



FINAL REPORT

AIC 20 - 1001

Applus Wokman

DJI Matrice 210 RTK

RPA collision with pylon during aerial inspection

**PNG ExxonMobil Marine Terminal,
20km Northwest of Port Moresby**

PAPUA NEW GUINEA

14 November 2019



About the AIC

The Accident Investigation Commission (AIC) is an independent statutory agency within Papua New Guinea (PNG). The AIC is governed by a Commission and is entirely separate from the judiciary, transport regulators, policy makers and service providers. The AIC's function is to improve safety and public confidence in the aviation mode of transport through excellence in: independent investigation of aviation accidents and other safety occurrences within the aviation system; safety data recording and analysis; and fostering safety awareness, knowledge and action.

The AIC is responsible for investigating accidents and other transport safety matters involving civil aviation in PNG, as well as participating in overseas investigations involving PNG registered aircraft. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The AIC performs its functions in accordance with the provisions of the *PNG Civil Aviation Act 2000 (As amended)*, and the *Commissions of Inquiry Act 1951*, and in accordance with *Annex 13 to the Convention on International Civil Aviation*.

The objective of a safety investigation is to identify and reduce safety-related risk. AIC investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not a function of the AIC to apportion blame or determine liability. At the same time, an investigation report must include relevant factual material of sufficient weight to support the analysis and findings. At all times the AIC endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why it happened, in a fair and unbiased manner.

About this report

The Papua New Guinea Accident Investigation Commission (AIC) was notified of the accident involving the remotely piloted aircraft by Civil Aviation Authority of Papua New Guinea (CASA PNG) on 24 January 2020. The approach taken by AIC to investigate this occurrence was similar to investigations conducted on manned aircraft.

This Final Report was produced by the PNG AIC, PO Box 1709, Boroko 111, NCD, Papua New Guinea and the Commission has made it publicly available in accordance with ICAO Annex 13, Chapter 3, paragraph 6.5. It will be published on the PNG AIC website.

This investigation was carried out in accordance with *Annex 13 to the Convention on International Civil Aviation*, the *PNG Civil Aviation Act 2000 (As Amended)*, and the *AIC Investigation Policy and Procedures*.

Remotely Piloted Aircraft collided with pylon during Marine Terminal inspection.

Occurrence Details

On 14 November 2019, at 09:42 local time (13 November 2019, 23:42 UTC¹), a DJI² Matrice 210 RTK remotely piloted aircraft (RPA), owned and operated by Applus Wokman (Applus), was being used to conduct an inspection of the underside of the jetty of the PNG LNG ExxonMobil Marine Terminal, about 20 km (11 nautical miles) North West of Port Moresby, Papua New Guinea, when it collided with one of the jetty's pylons and dropped into the sea.

The accident occurred during a flight conducted by Applus as part of the contract they had with ExxonMobil PNG to conduct aerial inspections, from 1 to 28 November 2019, of ExxonMobil's marine navigational aids and the marine terminal jetty.



Figure 1. Overview of the aerial inspection area (Image source. DJI GO 4).

The inspection was being conducted by an RPA pilot and a technical assistant from Applus. The pilot and the technical assistant each had a remote control equipped with its own monitor. The pilot was responsible for flying the RPA while the technical assistant controlled the camera mounted on top of the RPA, specifically to inspect the pylon. The RPA was being operated from a marine vessel (pilot boat).

The pilot and the technical assistant stated that the day before the accident they decided to move into the airconditioned cabin and continue to operate from there to prevent the monitors from overheating.

¹ The 24-hour clock, in coordinated Universal Time (UTC), is used in this report to describe the local time as specific events occurred. Local time in the area of the accident, Papua New Guinea Time is UTC + 10 hours.

² Da-Jiang Innovations.

The pilot also stated that immediately prior to the collision, he had lost his line of sight with the RPA because the pilot boat was being rocked and swayed due to the local conditions at the time. He subsequently stopped maneuvering the RPA and started moving from his starboard (right) side position to the center forward position in an attempt to re-establish line of sight (Refer to Appendix A). However, when he regained visual contact with the RPA, it had already collided with one of the pylons. The pilot mentioned that when he was moving positions, he may have inadvertently moved one of the remote-control sticks. The RPA was about 100 m from the pilot boat.

According to the telemetry data³, the RPA was positioned less than half a meter, from the northern side of the pylon, about 5.5 ft above mean sea level (AMSL) when the remote-control sticks were momentarily in the neutral position before the right control stick suddenly shifted fully to the right. The data recording ended less than half a second later. Blank data followed after that point which signifies the collision and subsequent drop and submersion of the aircraft into the sea. (Refer to Appendix B).

