الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Accident

- Summary Report -

AAIS Case Nº AIFN/0012/2020

Fatal Ground Impact after Loss of Control

Operator:	Jetman Dubai
Make:	Jetwing
Place of Occurrence:	Margham, Dubai
State of Occurrence:	The United Arab Emirates
Date of Occurrence:	17 November 2020

This Investigation was conducted by the Air Accident Investigation Sector of the United Arab Emirates pursuant to Civil Aviation Law No. 20 of 1991, in compliance with Air Accident and Incident Investigation Regulation, and in conformance with the provisions of Annex 13 to the Convention on International Civil Aviation.

This Investigation was conducted independently and without prejudice. The sole objective of the investigation is to prevent future aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

The Air Accident Investigation Sector issued this Summary Report in accordance with national and international standards and best practice. Consultation with applicable stakeholders, and consideration of their comments, took place prior to the publication of this Report.

The Summary Report is publicly available at:

http://www.gcaa.gov.ae/en/epublication/pages/investigationReport.aspx

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Investigation Process

The occurrence involved a jet-powered wing operated by Jetman Dubai, and was reported to the AAIS Duty Investigator by phone call to the Hotline Number +971 50 641 4667.

The occurrence was classified as an 'Accident' because of the fatal injuries sustained by the pilot.

The scope of this Investigation is limited to the events leading up to the occurrence; no in-depth analysis of non-contributing factors was undertaken.

Notes:

1. Whenever the following words are mentioned in this Report with first capital letter, they shall mean the following:
   - (Accident) - this investigated accident
   - (Jetwing) - the jet-powered wing involved in this accident
   - (Investigation) - the investigation into this accident
   - (Pilot) - the pilot of the jet-powered wing
   - (Report) - this Summary Report.
2. Unless otherwise mentioned, all times in the Report are United Arab Emirates local time (LT) (UTC minus 4 hours).
3. The structure of this Summary Report is an adaptation of the ICAO Annex 13 Final Report format.

Factual Information

History of the Flight

On 17 November 2020 at 0654 local time (LT), a Bell helicopter departed the Jetman Dubai facility at Margham in Dubai, the United Arab Emirates, with two pilots, an engine technician and a Jetwing Pilot onboard.

During the pre-flight briefing at 0530 LT, the Jetman team discussed the mission profile, which was a training flight simulating a takeoff from the ground, a triangular flight, and a jet-powered landing at an 800-feet-high platform.

At 0656 LT the helicopter arrived at an altitude of 4,000 feet above mean sea level (AMSL), where the preparations for the jet-powered flight began.

After three minutes of preparations, the Pilot jumped off and headed, jet-powered, towards the nearby Skydive Dubai airfield, where he briefly transitioned into a hover. He then headed east, followed by a right turn, descent towards the Skydive Dubai airfield, and a low-altitude pass near the Jetman Dubai facility. He then entered a right turn and climb towards the Skydive Dubai airfield, from where he returned towards the helicopter.

In the meantime, the helicopter was maintaining the location above the Jetman Dubai facility and had descended to an altitude of 800 feet above the ground, to indicate the nominated hover altitude for the Pilot.

After six minutes flying time, the Pilot returned

Figure 1. Jetwing pilot hovering

to the helicopter location and arrived hovering slightly above the altitude of the helicopter as shown in figure 1. He was then observed to reduce the altitude during the hover, but at a rate that appeared higher than usual.

Once the Pilot reached the approximate altitude of the helicopter, he was observed to enter a back-leaning attitude, followed by an abrupt back-flip. He entered a steep descent until he disappeared underneath the helicopter and out of sight of the helicopter occupants.

The cameras fitted to the winglets recorded the attempt by the Pilot to fly out of the descent, gain control of the Jetwing and recover the flight. However, the Jetwing impacted desert terrain at a distance of approximately 270 meters from the Jetman Dubai facility.

The Pilot was fatally injured.

Damage to the Jetwing

As a result of the impact with the ground, the Jetwing sustained damage to the pilot harness seat, the left wing leading edge and the left winglet, as shown in figure 2.

