korean and Japanese accident investigators and experts (ARAIB : 2, JTSB : 1, YAMAHA : 2, manufacturer : 3) participated
23) JRPROPO Company located in Masujaka City, Mie-gen, Japan

- Organization of the Osu AC aerial spray team

The Osu AC aerial spray team has been temporarily operated only in the aerial spray season. The team has been managed by the Guidance Executive of the Osu AC .

The aerial spray team is composed of three persons including a aerial spray team leader[24] and two pilots[25](a pilot and a co-pilot), and aerial spray is a job that is being assigned to the team members in addition to their own normal works.

For the job of unmanned rotorcraft pilot, volunteers who have relatively less workload were selected. Other than this, there were no special criteria for the pilot selection.

- Management and supervision of aerial spray flight

The aerial spray team leader had no training for unmanned rotorcraft operation. Two pilots completed the training course and obtained relevant certificates of qualification.

The Guidance Executive has not practically been engaged in unmanned rotorcraft aerial spray. He only supports administrative works for smooth performance of the aerial spray.

The aerial spray team leader is in charge of the aerial spray safety

24) Position: supervisor, duties: bond management / AC member management / aerial pest control safety management

25) Pilot #1(Accident operator) Position: specially appointed, duties: Crop treatment plant engineer/ low temperature warehouse management / operation and management of unmanned rotorcraft
Pilot #2 Position: specially appointed, duties: farm machinery repair center engineer / operation and management of unmanned rotorcraft

management. However, having no technical knowledge, he has been only taking actions to support the pilots on request.

Usually at the aerial spray site, the unmanned rotorcraft is operated by two persons, a pilot and a co-pilot, by turns. The team leader and the co-pilot used to assist the pilot in identifying the boundary using walkie-talkies at the boundary points of the aerial spray area, or refill the pesticide canisters when each round of aerial spray is completed.

On the day of accident, one pilot was absent for vacation, so the Guidance Executive substituted for him to act as a co-pilot.

Other than the manufacturer operation manual and guidance, there were no detailed operation standards or safety management guidance necessary for flight safety, such as the Osu AC's own daily flight time limitation or aerial spray operation limitation according to weather conditions.

1.17.2 Training provided by the Moosung Aviation

The initial training course provided for unmanned rotorcraft pilots by the Moosung Aviation, the importer of RMAX L17, takes three weeks in all. This training is composed of class room courses and flight control practices.

The content of class room courses is composed of flight theory, simulator training, relevant laws and regulations and aerial spray procedures. The flight control practices include hovering, takeoff and landing and aerial spray, and the practices utilize both the simulator and unmanned rotorcraft.

In addition to the initial training course, the Moosung Aviation provides the pilots with on-site training for the sake of safety before each aerial spray season starts. According to the statements of the Moosung Aviation's personnel, the interest and participation rate of the managers and pilots in this on-site training were not so high.

The on-site training for the year of 2009 included an instruction to verify the setting of various trim switches in neutral position before each flight.

1.17.3 Certification of Pilot Qualifications

Pilot of unmanned rotorcraft is not subject to obtain any certificate from the Minister of Land, Transport and Maritime Affairs. Thus, the Korea Agricultural Unmanned Helicopter Association (hereinafter referred to as "Unmanned Helicopter Association"), an incorporated association, issues pilot's skill certificates as needed by the association members, such as the Osu AC.

Evaluation for issuing the skill certificate is charged to the training instructors of the Moosung Aviation. According to the statistics made by the Moosung Aviation, the average pass rate was 96% or more, and in 2008 a 100% pass rate was recorded as well.

1.18 Other Information

1.18.1 Manual and Guidance for Agricultural Unmanned Rotorcraft

1.18.1.1 Unmanned Rotorcraft Operation Manual

The Operation Manual for agricultural unmanned rotorcraftr was

published by the Yamaha Motor Co. and translated into Korean and distributed by the Moosung Aviation. This Manual contains safety notes, specifications, pre-flight preparations and checks, flight procedures, etc.

The contents of the Operation Manual related to this accident are mainly as follows;

• Safety notes for unmanned rotorcraft operation

- At least 3 persons are necessary for aerial spray.
- Since operation of an unmanned rotorcraft brings about mental fatigue, flight for more than one hour without rest should be avoided.
- A person with unhealthy condition is not allowed to fly the unmanned rotorcraft.
- Staying within 15 m around an unmanned rotorcraft is not allowed until the main rotor blades completely stop .
- Flight is not allowed when wind speeds, measured at 1.5 m above ground level, is more than 3 m/sec.