The aircraft was recovered about 20 minutes after the accident. The aircraft's internal hardware and electronic systems were destroyed by salt water.

The Operator – Applus Wokman

Applus Wokman is a subsidiary company of Applus Oceania Group and is based in Papua New Guinea. The Applus Group provides a wide-range of human resources solutions and inspection services to the mining, oil and gas, engineering, construction and manufacturing sectors around the world. Applus Wokman provides testing and inspection services to ExxonMobil facilities.

ExxonMobil PNG has contracted Applus to conduct aerial inspection on ExxonMobil facilities. These facilities are the Hides Gas Plants, LNG Plants facilities, and other assets including the marine navigational aids and the terminal.

On 22 May 2019 Applus was issued a *Part 101.202(3) Instrument of Approval*, which was current at the time of the accident (Refer to Appendix C).

Notification

The AIC was notified of the occurrence by CASA PNG on 24 January 2020 in accordance with *Section 62 of the PNG Civil Aviation Act 2000 (As Amended)*.

On 22 January 2020 CASA was informed of the occurrence during a meeting with ExxonMobil PNG.

Applus stated in an interview with AIC that the occurrence was reported to the ATSB⁴ on 18 November 2019 in accordance with their internal procedures.

The investigation found that the PNG CAR Part 101 does not contain requirements for notification of RPA occurrences. The investigation also found that the *CAR Part 12* sections

³ These are recorded flight data logged on the DJI GO 4 Application.

⁴ Australian Transport Safety Bureau is the accident and incident investigation authority of Australia

associated with notification, investigation, and reporting of accident and incident, do not include requirements for RPA conducted under *CAR Part 101*.

Weather Conditions⁵

The DJI Matrice 210 RTK RPA is equipped with sensors and systems that allow it to obtain and record certain specific meteorological data. The AIC had access to this data and established that at the time and location of the accident, the wind speed was 3.3 knots from the South West, the temperature was 27.3 °C with clear visibility and mostly cloudy. Additionally, the pilot during his interview informed the AIC that on the day of the accident, weather conditions were suitable for the operation.

Aircraft

The Matrice 210 RTK RPA is manufactured by DJI. According to the manufacturer, the aircraft is mostly used for aerial works and can be flown with the First-Person Vision (FPV) camera, or can be configured with an additional gimbal to suit operational use. Figure 2 depicts the top gimbal configuration used during the aerial inspection by Applus.

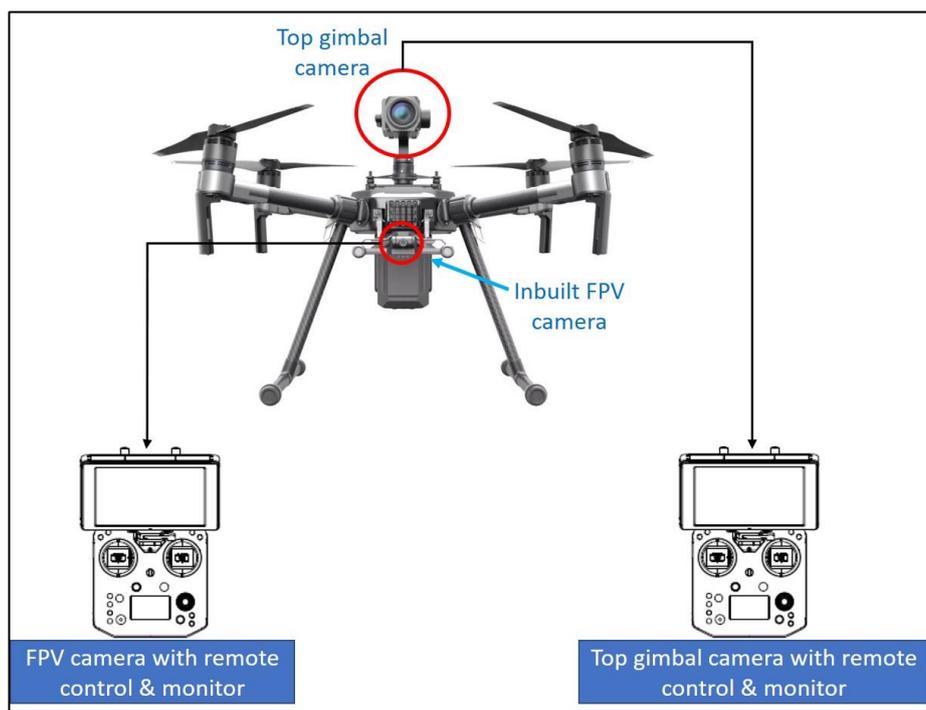


Figure 2. A pictorial layout of the two independently used camera, and their associated remote control and monitoring screens.

