COPY Nr.

MINISTÉRIO DAS OBRAS PÚBLICAS, TRANSPORTES E COMUNICAÇÕES

GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES

FINAL ACCIDENT REPORT

INAER - HELISUL

BELL 206 B3

CS-HFB

Serra da Estrela

13th of June, 2009

GPIAA
Homologo nos termos do nº 3 do artº 26º do D.L. 318/99, de 11/08/1999

05.MAR 2010

O Director,

Fernando Ferreira dos Reis

FINAL ACCIDENT REPORT Nr. 18/ACCID/2009

NOTE

This report states the technical findings regarding the circumstances and probable causes which led to this accident.

In accordance with Annex 13 to the International Civil Aviation Organisation Convention, Chicago 1944, Council Directive 94/56/EC, 21st NOV 1994, and article 11th nº 3 of Decree-Law nº 318/99, 11th AUG 1999, the sole purpose of this investigation is to prevent aviation accidents. It is not the purpose of any such accident investigation and the associated investigation report to apportion blame or liability.

The only aim of this technical report is to collect lessons which may help to prevent future accidents.

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SYNOPSIS

On the 13th of June, 2009, by 15:35 UTC[1], during an aerial photography mission, for an advert, in Serra da Estrela mountain, near Lagoa Comprida, Bell helicopter, model 206 B3, s/n 3640, registration CS-HFB, suffered an accident, which caused extensive damage and inflict serious injuries to its occupants.

After a pursuit to an automobile, which served as film model, the pilot executed a right turn, in order to join another target, when suddenly lost control of the helicopter. It started rotating to the right, lost its translation speed and crashed on the ground, on top of a rock, in a hillside.

GPIAA was informed and all measures to assist the victims and preserve the site were taken immediately. Next day a team was dispatched to the site and the investigation process started.

This report has been released in Portuguese and English Languages. In case of conflict, Portuguese version will take precedence.

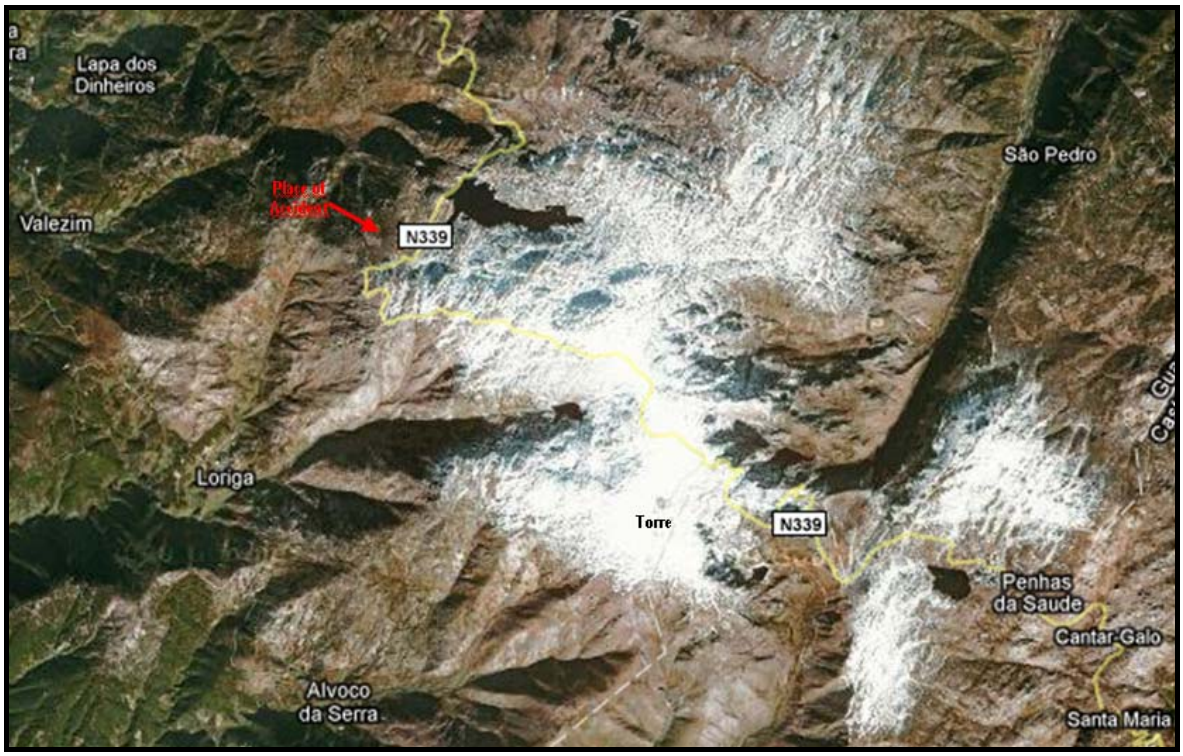
[1] - All timings in this report, unless other specified, are UTC (Universal Coordinated Time) times. By that date, local time was equal to UTC + 1 hour.