• Pre-flight preparations and checks

- Before flight, battery charge, operation of the radio control box and the antenna should be checked.
- Operation check of the radio control box is to verify the operational condition of the alarm and the output lamp of the radio control box.

※ But actually the check items of the radio control box did not include the checking of various trim switches position.

1.18.1.2 Pilot Flight Check Log

The 「Pilot Flight Check Log」 is an operational record in the form of a journal which was made by the Moosung Aviation and the Unmanned Helicopter Association and distributed to the pilots. This log contains aerial spray working schedules and results, as well as the checklists of the unmanned rotorcraft to be used by the pilots before and after the aerial spray work at each area.

The types of checklists contained in this log are as follows;

- Daily Checklist
  - A checklist for checking the airframe and the radio control box for each systems (See Figure 4)

- Cleaning Checklist

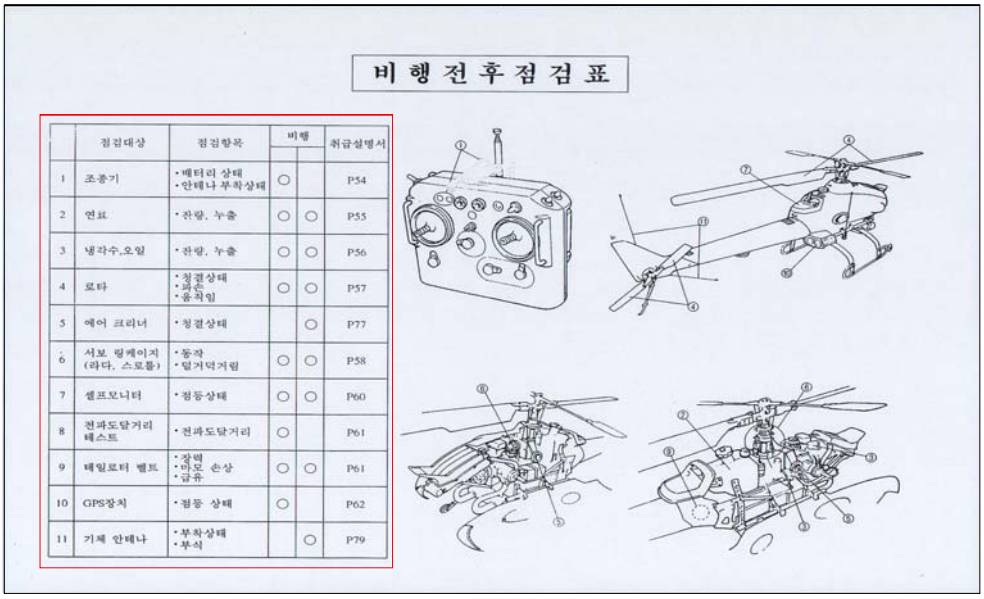
- Pre-flight and Post-flight Checklist
  - A checklist containing the items to be checked before and after flight (See Figure 5)
  - Identical to the Daily Checklist items

- Airframe Checklist (See Figure 6)
  - Same items with the Pre-flight and Post-flight Checklist
  - Possible to record only for one flight per day regardless of total number of flight.

일 일 점 검 사 항

	점 검 구 역	검 사 항 목	검 사 내 용	비 고
1	기체 우측	• 외부의 청결 상태 • 착륙장치의 상태	-긁힘,찍힘,균열,마모	
2	엔 진	• 점화플러그와 배선의 연결 상태 • 냉각수의 수위, 누수 여부 • 데몰프 밸브 유격 • 카브레이터 라인 누유 여부 • 메인 인선 오일 및 냉각수의 누유 여부		
3	에어 크리너	• 크리너 안의 청결 상태 • 케이스의 균열 손상 여부		
4	메인 로타	• 메인 로타의 축수, 축간 검사 • 로타 고정 볼트의 조임 상태 점검	-긁힘,찍힘,균열,마모	
5	메인 로타 계통	• 스테빌라이저의 상태 • 각 링크의 조임 상태 • 스트레이트 서보 콘넥터 점검	-긁힘,찍힘,균열,마모	
6	연료 탱크우측	• 기체와 연료탱크의 장착 상태 • 케이스의 손상여부 • 연료의 누유 여부, 증반 상태 • 캡의 조임 상태	-긁힘,찍힘,균열,마모	
7	테일 계통	• 테일 드라이브 샤프트의 상태, 오일 밀 확인 • 각 배선의 연결 상태 • GPS의 장착 상태 • 테일붐의 청결 상태		
8	테일 로타	• 테일 로타의 청결 상태 • 피치링크 베어링의 유격 • 송수신 안테나의 장착상태	-긁힘, 찍힘, 균열, 마모	
9	테일계통	• 마그네틱 플파스의 장착 상태 • 중간 기선의 오일 누유 여부 • 벨트의 장력 상태 확인	-테일로타 19회전= 벨트 1회전	- 스프레이 윤활제 급유
10	G P S	수신부 장착 상태		
11	연료 탱크 좌측	• 연료필터의 청결 상태, 고정 상태 • 연료 센서 점검		
12	배 터 리	• 배터리와 배선의 장착 상태 • 배터리 케이스의 균열 여부		
13	기체 좌측	• 외부의 청결 상태 • 착륙장치의 상태		
14	전기계통	• 조종기의 배터리 상태 • 전파체크 • 셀프 모니터의 점등 상태 • GPS지시등 및 경고등 점등 여부 • 스트레이트 / 회전서보의 움직임 상태 확인 • 트로틀 레버의 아이들 위치 확인	-안테나, 트림위치 점검 -스틱의 위치가 아래일때 높이에 점지 -스틱의 위치가 위쪽일때 마운트에 점지 (트림위치5~10이내안의 유격 이상무) -50M이동 하면서 서보의 움직임 확인	
15	부수장비	• 살로 장치의 장착 상태 • 살로 장치의 절상 작동 여부	-노즐의 막힘 여부	