⁵ The weather data in this section is not necessarily limited to the use of aviation terminology.

According to the specifications of the DJI Matrice 210 RTK, the RPA is equipped with Vision and Infrared Sensing Systems.

The Vision System uses ultrasound and image data to help the RPA to maintain its current position, enabling precision hovering indoors or in environments where a GPS signal is not available. The Vision System constantly scans for obstacles, allowing the RPA to avoid them by going over, going around, or hovering.

The Infrared Sensing System scan for obstacles on top side of the RPA and is active in certain flight modes.

In the RPA User Manual, the manufacturer advises that:

The performance of your Vision System and Infrared Sensing System is affected by the surface being flown over. Ultrasonic sensors may not be able to accurately measure distances when operating above sound-absorbing materials and the cameras may not function correctly in suboptimal environments (Refer to Appendix D).

During the investigation, the records of operator's maintenance and pre-flight checks (including flight and function tests) were reviewed. The investigation did not find any indication of malfunction of the power systems⁶ and sensors⁷ that could have affected the RPA in the context of the accident.

Area of Operations

The RPA operations were conducted over the sea in the Caution Bay area, a Danger Area⁸ (D902), designated for flight training operations situated within controlled airspace from ground level to 1000 ft (See Figure 3).



⁶ Telemetry data readout of the aircraft's Power systems consists of the Battery Efficiency, Battery Cells, Cells Graph, Voltage and Amps and Battery Information.

⁷ Telemetry data readout of the aircraft's sensors includes the Signal Map, Signal Score, GPS and Compass.

⁸ An airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times. This term is used only when the potential danger to aircraft has not led to the designation of the airspace as restricted or prohibited. The effect of the creation of the danger area is to caution operators or pilots of aircraft that it is necessary for them to assess the dangers in relation to their responsibility for the safety of their aircraft. *Source. PNG AIP ENR 5.1.-1.*

Figure 3. *Caution Bay area designated as Danger Area, D902.*

An application for the issuance of a NOTAM⁹ was sent by Applus to PNG Air Service Ltd (PNG ASL) on 29 August 2019 for a 30-day RPA operation within *D902* initially to commence on 9 September 2019.

PNG ASL subsequently issued a NOTAM, effective from 7 November 2019 to 7 December 2019, requiring the RPA crew to report to Air Traffic Control 5 minutes prior to and after operations (See Table 1). Applus commenced operation on 8 November 2019.

NOTAM Port Moresby A 1371
PNG MAIN PORTS/ DLY SUPPLEMENT
1911072000/1912070800 EST. BTN 2000/0800 DLY. CTN DRONE/UAV OPS WI 200M OF LNG PLANT SITE. COORD S09 19 47.60 E147 01 08.50. HGT 0 TO 300FT (91.44M). ATC NOTIFICATION 5MIN BFR AND AFT OPS.

Table 1. *The NOTAM A1371*

The Operating Station – Pilot Boat

The RPA operations were being conducted from a pilot boat owned by PNG Ports Corporation (See Figure 4).

⁹ NOTAM - Notice[s] to Airmen, identified as notice or as Airmen Advisory, disseminated by all means to give information on establishment, condition or change in any aeronautical facility, service, procedure or hazard.