Figure 2. Jetwing damage

The fuel bladder tank was damaged and leaking fuel as seen in figure 3. However, approximately two liters of fuel was drained from the bladder tank during the post-accident examination.

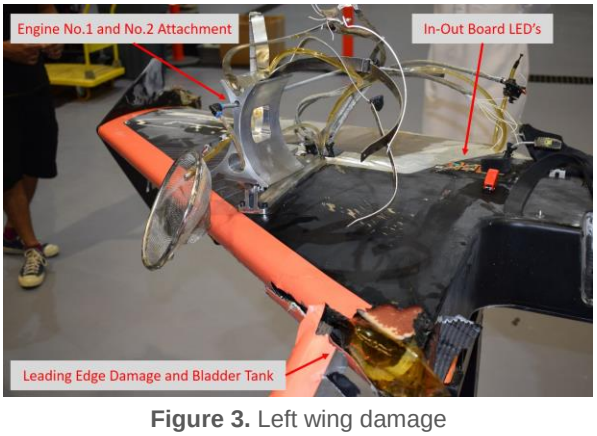

Figure 3. Left wing damage

Both left engines, No.1 and No.2, were separated from the wing and damaged.

The No.1 engine thrust vector unit and the No.2 engine exhaust protection shield were damaged.

Footage retrieved from the two winglet cameras and the two helmet cameras captured post-impact fire at the separated No.2 engine and the wing, after impact with the ground as seen in figure 6. The fires extinguished after a minute.

The pyro-rocket emergency parachute deployed during impact with the ground, as captured by both winglet cameras.

There was no damage to property, or the environment.

Personnel Information

The Pilot was an experienced professional skydiver with over 17,000 jumps. He was also a base jumper with 1,400 jumps, a wingsuit operator since 2002, skydive instructor, and wind tunnel instructor with over 1,000 hours of experience.

In his 21-year skydive career, which began at the age of fifteen, the Pilot had achieved a number of World Champion titles and entries in the Guinness Book of Record.

In 2015, after five years of Jetwing training, the Pilot was officially announced a 'Protégé' of the inventor of the Jetwing. As a member of Jetman Dubai, he has since been involved in every aspect of Jetwing development.

The Pilot was described by his team members as very safety conscientious, and well-prepared for every flight.

There was no evidence that physiological factors or incapacitation affected the Pilot's performance during the flight. A post-accident toxicology report showed no indication of drugs, alcohol, or any psychoactive substance that could have degraded the performance of the Pilot. The autopsy report referred the cause of death to high impact forces.

Jetwing Information

The Jetwing is a carbon-fibre delta-shaped wing, fitted with four JetCat P550-PRO-GL jet engines. Each engine was de-rated from a maximum thrust of 550 Newton to 530 Newton. The two outer engines were fitted with thrust vector units to support the hover in an upright wing position.

A Jetwing pilot is attached to the wing by the pilot harness seat as shown in figure 4, and is equipped with a main and reserve parachute. The main parachute is deployed for normal landings where the wing is still attached, or when the wing is released from the pilot.

A pyro-rocket emergency parachute is provided in the reserve section of the pilot's parachute for operations at altitudes below 700 meters.

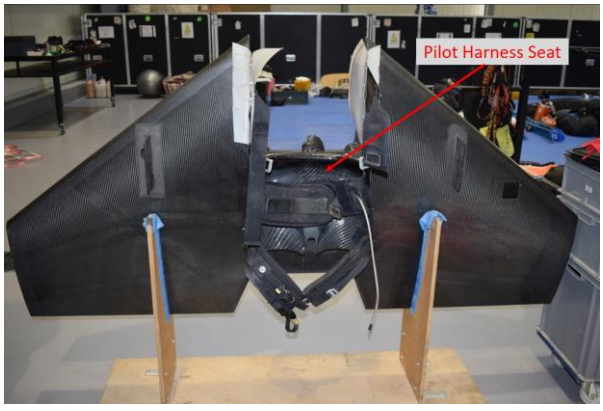

Figure 4. Jetwing underside and pilot attachment

The wing was equipped with a separate parachute, which deploys automatically when the pilot separates from the wing.