1. FACTUAL INFORMATION

1.1 History of the Flight

The aircraft had been hired by an advertising enterprise (*Readytoshoot*) for a German movie maker team to register some images for an advert promoting an automobile new model. A mountain scenery had been chosen and the team headed to Serra da Estrela, setting its base in the snow cleaning centre premises.

That morning some takes have been performed along a road connecting Loriga with Seia and passing near Lagoa Comprida (*picture nr. 1*).



Picture Nr. 1

The director took the front left seat and the cameraman was installed on a special mounted kit, on the right side, behind the pilot, who tried to fly the helicopter cutting car's track and giving the best positions for shooting.

That one was supposed to be the last shooting mission and the helicopter was following one of two cars along the winding road, climbing the mountain, flying 150ft above ground, at an altitude of 5000ft (AMSL) approximately, sustaining an average air speed of 35kt.

By 15:35 the director announced that the first car takings were completed and requested the pilot to join the second car, driving the same route behind number 1.

At that time, the pilot started a right turn, using cyclic control, coordinated with right pedal application.

That's when the helicopter started an anticipated rotation on its axle to the right without left pedal actuation having enough capacity to counteract that yaw force.

Being the pilot unable to regain its control, the helicopter made four 360º rotations to the right, lost its translation speed and collided violently with the ground, some metres below.

After the impact the engine couldn't be shut-down by normal throttle actuation and the pilot had to cut-off fuel supply with fuel valve switch.

After the recommended procedures were performed, the pilot contacted company head-quarters stating the situation and requested rescue and emergency services for medical assistance to the victims.

Police and rescue services arrived promptly and the victims were assisted in place before they were transferred to hospitals in Covilhã (pilot), Viseu (director) and Coimbra (cam-eraman). Later on, the director was transferred from Viseu hospital to Coimbra, due the seriousness of his injuries.

1.2 Injuries

Cabin structure resisted well to impact but the occupants suffered serious injuries on spine, thorax and legs, being subjected to some chirurgical operations.

Injuries	Crew	Passengers	Others
Fatal:	0	0	0
Serious:	1	2	0
Minor/None:	0	0	0
Total:	1	2	0

1.3 Aircraft Damage

The terrain slope was high and the helicopter was rotating and descending vertically until it hit a big rock, protruding from the hillside.

Cabin impact with the rock was very hard and its underneath became smashed. The tail cone broke near the body attachment and vertical stabilizer and tail rotor blades hit the ground, suffering substantial damage, with broken blades and rear transmission torque tube. Skids were broken, on both sides. Number 5 Main Gear Box mounting broke and main rotor mast moved forward. Windshields cracked (*picture nr 2*).

Picture Nr. 2

1.4 Other Damage

There was no third party damage reported.

1.5 Persons Involved

1.5.1 Pilot

Spanish nationality, 37 years old, male, the pilot was one of company instructor pilots more experienced on this kind of aerial work, reason for him to be requested for that mission.

From his documents the following references were retrieved:

Flight License: Type:	ATPL(H)	
Validity:	12-11-2008	
Ratings:	AS-350; Bell-206/212/412; KA-32	
Last Medical Examination:	03-04-2009	
Restrictions/Limitations:	Nil	
Flight Experience:	**Total**	**On Type**
Total:	3047:55	500:00
Last 90 days:	55:40	14:00
Last 30 days:	23:25	04:25
Last week:	04:25	04:25
Last 24 hours:	04:25	04:25

1.5.2 Cameraman

Male, 43 years old, Deutsch nationality, the cameraman was seated behind the pilot, with his legs suspended outside the cabin, installed on a photographic operations dedicated kit (*Tyler middle mount*), being the normal rear seat and rear cabin door removed from the aircraft.