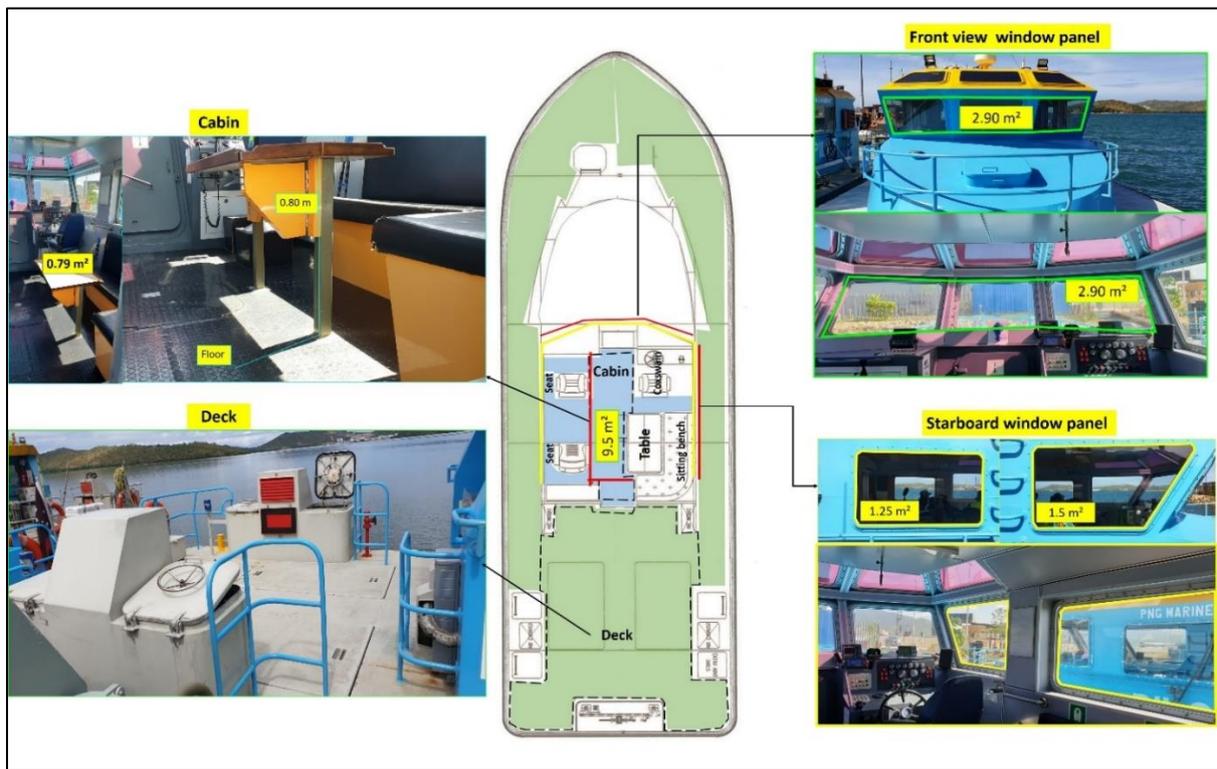


Figure 4. Pilot boat used during the RPA operation.

On the day of the accident, the pilot boat was positioned about 100 meters from the shoreline. The coxswain¹⁰ reported that the boat could not be brought closer to the pylon near the shoreline because the tide was low and the boat's keel clearance¹¹ was 2.5 m. The coxswain reported that he was concentrating on the maneuvering the boat to keep it in a steady position, safe from the low tide depth.

The RPA Pilot Qualification

The RPA pilot stated that the operation was conducted under PNG Civil Aviation Rules (CAR) Part 101.

The pilot did not have a PNG RPA pilot licence, nor was it required under PNG CAR Part 101. The pilot was a Civil Aviation Safety Authority (CASA) Australia licenced RPA pilot and held an Aeronautical Radio Operator Certificate (AROC).

The pilot had over 400 hours on RPA operations.

Damage to Aircraft

A *damage report* was submitted by Applus to AIC. The report stated that the RPA was damaged beyond repair (Refer to Appendix F).

¹⁰ The person in charge of a boat, particularly its navigation and steering.

¹¹ The vertical distance between the deepest underwater point of the ship's hull and the water area bottom or ground.

AIC comment

The accident occurred while the flight was being conducted from inside the cabin of the pilot boat by the RPA pilot. The pilot boat was at a distance of about 100 m from the inspection location. Maintaining clear visual reference with the low flying RPA, operating at about 5ft above sea level, would have been challenging from that distance.

The RPA pilot was operating from the cabin of a swaying pilot boat with limited view of the outside, through the window panels. The AIC determined that the decision to operate the RPA from inside the cabin posed a high risk of losing sight of the RPA.

The operator was issued with the Part 101.202 Instrument of Approval, and was required to conduct all unmanned aircraft operations in Papua New Guinea in accordance with *CAR Part 101*. The AIC found that the technical assistant was not performing the role of an observer as specified in *CAR Part 101*. In fact, the operator was conducting RPA operations without an observer. The use of an observer was necessary to maintain visual reference with the RPA and surrounding area at all times during operations.

The investigation determined that the RPA moved towards the pylon as a result of an input to the right control stick. However, the obstacle avoidance system was unable to maintain obstacle clearance. The investigation determined that by flying close to the sea surface, the system may have been disabled.

The operator did not notify the occurrence to the relevant PNG authorities. The AIC determined that due to the lack of notification provisions in the Civil Aviation Rules regarding RPA occurrences, operators are not obliged to notify the relevant authorities whenever there is an RPA occurrence.