'In-Out board' connectors located at the underwing enable adjustment of each engine control unit and retrieval of recorded engine data. Light emitted diodes (LED) fitted to these boards provide engine status information. Video recording taken by the engine technician in the helicopter at the time of the Accident showed that the 'In-Out board' LEDs indicated normal operation of the four engines.

The commercially available jet engines were manufactured by JetCat Germany with primary use in the model aircraft application. The jet engines were not aviation-standard, certified engines. However, the manufacturer restricted the engines to 25 operating hours between overhauls. All four Jetwing engines had accumulated approximately 12 hours.

The four engines operate at a maximum of 83,000 rpm, and were equipped with engine control units which record engine data. Recorded data could only be recovered from the No.3 and No.4 engines due to the impact damage to the No.1 and No.2 engines. The data indicated that both engines were operating normally at the time of the Accident.

Jet A1 fuel was stored in six connected bladder tanks, distributed evenly in the wing structure, containing 42 liters.

No technical anomalies were reported by the Pilot or the engine technician before the flight.

Meteorological Information

The Dubai International Airport Aviation Weather Forecast issued at 0557 LT on the day of the Accident projected a 10-knots wind at an altitude of 1,000 feet with varying directions from 070 to 340 degrees.

The nearest weather station, located in Margham at a distance of approximately 8.5 kilometres to the Jetman Dubai facility, recorded the following data at the time of the Accident:

Table 1. Margham Weather Station data

Time	0230 UTC (0630 LT)
Wind	103 degrees / 14 km/h (7.5 Knots)
Air Temperature	19.3 degrees Celsius
Air Pressure	1016.7 Hectopascal
Relative Humidity	86%

Sunrise at Dubai on 17 November 2020 was at 0637 LT.

Organizational Information

Jetman Dubai

Jetman Dubai organization was established in 2013 as part of the marketing company X-Dubai. It is a research and development organization with the objective "to advance human flight". It was issued approvals for helicopter operations by the General Civil Aviation Authority of the United Arab Emirates (GCAA) at the time of the Accident. Jetman Dubai was recognized as an 'Aviation Entity' and authorized 'to practice the profession' by the Dubai Civil Aviation Authority (DCAA).

Jetman Dubai team consisted of a manager, one administrator, three engine technicians, two Jetwing pilots and two facility security staff.

Jetman Dubai operated its own facility near Margham, approximately 42 kilometres south-east of Dubai International Airport, in the United Arab Emirates. The facility consisted of a hangar, workshops and equipment for tethered Jetwing test operations. The facility's heliport was accepted by the GCAA and DCAA approved.

Jetman Dubai facility was surrounded by desert with a ground elevation of approximately 500 feet above sea level.

Pre-flight Briefing

The pre-flight briefing on the day of the Accident included weather information, flight profile, drop-off altitude, hover altitude, and flight timings.

The briefing also included the use of the pyro-rocket parachute in emergencies at low altitudes, and the use of the terms "finito, finito" for the termination of the mission for any reasons.

Standard Operating Procedures (SOP)

Jetman Dubai issued a *Standard Operating Procedures Manual* on 8 August 2020. It covered the procedures for the helicopter operation, crew composition, training, maintenance, experience, duties, and risk management. *A Hazard Analysis Log* was included as Annex A.

Section 2.7 - *Normal, Abnormal and Emergency Procedures*, generally described the procedures to be followed by the helicopter crew and the Jetwing pilot during the helicopter flight. There were no procedures for the Jetwing operation.

Section 2.8 – *Maintenance*, included the scheduled maintenance and service tasks for the Jetwing and engines.

Chapter 3 - *Risk Management*, described in detail the risk management process adopted from the ICAO *Document 9859 – Safety Management Manual*.

Annex A of the *Standard Operating Procedures - Hazard Analysis Log*, described the identified hazards and associated risks for the Jetwing operation. While it included hazards pertaining to the operation of the Jetwing, weather, and the involvement of air traffic control, it did not include hazards specifically during hover or low altitude operations.

The Investigation noted that the completion date of the *Hazard Analysis Log* was 12 February 2015, and no updates to the Log took place.

Jetwing Flight Characteristics

The Jetwing was designed in 2004 to be operated as a jet-powered fixed-wing structure during skydive operations.