Figure 4. Daily checklist



비 행 전 후 점 검 표

	점검대상	점검항목	비행		취급설명서
1	조종기	• 배터리 상태 • 안테나 부착상태	○		P54
2	연료	• 잔량, 누출	○	○	P55
3	냉각수,오일	• 잔량, 누출	○	○	P56
4	로타	• 청결상태 • 파손 • 움직임	○	○	P57
5	에어 크리너	• 청결상태		○	P77
6	서보 링케이지 (라다, 스로틀)	• 동작 • 덜거덕거림	○	○	P58
7	셀프모니터	• 점등상태	○	○	P60
8	전파도달거리 테스트	• 전파도달거리	○		P61
9	테일로터 벨트	• 장력 • 마모 손상 • 급유	○	○	P61
10	GPS장치	• 점등 상태	○		P62
11	기체 안테나	• 부착상태 • 부식		○	P79

Figure 5. Pre-flight and Post-flight checklist

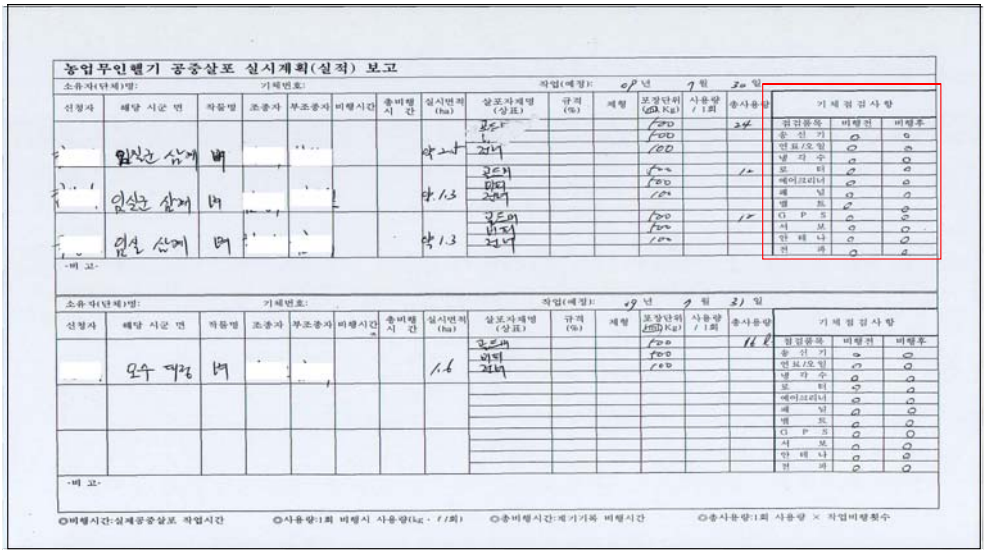


Figure 6. Airframe checklist

1.18.1.3 Working Guidance for Insect Pest Control

The 「Working Guidance for Insect Pest Control」 prepared and distributed by the Unmanned Helicopter Association, contains the items necessary for conducting the aerial spray work safely and efficiently.