Recommendations

Recommendation number AIC 20-R13/20-1002 to the Minister for Civil Aviation

The PNG Accident Investigation Commission recommends that the Minister for Civil Aviation should include provisions for notifying accidents and incidents involving remotely piloted aircraft in the appropriate Civil Aviation Rules, to ensure that in such an event, timely notification is made by operators of remotely piloted aircraft to the relevant PNG authorities.

Recommendation number AIC 20-R14/20-1002 to Applus Wokman

The PNG Accident Investigation Commission recommends that Applus Wokman should ensure that all remotely piloted aircraft operations are conducted in accordance with the provisions of *CAR Part 101* and procedures are developed to ensure that visual line of sight is maintained and the role of an observer is included during these operations.

General Details

Date and time	14 November 2019, 09:42	
Occurrence category	Accident	
Location	PNG LNG ExxonMobil Marine Terminal	
	Latitude: 9° 20' 13".93 S	Longitude: 147° 0' 10.82" E
Flying Mode	GPS Positioning mode	
Accident total flight time	1minute 1sec	
Distance from home	300 feet (91m)	
Altitude above mean sea level	5 feet (1.5 m)	

RPA Pilot Details

Nationality	Australia	
Gender/Age	Male / 40-year-old	
RPA Controller Certificate	CASA Australia	Date of Issue: 1 Sep 2016
RPA Class/ Type	Multi rotor below 7 kg	
Certificate remark	The RPA must only be operated in visual line of sight, and clear of cloud.	
Licence number	1014498	
AROC Certificate number	1014498	Date of Issue: 1 Sep 2016
Total flight hours	428.5 flight hours	
Total hours on type	86 flight hours	

Technical Assistant

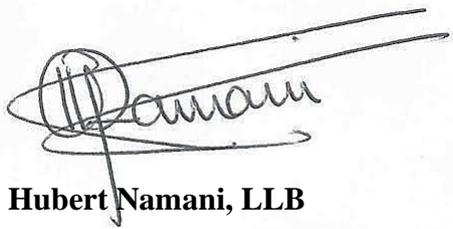
Nationality	Australia	
Gender/ Age	Male / 41-year-old	
RPA Controller Certificate	CASA Australia	Date of Issue: 5 July 2018
RPA Class/ Type	Multi rotor up to 25 kg – restricted	
Certificate remark	Up to 25kg – restricted – The RPA pilot is limited to the operation of RPA up to 7kgs only, for the category indicated as ‘restricted’.	
Licence number	1047202	
RPA Total flight hours	320 flight hours	
RPA Total hours on type	110 flight hours	

Aircraft Details

Aircraft manufacturer and model	DJI Matrice 210 RTK	
Max take-off weight	6.14 kg	
Max payload (inclusive of 2xTB50 batteries)	1.7 kg	
Serial Number	0N4DFBQ0220073	
Battery serial number (Submerge batteries)	Battery 1: 0KPAE7423100V0	
	Battery 2: 0KPAE7423101LC	

Remote Control serial number	DJI Cendence S/N: OJDJEAD0C10106 (Crystal Sky Monitor).	
Type of propulsion system	Four electric motors with attachable propellers	
Type of operation	Aerial works.	
Injuries	Crew: nil	Passengers: N/A
Damage	Aircraft's internal hardware and electronic system damaged after being submerged under seawater for about 20 minutes. The aircraft cannot be operated.	