A pilot can control the direction of flight by shifting his body position, which allows roll, pitch and yaw movements. The engines thrust is controlled by a hand-mounted throttle control.

Application of thrust results in a wing-up moment due to the jet engines' location beneath the wing. During forward flight or in hover, this moment is counteracted by the pilot shifting their body position.

The development of the thrust vector units at both outboard No.1 and No.4 engines enables roll movement of the wing around the longitude axis during the hover, whilst the wing and pilot are in a vertical position. The thrust vector units expanded the flight capabilities of the Jetwing and supported the takeoff from and, potentially, landing on the ground.

According to Jetman Dubai, the Jetwing had the capabilities to operate for approximately seven to eight minutes with a maximum speed of 250 knots, up to an altitude of 17,000 feet.

Jetwing Hover Dynamics

The hover requires the Jetwing pilot to transition from forward flight into an upright wing attitude until the jet engines produce an equal thrust to the weight of the pilot and Jetwing.

One of the challenges for maintaining a stable hover is the application of the required magnitude and direction of thrust; to maintain height and direct the thrust to maintain the Jetwing in an upright position without leaning too much forward or back.

During hover, a back-leaning attitude may result when applying more thrust for maintaining hover altitude. With thrust increase, the pitch moment and back-leaning attitude may increase. If the Jetwing enters a back-leaning attitude that cannot be rectified by shifting the body weight, the Jetwing may abruptly and uncontrollably flip backwards. In this situation, the pilot can only re-gain control of the wing by completing the back-flip and transitioning from descent into forward flight until sufficient airflow allow steering the wing by shifting their body position.

Footage from previous flights showed that the Pilot had successfully managed similar situation before, when the height was adequate for such recovery manoeuver.

Training Flight Objective

Jetman Dubai team were provided with training for a jet-powered takeoff and landing since 2014.

The objective of the training mission on the day of the Accident was practicing the jet-powered hover at a height of 800 feet above ground for simulating a landing on a platform of that height as part of a planned public demonstration.

On previous training missions, the simulated landing height was gradually reduced from 5,000 feet. On the day of the Accident, a simulated landing height of 800 feet above ground level was attempted.

The helicopter commander advised during the interview with the Investigation that he confirmed the altitude of 800 feet on the helicopter radar altimeter, which indicated the altitude above ground.

Hover Training

Jetman Dubai facility was equipped with tethered Jetwing towers which was utilized for hover training. The training included the takeoff from and landing on a raised platform as shown in figure 5.

Figure 5. Tethered hover test [Source: Jetman Dubai]

It was identified during these sessions that a back-leaning attitude during hover was one of the hazards a pilot may encounter while maintaining control of the Jetwing.

Jetman Dubai considered the future development of an electronic attitude-stabilizing mechanism which would automatically correct, with the aid of the thrust vector units, any impending uncontrollable Jetwing attitudes.

The jet-powered take-off and hover capability was successfully demonstrated during a public demonstration flight that took place in February 2020. On this flight, the Pilot demonstrated the jet-powered takeoff from the ground, hover above water, and jet powered landing. The Pilot then took off again and transitioned from the low-level hover into a forward flight and climb. The landing was initiated after three minutes flight time by the deployment of the main parachute.

Additional Information

Camera Recordings

The Jetwing was fitted with one inward-facing camera in each winglet, recording the upper wing surface and the Pilot movement.

The Pilot's helmet was fitted with a camera facing forward and a camera recording a 360-degrees angle.

The four cameras recorded the flight from the helicopter takeoff until impact with the ground. This enabled the Investigation to track the events, document the flight path, observe the actions taken by the Pilot, and evaluate the impact damage to the Jetwing.

After ground impact, the left winglet camera recorded an initial fire at the underside of the right wing and in the separated No.3 engine, as seen in figure 6. Both fires extinguished within a minute.

Figure 6. Jetwing fire after impact

Both winglet cameras captured the deployment of the pyro-rocket emergency parachute by impact forces.

Additional camera footage was provided by the engine technician located in the helicopter. He recorded the Pilot commencing the flight, returning to the helicopter, transitioning into hover, and losing control of the Jetwing.