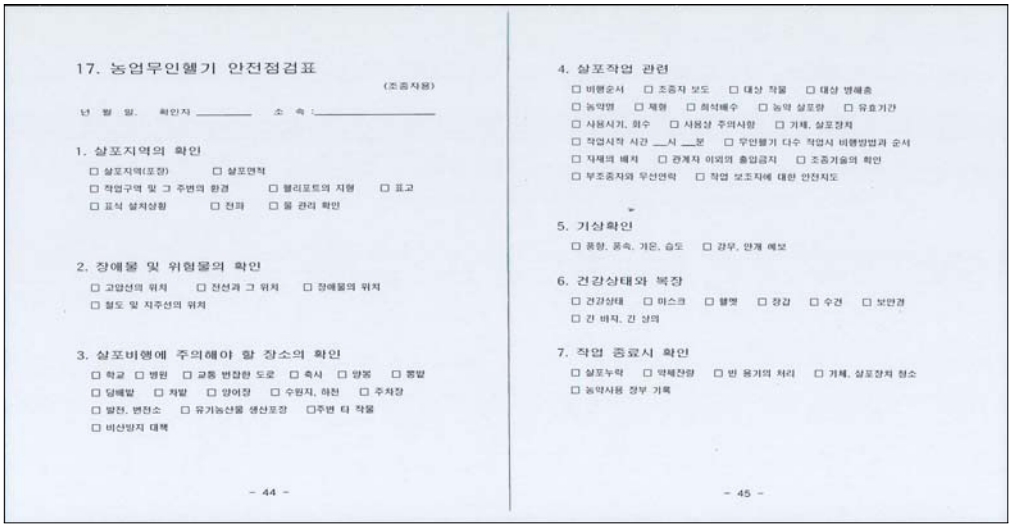
The items to be performed before aerial spray work (See Figure 7), which put an emphasis on working procedures, whereas the checklists of the「Pilot Flight Check Log」focus on airframe check.

※ But some check items, such as confirming operating skill and arrangement of material, are ambiguous in word, and are not appropriate to be included in the checklist due to their characteristics.

Other operational limitations are as follows;

- Weather limitations: Wind speed 3 m/s at 1.5 m above the ground
- Minimum separation between the airframe and pilot and other persons: 15 m

- Maximum operating distance: 150 m
- Spray time restriction: Before noon, at least one rest per hour
- Spray flight speed: 10 ~ 20 Km/h
- Roles of co-pilot: To ensure safety by sharing the works and assisting the pilot in the aerial spray site. The co-pilot shall be able to operate the unmanned rotorcraft
- Make prompt countermeasures by coordinating with the person in charge when the aerial spray work plan is changed



17. 농업무인헬기 안전점검표

(조종자용)

년 월 일. 확인자 _____ 소 속 :_____

1. 살포지역의 확인

□ 살포지역(포장) □ 살포면적
□ 작업구역 및 그 주변의 환경 □ 헬리포트의 지형 □ 표고
□ 표식 설치상황 □ 전파 □ 물 관리 확인

2. 장애물 및 위험물의 확인

□ 고압선의 위치 □ 전선과 그 위치 □ 장애물의 위치
□ 철도 및 지주선의 위치

3. 살포비행에 주의해야 할 장소의 확인

□ 학교 □ 병원 □ 교통 번잡한 도로 □ 축사 □ 양봉 □ 통발
□ 당배밭 □ 차밭 □ 양어장 □ 수원지, 하천 □ 주차장
□ 발전, 변전소 □ 유기농산물 생산포장 □주변 타 작물
□ 비산방지 대책

- 44 -

4. 살포작업 관련

□ 비행순서 □ 조종자 보도 □ 대상 작물 □ 대상 병해충
□ 농약명 □ 제형 □ 희석배수 □ 농약 살포량 □ 유효기간
□ 사용시기, 회수 □ 사용상 주의사항 □ 기체, 살포장치
□ 작업시작 시간 __시 __분 □ 무인헬기 다수 작업시 비행방법과 순서
□ 자재의 배치 □ 관계자 이외의 출입금지 □ 조종기술의 확인
□ 부조종자와 무선연락 □ 작업 보조자에 대한 안전지도

5. 기상확인

□ 풍향, 풍속, 기온, 습도 □ 강우, 안개 예보

6. 건강상태와 복장

□ 건강상태 □ 마스크 □ 헬멧 □ 장갑 □ 수건 □ 보안경
□ 긴 바지, 긴 상의

7. 작업 종료시 확인

□ 살포누락 □ 약제잔량 □ 빈 용기의 처리 □ 기체, 살포장치 청소
□ 농약사용 장부 기록

- 45 -

Fig. 7. Before-work check items of the Working Guidance

1.18.2 Regulations Related to Unmanned Rotorcraft

According to Paragraph 28 of the Article 2 (Definitions), the Aviation Act, this unmanned rotorcraft is categorized as an ultralight vehicle, and falls under the unmanned powered vehicle.