Approved

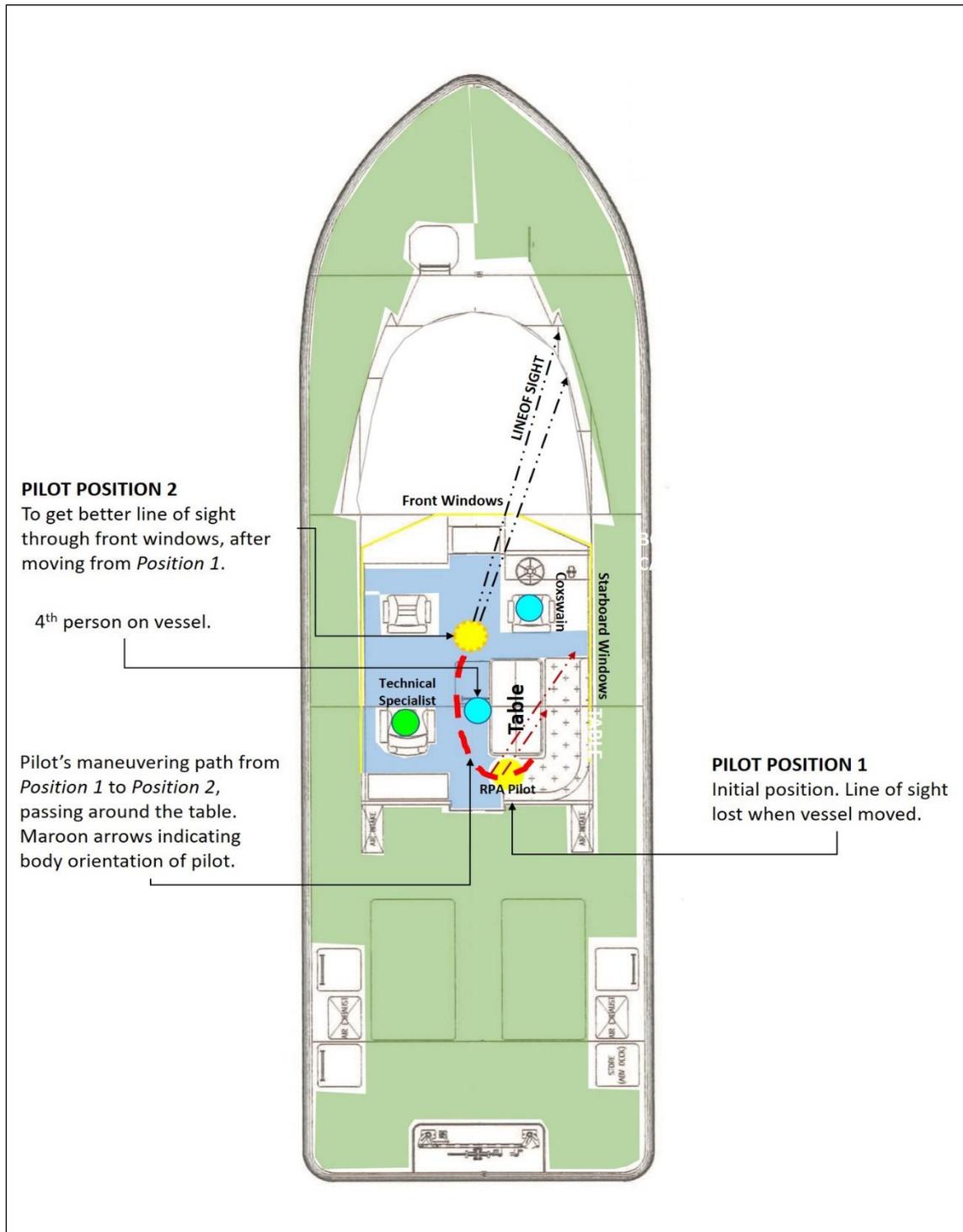


Hubert Namani, LLB

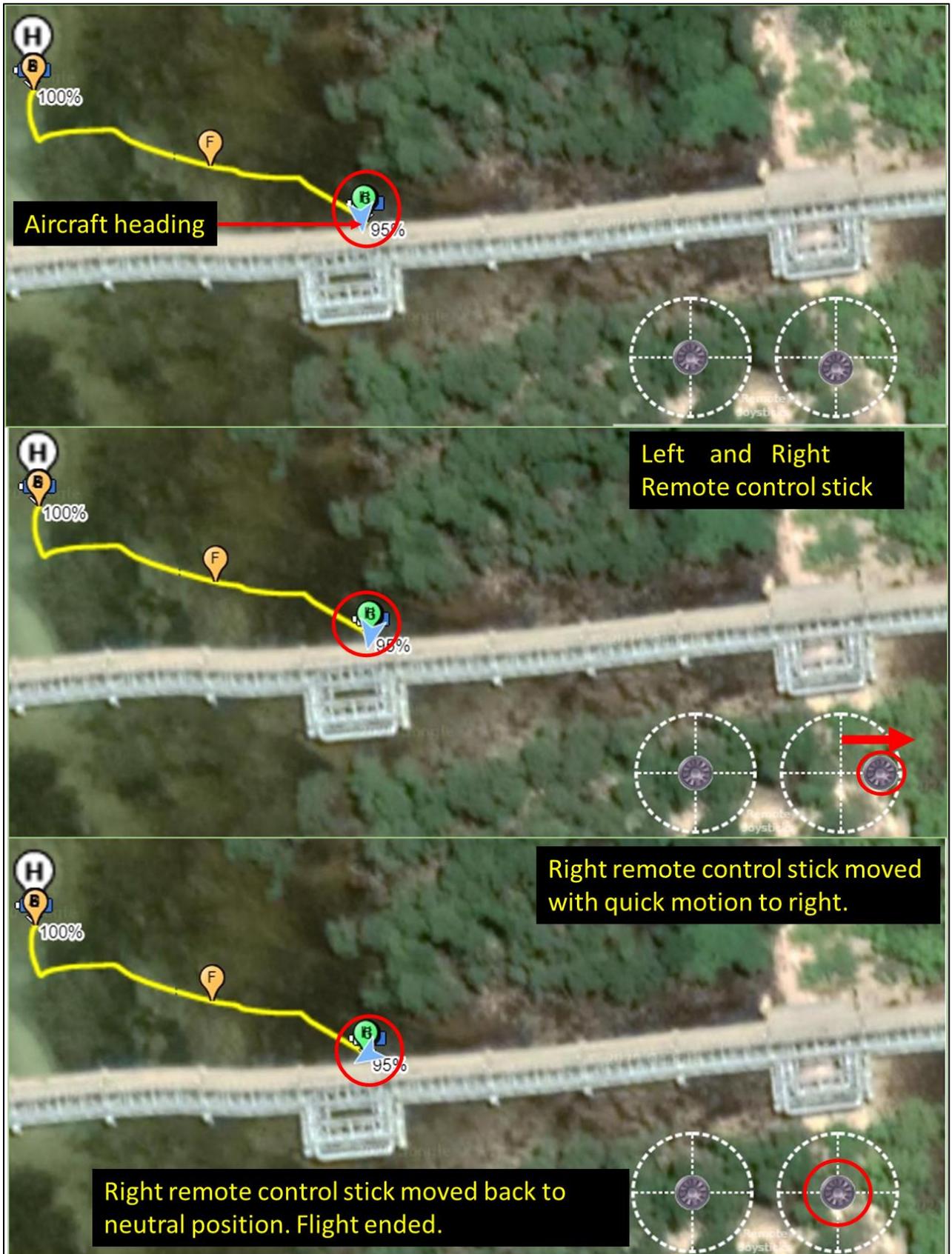
Chief Commissioner

16 October 2020

Appendix A Sketch of the RPA Pilot's position change from Starboard windows to Front Windows.



Appendix B Aircraft Controls and Heading



Appendix C Part 101.202 Instrument of Approval Certificate

<p style="text-align: center;"> CIVIL AVIATION SAFETY AUTHORITY OF PAPUA NEW GUINEA</p> <hr/> <p style="text-align: center;">CIVIL AVIATION ACT 2000 <i>(as amended)</i> <u>Part 101.202 Instrument of Approval</u> Instrument of Approval No. 101F/1001-1623/MR</p> <p>Pursuant to Section 44(2) of the Civil Aviation Act 2000 as amended, I, Tom Waqa, Deputy Director of Civil Aviation hereby approve:-</p> <div style="border: 1px solid black; padding: 10px; text-align: center;"><p>APPLUS WOKMAN, ENB Haus, Harbour City, NCD, Port Moresby.</p></div> <p>(A) To carry out the following functions as an Approved Organisation in accordance with Rule 101.202(3):-</p> <ul style="list-style-type: none">- authorising a person to notify the aeronautical information service provider, for the issue of a NOTAM, of remotely piloted aircraft operations; <p>(B) To exercise the functions of paragraph (A) above after satisfying the following Rule requirements of having:</p> <ol style="list-style-type: none">1) appropriate expertise in the operation of remotely piloted aircraft (Rule 101.202); and2) appropriate knowledge of airspace designations and restrictions (Rule 101.12). <p>(C) To be issued this Instrument of Approval ('Approval) subject to the following conditions, the breach of any of which shall invalidate this Approval:</p> <ol style="list-style-type: none">1) The functions of this Approval shall be exercised:<ol style="list-style-type: none">(a) solely in respect of the conduct of remotely piloted aircraft operations within Papua New Guinea strictly in accordance with Part 101 undertaken by Applus Wokman; and(b) in conjunction with and the consent of Exxon Mobil PNG for remotely piloted aircraft inspection and photography operations in the vicinity and over its LNG plants and facilities; and <p style="text-align: center;">Instrument of Approval No. 101F/1001-1623/MR Page 1 of 2</p>

- (c) only after permission has been granted and an appropriate 'Notice to Airmen' (NOTAM) has been issued by PNG Air Services Ltd (PNGASL) in respect of the time, geographical coordinates, and maximum altitude of the remotely piloted aircraft operations,
- 2) This Approval and its functions shall not be delegated to any other person or persons.
- (D) To exercise the functions of this Approval within the validity period commencing **21st May 2019** and ending **20th November 2019** provided:
 - 1) Applus Wokman continues to satisfy the requirements of Rule 101.202; and
 - 2) The appropriate Radio Communication Licence has been issued by, remains current and a copy obtained from the National Information Communications Technology Authority (NICTA); and
 - 3) this Approval has not expired, been cancelled, revoked or voluntarily surrendered to the Director of Civil Aviation.