In front of him was the camera mounting and support pod (*picture nr 3*).

Picture Nr. 3

1.5.3 Director

Picture Nr. 4

The director, Deutsch nationality, 42 years old, male, occupied the front left seat, side-by-side with the pilot.

For safety reasons and complying with legal requirements, left seat flight controls had been removed but the pedals, which had been inhibited, by disconnecting them from actuating system, and were only used as footrest, having no movement at all (*picture nr 4*).

1.6 Aircraft

1.6.1 General

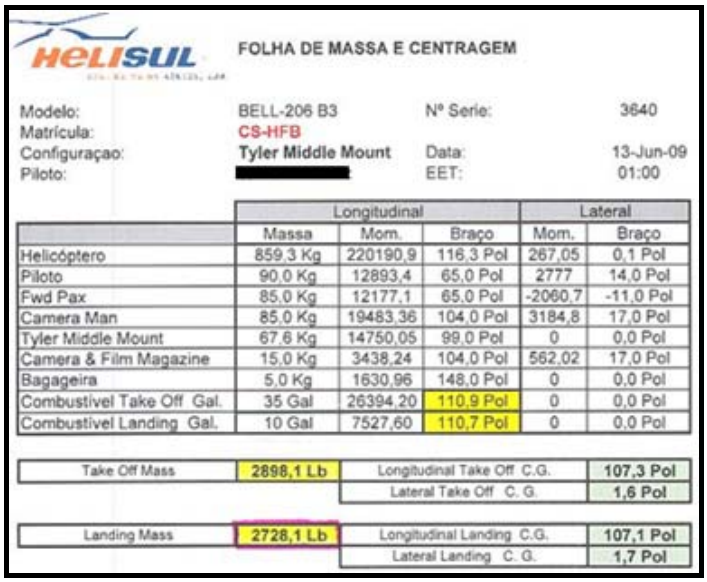
The aircraft was a single engine helicopter, with skids, two pales main rotor, rotating anti-clockwise, and two blades tail rotor, mounted on the left side of tail boom (*picture nr 5*), able to carry up to 5 people and a Maximum Take Off Mass (MTOM) of 3350lb (1519kg).

Picture Nr. 5

CS-HFB registered aircraft had all licenses and certificates valid and all maintenance actions have been performed, according Civil Aviation Authority approved maintenance programme. There were no registered restrictions or operating limitations to the aircraft or its systems and these were its references:

Reference	Airframe	Engine	Main Rotor
Manufacturer:	Bell Helicopter Textron	Allison	Bell Helicopter Textron
Model:	Bell 206B	250-C20J	206-010-100-137
Serial Nr.:	3640	CAE-270059	AAB-05473
Year of Manufacture:	1983	N/D	N/D
Flight Time: TSN:	5387:15	5298:00	5387:15
TSO:	13:45	23:10	13:45
Landings / Cycles:	12975	7642	N/A
Last Inspection:	19-05-2009	17-03-2009	19-05-2009

1.6.2 Mass & Balance



HELISUL — FOLHA DE MASSA E CENTRAGEM

Modelo: BELL-206 B3 — Nº Serie: 3640
Matrícula: CS-HFB
Configuraçao: Tyler Middle Mount — Data: 13-Jun-09
Piloto: [redacted] — EET: 01:00

	Longitudinal			Lateral	
	Massa	Mom.	Braço	Mom.	Braço
Helicóptero	859,3 Kg	220190,9	116,3 Pol	267,05	0,1 Pol
Piloto	90,0 Kg	12893,4	65,0 Pol	2777	14,0 Pol
Fwd Pax	85,0 Kg	12177,1	65,0 Pol	-2060,7	-11,0 Pol
Camera Man	85,0 Kg	19483,36	104,0 Pol	3184,8	17,0 Pol
Tyler Middle Mount	67,6 Kg	14750,05	99,0 Pol	0	0,0 Pol
Camera & Film Magazine	15,0 Kg	3438,24	104,0 Pol	562,02	17,0 Pol
Bagageira	5,0 Kg	1630,96	148,0 Pol	0	0,0 Pol
Combustivel Take Off Gal.	35 Gal	26394,20	110,9 Pol	0	0,0 Pol
Combustivel Landing Gal.	10 Gal	7527,60	110,7 Pol	0	0,0 Pol