According to the Article 23 (Ultralight vehicles, etc.) of the same Act, an unmanned powered vehicle shall obtain, from the Korea Transport

Safety Authority, a safety certificate certifying its conformity with the technical standards for flight safety which was established and promulgated by the Minister of Land, Transport and Maritime Affairs.

But according to the Article 66-2 of the Enforcement Regulations of the Aviation Act that specifies the qualifications standards of the pilot, the person who utilizes an unmanned rotorcraft to fly is not subject to be certified that he/she is in conformity with the qualifications standards.

2. Analysis

2.1 General

The S7044 was lawfully certified of safety and has been maintained in accordance with the methods and procedures issued by manufacturer. No meteorological factors affected this accident.

In connection with this accident, the ARAIB analyzed with focus on the pitch trim switch setting, pilot's performance, the Osu AC's management and supervision of the aerial spray operation, pilot training, the types and use of the checklist in the「Pilot Flight Check Log」.

2.2 Pitch Trim Switch Setting

According to the statements of the witnesses and the result of FDR analysis, the S7044 took off with safety distance secured about 15 m ~ 20 m. the S7044 started to move rearward after takeoff and collided with the pilot in 6 seconds. According to the test flight and the results of analysis of the FDR, it was revealed that the S7044′s rearward moving was attributed to the pitch trim switch setting at the pitch up 3 unit, rather than to the pilot′s pitch control switch operation.

On normal occasions, pilots would not make an unmanned rotorcraft take off with the pitch trim switch setting at pitch up 3 unit. Therefore, considering that the circumstances were not such as to set the pitch trim switch manually at the pitch up 3 unit, the setting of the pitch trim switch at pitch up 3 unit is determined to be not the pilot′s intention. And the possibility of the pitch trim switch setting by any person other than the pilot is estimated very low, considering the statements of the

witnesses and other circumstances.

Therefore, the ARAIB determined the cause of the improper pitch trim switch setting is that, in the process of storing or transporting the radio control box after completion of the morning work, the pitch trim switch was positioned at the pitch up 3 unit unintentionally. And such improper setting was not checked out by the pilot before the afternoon work.

2.3 Pilot Performance

2.3.1 Preflight Check

The aerial spray team of the day of accident was composed of the team leader, the pilot and the Guidance Executive. Among the team members of the day, there were no person who can operate the unmanned rotorcraft other than the pilot.

According to the「Working Guidance for Insect Pest Control」, it is recommended that the aerial spray team should have at least two persons who can operate the unmanned rotorcraft. This recommendation follows the manufacturer's operational concept that, in the stages of checking, starting engine and spray working, proper division of workload among the persons who are able to fly an unmanned rotorcraft is necessary.

At the day of the accident, the pilot checked the unmanned rotorcraft, started engine and made the take off without co-pilot's assist. In such a case, the pilot might have more chances of committing error, such as omission of a check item, careless performing of checklist, than when he was assisted by a co-pilot.

In this context, the ARAIB does not exclude the possibility of correlation between the improper pitch trim switch setting undetected and the absence of a co-pilot.

2.3.2 GPS Switch Operation

After starting up the engine, the pilot turned the GPS switch on twice on the ground. This is suggestive that the pilot made unnecessary action hastily while the GPS indication lamp was not illuminated after the engine start-up as the reception of GPS signal was defective at the time. This could be a circumstantial evidence that the pilot was not familiar with the GPS operating procedures.

If the GPS switch is not turned on after an unmanned rotorcraft lifts off, it loses the acceleration control function, then the pilot should make an additional stick control to keep the unmanned rotorcraft from moving by its momentum. In this accident, such an accelerative response of the unmanned rotorcraft combined with rearward-moving command of the pitch trim switch set at 3 unit, might be somewhat different from that he usually experienced during his routine flight.

2.3.3 Operation of the Radio Control Box

While the S7044 was moving toward the pilot, he seemed to try to stop the unmanned rotorcraft by pushing the pitch control stick forward twice. But the way of the pilot's pitch control stick handling, that is, the corrective control input, was not appropriate to stop the S7044's rearward-movement. To stop the S7044, pitch control stick should have been pushed in a prolonged way.

[Figure 8] below shows the corrective control input of the pitch

control stick performed by the pilot to stop the S7044's rearward-movement. The duration of one input appears a little longer than one second, and amount of the input is 4.8.