Signed in Port Moresby, PNG on
 the 22nd day of May 2019
 for the Director of Civil Aviation

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Tom Waqa (Capt.)

Deputy Director of Civil Aviation, PNG



**Common Seal of the
 Civil Aviation Authority of PNG**

Appendix D Environmental Condition affecting Vision and Infrared System.

-  • The performance of your Vision System and Infrared Sensing System is affected by the surface being flown over. Ultrasonic sensors may not be able to accurately measure distances when operating above sound-absorbing materials and the cameras may not function correctly in suboptimal environments. The aircraft will switch from P-mode to A-mode automatically if neither GPS nor Vision System and Infrared Sensing System are available. Operate the aircraft with great caution in the following situations.
- The Vision System will be disabled when:
- Flying over monochrome surfaces (e.g. pure black, pure white, pure red, pure green).
 - Flying over highly reflective surfaces.
 - Flying over water or transparent surfaces.
 - Flying over moving surfaces or objects.
 - Flying in an areas where the lighting changes frequently or drastically.
 - Flying over extremely dark (lux < 10) or bright (lux > 100,000) surfaces.
 - Flying over surfaces without clear patterns or texture.
 - Flying over surfaces with identical repeating patterns or textures (e.g. tiling).
 - Flying at high speeds of over 31 mph (50 kph) at 2 meters or over 11 mph (18 kph) at 1 meter.
- The Ultrasonic sensors will be disabled when:
- Flying over surfaces that can absorb sound waves (e.g. thick carpet).
 - Flying over inclined surfaces that will deflect sound waves away from the aircraft.
- The Infrared be disabled when:
- Flying over obstacles with too small effective infrared reflective surface.
 - DO NOT cover the protective glass of the infrared module. Keep it clean and undamaged.
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-  • Keep sensors clean at all times. Dirt or other debris may adversely affect their effectiveness.
- Vision System is only effective when the aircraft is at altitudes of 0.3 to 10 meters.
 - The Vision System may not function properly when the aircraft is flying over water.
 - The Vision System may not be able to recognize pattern on the ground in low light conditions (less than 100 lux).
 - Do not use other ultrasonic devices with frequency of 40 KHz when Vision System is in operation.
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-  Keep away from animals while operating the aircraft, as the ultrasonic sensors emit high-frequency sounds which may disturb them.

Return-to-Home (RTH)

The Return-to-Home (RTH) function brings the aircraft back to the last recorded Home Point. There are three types of RTH: Smart RTH, Low Battery RTH, and Failsafe RTH. This section describes these three RTH types in detail.

	GPS	Description
Home Point		If a strong GPS signal was acquired before takeoff, the Home Point is the location from which the aircraft launched. The GPS signal strength is indicated by the GPS icon  . Less than 4 bars is considered a weak GPS signal. The aircraft status indicator will blink rapidly when the home point is recorded.

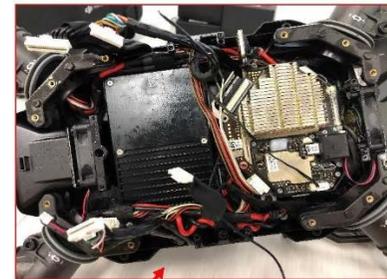
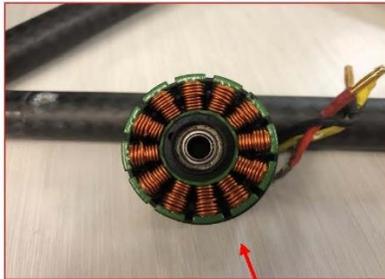
Appendix E RPA Damage Report

APPLUS MATRICE 210 RTK V1 - COLLISION DAMAGE REPORT



Matrice 210 RTK V1 Frame

Due to the low impact speed there is no damage present on the motors, arms, body, gimbal attachment frame, legs and skids, battery housing



Matrice 210 RTK V1 Hardware

Due to the submersion in the ocean water, the internal hardware/electrical components have been rendered unusable. All four motors have corrosion in the bearings. Flight controller, GPS module, receiver, VTX etc would have short circuited due to the batteries being attached when it entered the water, corrosion on the boards and components would also render these parts unusable.