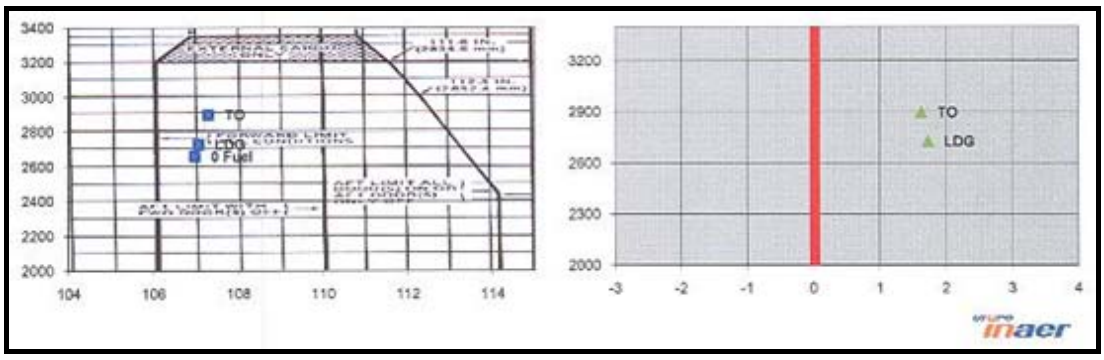
Take Off Mass	2898,1 Lb	Longitudinal Take Off C.G.	107,3 Pol
		Lateral Take Off C. G.	1,6 Pol
Landing Mass	2728,1 Lb	Longitudinal Landing C.G.	107,1 Pol
		Lateral Landing C. G.	1,7 Pol

Picture Nr. 6

The aircraft have been equipped for the mission, carrying aboard one pilot and two passengers, occupying the referred seats. It was refuelled for a take-off 35USG fuel quantity making a Total Take-Off Mass of 2900lb (1315kg) (*picture nr 6*).

By the time the accident happened there was 10USG of fuel on board and Total Mass was 2730lb (1238kg).

Applying respective arms & moments a Balance chart was drown, with a Longitudinal Centre of Gravity (CG) of 107.3in for take-off and 107.1in on accident occasion and a corresponding Lateral CG of 1.6in and 1.7in, well inside the approved envelope (*picture nr 7*).



Picture Nr. 7

1.7 Meteorology

The weather in the area of the accident, by that time, was cloudy, with cumulus and altocumulus, bases between 1000m (3300ft) and 3000m (10000ft) altitude and a horizontal visibility above 20km (12mi). The wind was blowing from west between 10 and 18km/h (5/10kt), the temperature rounded 24ºC and atmospheric pressure was 850hPs at 5000ft.

Westerly winds caused some upward currents along the slopes facing west and light turbulence inside interior valleys.

1.8 Navigation Aids

Not applicable.

1.9 Communications

During the entire mission the aircraft had no communication with ATM services, be it Flight Information (FIS) or Air Traffic Control (ATC).

1.10 Accident Site

The accident occurred in a mountainous region (Serra da Estrela) located at 40º 21' 29'' N / 007º 39' 57'' W, altitude 5060ft on a high slope with level differences of 4900ft to 5100ft (*picture nr 8*).

Picture Nr. 8

When the accident took place construction works were finished and the place showed like on picture nr 9, where we can see the helicopter, after the accident, from above (in the main picture) or from bellow (in the inserted picture).

Picture Nr. 9

1.11 Flight Recorders

The aircraft was not equipped with flight recorders as they were not mandatory for this type of aircraft.

1.12 Wreckage & Impact

As it was a vertical fall of the aircraft on the ground, all parts remained together. Even detached parts, like windshield fragments, were kept inside the cabin. The other broken parts, like skids or tail boom, vertical stabilizer and tail rotor, were not detached from main structure, as seen in picture nr 2, confirming the absence of translational speed.

1.13 Medical or Pathological

1.13.1 Pilot

The pilot was observed at Covilhã Hospital and later assisted at Cascais Orthopaedic Hospital. In face of the violent vertical impact, he suffered a spine compression, with fracture of one vertebra on lumbar region, which forced him to stop his flying activity for a long period.

1.13.2 Cameraman

The cameraman was sat behind the pilot, facing outside towards the hill side, with his legs suspended out of the cabin. He suffered the fracture of the right tibia, right clavicle and shoulder blade, three ribs and L1 vertebra body.