Figure 8. Pilot's corrective input taken immediately before collision

[Figure 9] below shows the movements of the pitch control stick taken by pilot to stop the S7044's rearward flying in which the pitch trim switch is set at 1, 2 and 3 unit respectively in the test flight. It is shown that in order to stop the S7044's rearward-movement when the pitch trim switch is set at 3 unit, pitch control stick input of 12.3 (from swashplate position 4.8 to -7.5) is required.

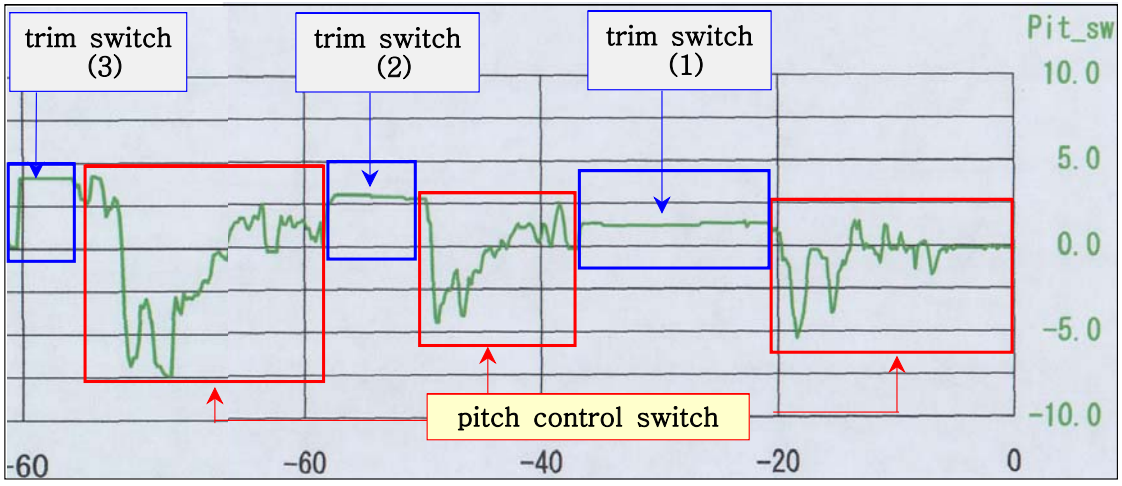


Figure 9. Corrective inputs shown in the test flight

From two figures shown above, it is revealed that the two momentary control stick inputs made by the pilot were not enough to stop the S7044's rearward movement in its quantity and time duration.

2.3.4 Actions taken by the Pilot to Avoid a Collision

As soon as the S7044 took off, it moved rearward to the pilot about 18 m in about 6 seconds. Even considering the acceleration for the elapsed time, the speed at the time of collision was in the range of normal operation speed[26]. The 15 m or more of the safety distance between a pilot and an unmanned rotorcraft, that is specified by the manufacturer, is considered to be established to allow the pilot to take required response and actions in case of abnormal movement of the unmanned rotorcraft.

The safety distance of 15 m was secured between the pilot and the S7044, and the results of test and examination showed that the S7044 and the function of the radio control box were normal. Then, the facts of that the S7044's flying rearward to the pilot was not recognized early enough, that the corrective inputs by the radio control was not enough to stop the S7044's flying, and that the pilot tried to avoid collision with the S7044 by stepping backward only are the supporting evidences that the pilot's situational awareness and avoidance actions were not sufficient.

In addition, notwithstanding the evident contribution of human error to this accident, it still remains in doubt that a 15 m of safety distance is sufficient enough to clear itself from being considered as another

26) According to the Operation Manual, the normal operation speed is 10~20 km/hour (2.7~5.5 m/sec)

contributing factor to this accident. According to the theory of behavioral scientist, it usually takes 1 to 2 seconds for average human to percept stimulus, process and respond accordingly. In this connection, a 15 m of safety distance seems to be not sufficient to provide the pilots with enough protection against abnormal movement of the unmanned rotorcraft.

2.3.5 Summary of Pilot Performance

In summary, the improper pitch trim switch setting that was not checked out at the preflight check stage possibly by an ommission or careless performing of the checklist, and thereby followed by an unexpected movement of the unmanned rotorcraft which was different from his usual experience, and that proper corrective action was not performed during the rearward-movement, are determined to be the direct causes of this accident.

2.4 Operation of the Osu AC Aerial Spray Team

The aerial spray work is required in Summer time only, so the Osu AC is operating the aerial spray team in Summer.