Helicopter Rotor Downwash Considerations

In the interview with the two helicopter pilots, it was established that both had a solid knowledge of the rotor downwash aerodynamics.

The helicopter was positioned facing north-west to ensure that the rotor downwash was not affecting the Jetwing Pilot who exited the helicopter from the right side.

The commander, in the right seat, was the pilot flying and had visual contact with the Jetwing Pilot at the commencement of the training flight and when he transitioned into hover on his return, upwind from the helicopter position.

Analysis

Jetwing Operation

The Jetwing operated by Jetman Dubai was the product of further development and modification of the original Jetwing. It culminated in a jet-powered carbon-fibre wing with thrust vector units, enabling the control of the wing during hover.

The controlled hover ability expanded the flight capabilities of the original Jetwing design to

include a jet-powered takeoff from the ground and, potentially, landing without the use of the parachute.

The jet-powered takeoff and hover capability was successfully established during a demonstration flight in February 2020, which encouraged Jetman Dubai to carry out further testing and development.

During every jet-powered takeoff from the ground or from low heights, a pilot may encounter a condition, similar to the one encountered during this Accident. Therefore, further development of in-flight safeguards should be considered to improve the safety of the Jetwing operation.

The Investigation noted that the *Hazard Analysis Log* was not updated and did not include any identified hazard pertinent to the Jetwing operation, and in particular to hover. However, the Investigation determines that, while the *Hazard Analysis Log* required updating, the Jetman Dubai facility, pilots' experience, and qualifications were well-established as a research and development operation.

Training Flight

Jetwing operation is a new type of flying that utilizes new technology with associated hazards and risks, which are sometimes only identified during the testing in real flight scenarios, when ground tests with safeguards are exhausted.

The transition from forward flight into hover is one of these scenarios, where flight dynamics are slowly explored and tested. A tethering system can provide safeguards for hover training near the ground. However, at higher altitudes, manually operated systems like the pyro-rocket emergency parachute become vital.

On previous missions, the Jetwing pilots gradually reduced the altitude for hover from 5,000 feet until they reached the target altitude of 800 feet above the ground. This height significantly reduced the safety margin and relied solely on the flight experience, judgement, and quick decision making of the Pilot.

The morning briefing prior to the Accident flight included the use of the pyro-rocket emergency parachute should an unsafe condition be encountered at low height. The Investigation concluded that this adequately addressed this hazard under the circumstances of a research and development operation.

Pilot Proficiency and Jetwing Handling

The Pilot was an experienced skydiver, base jumper and Jetwing operator. He was involved in every aspect of the Jetwing development project and performed test flights after every modification to the Jetwing.

There is no indication that the Pilot was not fit to fly on the day of the Accident. He was described as very safety conscientious.

A review of the camera recordings showed no technical anomalies with the equipment during the flight and the transition into hover.

The analysis of the camera footage showed that when the Jetwing back-flipped and the Pilot lost control during hover at 800 feet, he completed the back-roll, entered the descent, and attempted to establish airflow. He was observed to move his arms forward, which may indicate that, prior to contact with the ground, he attempted to enter a hover.

Back-flip and recovery manoeuvres were recorded on previous flights, and seemed very familiar to the Pilot. However, it required sufficient altitude to safely transitioning from a steep descent into forward flight.

The risks of the 800-feet hover was discussed during the pre-flight briefing and, as a risk mitigation, it was decided to abort the flight and to deploy the pyro-rocket emergency parachute should the Jetwing become uncontrollable. The Investigation could not determine why the Pilot did not choose this mitigation action.

Jetwing Performance

The Jetwing was regularly maintained and inspected. Prior to the Accident flight, the engine technicians prepared the Jetwing and checked the engines with the 'In-Out board' LEDs.

During the transition from flight into hover on the return to the helicopter, the 'In-Out board' green status lights were recorded by the camera operated by the engine technician in the helicopter.

The fuel tank was filled for the training flight, and two litres of fuel were drained during a post-Accident examination.

The two left engines (No.1 and No.2) were severely damaged because of the impact forces and retrieving data from their corresponding control units was not possible. Data from the control units of the right engines (No.3 and No.4) was successfully downloaded and indicated that

both engines were producing full thrust during the entire flight until the impact. There was no indication that No.1 and No.2 engines were not generating thrust.