He has been transported directly to Coimbra University Hospital where he went a chirurgical intervention, being later transferred to his home country (16-06-2009).

1.13.3 Director

The director was sat on pilot's left-hand side and suffered the vertical impact on his spine causing several fractures on L4 and L5 vertebrae, which limited his legs movement capacity. When trying to leave his seat he fell down a hole, hidden by the vegetation, which aggravated his injuries.

Rescued by the emergency people he was conducted to Viseu Hospital but, next day (14-06-2009), he was transferred to Coimbra University Hospital, where a chirurgical operation was performed. Two day later (16-06-2009) left, together with the cameraman, to his home country (Germany).

1.14 Fire

There was no fire.

1.15 Survival Aspects

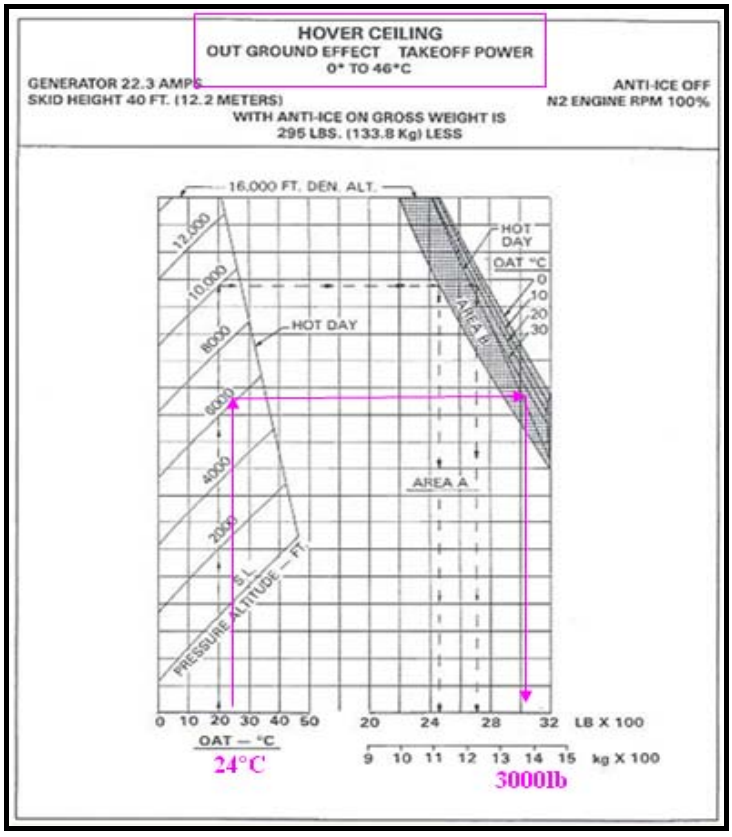
All on board were wearing seat belts fastened and structural cabin resistance helped to minimize injuries. The ground impact was very hard because the aircraft fell on a granitic rock, but its presence prevented the helicopter from rolling down the mountain and it saved occupants lives.

The immediate pilot communication with rescue services, through his mobile phone, allowed an expedite arrival of medical care services and helped on victims survivability.

1.16 Tests & Research

Being not in the presence of material failure or system's malfunction, it was decided not to investigate the equipment and no mechanical tests were carried out.
Research was pointed to aircraft performance and aerodynamic factors, especially to mountain flying at low altitude, reduce airspeed and high engine power.

Performance table, on Aircraft Flight Manual (AFM), regarding aircraft hover performance, out of ground effect, was used (*picture nr 10*) to determine if the aircraft could comply with altitude limited performance.
Considering an outside temperature of 25ºC and a pressure altitude of 6000ft, the table showed that Total Mass could be up to 3000lb (1360kg).
Going back to 1.6.2, Actual Mass of 2730lb (1238kg) was confirmed, though bellow the Maximum Mass allowed for those conditions.



Picture Nr. 10

1.17 Organizational & Management

The operator was dully certificated by Civil Aviation Authority to operate that kind of aerial work with helicopters.

All operations were performed according its Flight Operations Manual (FOM) and Aircraft Operating Manual (AOM) standards and other regulations issued by Civil Aviation and other Authorities and respecting its Aerial Work Operator Certificate (AWOC), issued by INAC.

Aircraft maintenance used to be accomplished by its own technicians or by certificated maintenance providers, in accordance with its Maintenance Management Exposition.