But that the Osu AC did not have its own safety procedures for the aerial spray work, that the aerial spray team was assembled extemporaneously on the day of this accident, and that the configuration of the team did not conform to the guidance established by the manufacturer that at least two persons should be qualified as the unmanned rotorcraft pilot, could be interpreted that the safety management and supervisory activities of the Osu AC did not function properly.

In order to properly operate and supervise the aerial spray team, the Osu AC needs to establish its own safety procedures. In addition, the unmanned rotorcraft manufacturer should provide the operators with detailed grounds which are necessary in establishing safety procedures.

2.5 Training of the Pilots

According to the pilot training records and the results of evaluation made by the Moosung Aviation instructors, the knowledge and skill of the pilot were marked as generally good. But the pilot had once experienced an occurrence of his unmanned rotorcraft colliding with the wire due to carelessness at his first aerial spray work in 2008.

The facts that the pilot having evaluated as generally good in training was involved in two accidents, and that 61 out of 75 unmanned rotorcraft, in the same type, registered in the republic of Korea experienced of safety events due to pilot's human error, suggest that there might be matters of concern with the training programme of the Moosung Aviation.

The ARAIB took note of the fact that a preventive programme for human error that accounts for the most of causes of unmanned rotorcraft safety events, were not included in the Moosung Aviation's training programme.

In order to reduce the safety events caused by human error, it is judged that a human error prevention programme should be developed and included in the training programme.

And the ARAIB found out that, other than the initial training provided by the Moosung Aviation and the test operation at the

beginning of each aerial spray season, there was no recurrent training for the pilots to maintain their skill.

In this accident, the facts that the action for stopping the unmanned rotorcraft flying rearward was not adequately taken, and that the avoidance maneuver was not decisively made, are considered to be caused by an immature skill of the pilot, and the immature skill seems to have its roots in the absence of recurrent training for the pilotl.

Based on such analysis, the ARAIB determined that it is necessary for the operator, with support of the manufacturer, to improve the training method and develop training requirements for maintenance of pilot's skill.

2.6 Checking Trim Switches and Method of Using the Checklist

2.6.1 Procedures for the Trim Switch Check

The documents necessary for unmanned rotorcraft operators and pilots to operate and manage unmanned rotorcraft include the「Operator Manual」published by the manufacturer and「Pilot Flight Check Log」and the「Working Guidance for Insect Pest Control」established by the Unmanned Helicopter Association. These documents contain various checklists necessary for performing the aerial spray works.

As a result of reviewing the「Operator Manual」, it was found that, in the Pre-flight checklist, there was no item for checking the radio control box trim switches. The trim switch check is clearly stated in the Daily checklist of the「Pilot Flight Check Log」which pilots accompany with at the work site, but there was no item for checking the position of trim switches in the radio control box.

If checking of the position of various trim switches had been clearly stated in the preflight checklist of the「Operator Manual」and if the Pre-flight and Post-flight checklist of the「Pilot Flight Check Log」had contained the procedures of checking the position of trim switches, the improper setting of pitch trim switch by carelessness could have been avoided.

2.6.2 Pre-flight and Post-Flight Checklist and its Usage

The Pre-flight and Post-flight checklist containing the items to be checked before and after flight should be used for each flight, but the form of the Pre-flight and Post-flight checklist contains only a list of objects and items to be checked, and is to record just once per day. The current Pre-flight and Post-flight checklist in the booklet form cannot afford the multiple-flights of a day and also it is not handy for the pilots to carry.

Therefore, to ensure that this checklist is effectively used by the pilots at the site, it is necessary to improve its format to enable the multiple-flight use and easy carry.

In addition, if the 'challenge and response' method,in which one pilot calls out the check item and another pilot takes action accordingly, is adapted, it would help the pilots perform the checklist effectively.

2.7 Design of Trim Switches

The exact reason of the pitch trim switch setting at pitch up 3 unit was not determined. But considering that the function of the S7044 and radio control box were found normal through the examination and that the wave pattern of pitch control radio signal shown in the FDR did not

seem to be controlled by the pilot, the ARAIB estimated that the pitch trim switch was unintentionally set at the position of the pitch up 3 unit by somebody or by a negligent contact with other object.

All the trim switches are convex feature on the surface of the radio control box as shown in [Photo 9] below, so that there exists a high possibility of setting change caused by careless handling. To prevent the risk of unintentional change of switch setting by mistakes, the design of trim switches and panel and/or relevant software modification should be considered.

Photo 9. Convex trim switches on the panel of radio control box

3. Conclusion

3.1 Findings

1. The pilot of S7044 completed an unmanned rotorcraft pilot training course provided by the importer of the rotorcraft, and held a skill certificate issued by the Korea Agricultural Unmanned Helicopter Association.