Based on these findings, the Investigation concluded that the Jetwing and its engines were serviceable at the time of the Accident and not considered a contributing factor to the Accident.

Helicopter Rotor Downwash

The helicopter commander placed the helicopter in a hover at an altitude of 800 feet above the ground in a direction where he could observe the Jetwing Pilot hover position from a safe distance. He was considering the effects of the rotor downwash in relation to the wind direction at the time of the Accident.

The helicopter was well-positioned to accommodate the training flight and to mitigate the risk of the rotor downwash effecting the pilot during the hover. The Investigation concluded that the helicopter's downwash was not contributing factor to the Accident.

Weather

The Jetman Dubai team obtained the weather forecast from Dubai International Airport prior to the training flight. This recorded a wind of 10 knots with a varying direction of 070 to 340 degrees.

The wind direction recorded at the nearby weather station at the time of the Accident showed a wind direction of 103 degrees and 7.5 knots.

Observations of the camera recordings show that the weather conditions during the training flight were stable with no indications of gusts or varying wind directions, which could have challenged the Pilot during the hover.

The Investigation concluded therefore that the weather conditions at the time of the Accident were not contributing factor to the Accident.

Conclusions

From the evidence available, the following findings, causes, and contributing factors were made with respect to this Accident. These shall not be read as apportioning blame or liability to any particular organization or individual.

- **Findings.** Statements of all significant conditions, events or circumstances in this Accident. The findings are significant steps in this Accident sequence but they are not always causal or indicate deficiencies.
- **Causes.** Actions, omissions, events, conditions, or a combination thereof, which led to this Accident.
- **Contributing factors**. Actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the Accident occurring, or mitigated the severity of the consequences of the Accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

Findings

a) The Jetwing and its engines were serviceable during the entire flight.

b) The Pilot was adequately trained and experienced to operate the Jetwing.

c) There was no indication that physiological factors, or psychoactive substances were existent and could have degraded the Pilot's performance.

d) The Pilot commenced the flight at an altitude of 4,000 feet above sea level.

e) The helicopter descended and hovered at an altitude of 800 feet above the Jetman Dubai facility to mark the simulated height of the landing platform.

f) The Jetwing Pilot returned to the helicopter higher than anticipated and entered a hover.

g) During hover, the Jetwing was observed to enter a back-leaning attitude before it abruptly flipped backwards and steeply descended.

h) The Pilot attempted to re-gain control of the Jetwing.

i) There was no attempt made by the Pilot to manually deploy the pyro-rocket emergency parachute.

j) The Pilot was fatally injured when the Jetwing impacted the ground.

k) The pyro-rocket emergency parachute deployed by impact forces.

l) The Jetman Dubai *Standard Operating Procedures* did not include procedures pertinent to hover operations.

m) The Jetman Dubai *Hazard Analysis Log* did not include identified hazards during hover operations.

Causes

The Air Accident Investigation Sector determines that the causes of the fatal impact were:

(a) The loss of the Jetwing control due to an unrecoverable back-leaning attitude during hover, which resulted in an abrupt flip backwards, steep descent, and ground impact.

(b) The Pilot did not abort the flight by deploying the pyro-rocket emergency parachute as discussed in the pre-flight briefing. The Investigation could not determine the reasons why the Pilot did not abort the flight.

Safety Recommendations

The development of new technology comes with uncertain hazards and risks, where, in extreme circumstances, the only remaining safeguards remain with the pilot.

In the absence of independent technology that can provide an additional level of safety, the correct decisions made by pilots in these circumstances may be the last defence to a safe mission.

The Air Accident Investigation Sector recommends that:

Jetwing Dubai

SR02/2021

Explores the development of technology that assist the pilot during the hover by limiting the back-leaning attitude within safe margins.

SR03/2021

Revise the *Hazard Analysis Log* to ensure that hazards during Jetwing operations, and in particular during hover, are identified, recorded and mitigated.

SR04/2021

Revise the *Standard Operating Procedures* to ensure that newly developed flight maneuvers are included and regularly updated.

This Summary Report is issued by the:
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The United Arab Emirates

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