2. The S7044 was certified of the airframe safety by the Korea Transportation Safety Authority, and was maintained in accordance with the methods established by the manufacturer.

3. There was no evidence of any pre-existed system failures of S7044.

4. Weather was not a factor in this accident.

5. According to the analysis of FDR and the result of the radio control box examination, there was no system failure of S7044 and malfunction of the radio control box.

6. Based on the analysis of FDR and the results of fight test, it was concluded that the pitch trim switch was already set at pitch up 3 unit from the time of engine start.

7. The improper pitch trim switch setting at pitch up 3 unit was not recognized and corrected before the afternoon aerial spray flight.

8. The pilot had maintained at or more than 15 m of safety distance from the S7044 at the time of engine start.

9. The S7044 was taken off while valid GPS signal was not available.

10. The pilot did not turn the GPS switch on after airborne of S7044 while valid GPS signal was available.

11. The pilot tried to stop the rearward movement of rotorcraft, but his signal input to the rotorcraft was not sufficient enough to stop the rearward movement.

12. S7044 flew 18m rearward for 6 seconds after takeoff, and crashed on the ground after collision with pilot.

13. There was no human error prevention programme for the pilots in the training syllabus of the unmanned rotorcraft importer.

14. There was no method and requirements of training for the pilots to keep up with their proficiency after the initial training.

15. The requirements of the manufacturer that at least two of the aerial spray team members should be certified pilots, was not met.

16. The safety regulations of the Osu AC regarding the aerial spray work were insufficient and the supervision of the safety management did not work properly.

17. The provision of the「Working Guidance for Insect Pest Control」 that prohibits the aerial spray work during afternoon time was not observed.

18. There was no items checking if the trim switches are set at the 'zero' position, in the 「Operator's Manual」.

19. It is very likely that the position of trim switches convex on the surface of the radio control box can be changed by careless handling.

20. The Pre-flight and Post-flight checklist was not convenient to use due to its booklet form, and was only listing the objects and items to be checked without a guidance on how to use.

21. A 15 m of safety distance was considered to be not sufficient to provide the pilots with enough protection against abnormal movement of the unmanned rotorcraft.

3.2 Cause

The Aviation and Railway Accident Investigation Board determines that the cause of this accident was:

1. An inadequate setting of pitch trim switch at the pitch up 3 unit was not recognized and corrected, and the rearward movement of the rotorcraft was not properly controlled.

Contributing to this accident were :

1. The safety regulations of the Osu AC regarding the aerial spray work were insufficient and the supervision of the safety management did not work properly.

2. There was no items checking if the trim switches were set at the 'zero' position, in the 「Operator's Manual」.

3. A 15 m of safety distance was considered to be not sufficient to provide the pilots with enough protection against abnormal movement of the unmanned rotorcraft.

4. There was no method and requirements of training for the pilot to keep up with their proficiency after the initial training.

4. Safety Recommendations

As a result of the investigation of the S7044 unmanned rotorcraft accident occurred on 3 August 2009 at Imsil-Gun, Republic of Korea, the Aviation and Railway Accident Investigation Board makes the following safety recommendations;

To the Osu Agricultural Cooperative:

1. Establish and implement the safety procedures of the aerial spray works containing the followings (UAR0903-1);

   a. Personnel composition of the aerial spray team,
   b. management and supervision of the aerial spray works, and
   c. working conditions of pilots and limitation on successive working hours

2. Add the trim switches position check item to the checklist in the 「Pilot Flight Log」(UAR0903-2);

3. Consider the adaption of the 'challenge and response' method in which one pilot calls out the check items loud and another pilot takes action accordingly (UAR0903-3); and

4. Improve the current training programme in order to reduce the number of safety occurrence caused by human error, to include but not limited to (UAR0903-4);

   a. a human error prevention programme, and
   b. training methods and requirements for the pilots to keep up with proficiency.

To the Yamaha Motor Company:

1. Consider the improvement of the trim switches and panel of the radio control box and/or modification of relevant software , including the disabling of engine start if the trim switches are inadequately set, to prevent the risk of unintentional switch setting by an inadequate handling (UAR0903-5);

2. Provide the unmanned rotorcraft operators with the detailed grounds which are necessary in establishing safety procedures (UAR0903-6);

3. Add a procedure for checking the position of trim switches of the radio control box in the「Operator's Manual」(UAR0903-7); and

4. Reconsider the appropriateness of the 15 m of current safety distance between pilot and unmanned rotorcraft (UAR0903-8).