1.18 Additional Information

There's no other relevant information to refer.

1.19 Useful or Effective Investigation Techniques

No special investigation techniques were used during this investigation. All evidences were collected in site or retrieved from approved manuals or other publications issued by the manufacturer.

2. ANALYSIS

2.1 Flight Planning & Progress

"READYTOSHOOT" was an enterprise dedicated to advertisement spots & movies production and it has been appointed to produce an advertisement for a new model car promotion.

Serra da Estrela scenery was selected and the enterprise contacted the operator in order to have a helicopter at its disposal for the exterior takes, suggesting the name of the pilot to be rostered for that operation, once he was known and recognized by its capacity.

On the 13th of June, 2009, all people involved moved to Serra da Estrela and settled at Snow Cleaning Centre, from where they used to leave for the shootings.

For the third sortie, by 16:00, the team headed to an area near Lagoa Comprida, where some takes from the cars climbing the road connecting Loriga to national road N-339 were to be shot.

All necessary equipments were installed, namely the "Tyler Middle Mount" kit, for image's registration, taking out the rear seat and right-hand side rear door.

The helicopter has been refuelled with 35USG of fuel, in order to grant a more comfortable margin of engine power available. The pilot was aware of mission requirements and all the meteorological & aerodynamic phenomenon he could face and its implication on flight performance.

The previous two flights were uneventful and the third one was progressing normally. The aircraft was in pursuit of the first car, meandering between the mountains, some times cutting its track, trying to provide the best angle for the cameraman to get the best images. As the terrain was rising, the helicopter was climbing accordingly, using a power setting close to maximum power. To follow the car, the helicopter speed couldn't be high, which required more power.

When the director announced the first car shootings were finished and asked to go to the second car, the aircraft was flying at low speed (35kt) and using high power setting. When the pilot started a quick right turn, he automatically relieved foot pressure on left pedal allowing the helicopter to enter an unanticipated right yaw situation.

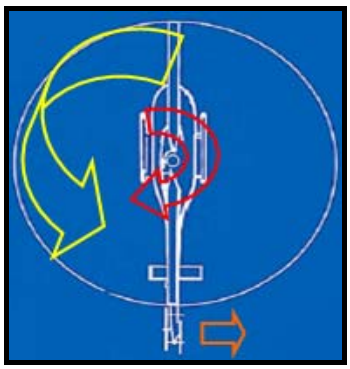
Left pedal application was not enough to counteract the rotation moment and, because he was flying too low, too slow and with too much power applied, the pilot couldn't exchange height for speed or reduce power setting, becoming unable to recover aircraft control.

2.2 Unanticipated Right Yaw or Loss of Tail Rotor Effectiveness

2.2.1 Tail Rotor Purpose

Tail rotor is intended to counteract torque effect generated by main rotor rotation and to provide a smoother and coordinated flight (*picture nr 11*).

It is powered by the engine through a dedicated rear transmission system and controlled by the pedals movement, augmenting or reducing tail rotor blades angle of attack, in order to increase or decrease thrust and balance those forces.



Picture Nr. 11

Tail rotor is effective at all speeds, from hover to maximum speed (VNE) and covers entire engine power range, as applicable to Main Transmission Gear Box, unless a distortion occurs with aerodynamic flux passing through it.

2.2.2 Unanticipated Right Yaw

Unanticipated Right Yaw is the occurrence of an uncommanded right yaw rate which does not subside of its own accord and which, if not corrected, can result in loss of aircraft control. This happens at speeds less than 30kt and applies to all single rotor helicopters, aggravated for high mass and high power regimen. It's not related with an equipment failure nor does it represent a loss of tail rotor.

Sometimes this phenomenon is called "*loss of tail rotor effectiveness*", which is misleading. In fact several studies and wind tunnel experiments showed that tail rotor never lost its capability to produce thrust during all approved flight regimes.

When talking about unanticipated right yaw it's not excluded the existence of a similar unanticipated left yaw. This rotation develops to opposite direction of main rotor rotation and it becomes critical when flying out of ground effect with a translational speed below 30kt, and a turn is initiated towards that direction.

As we are investigating an occurrence with a Bell 206 helicopter and it has an anticlockwise rotation main rotor, critical turn is to the right, so we will continue to refer to right yaw, all along this explanation.

For helicopters with main rotor rotating on opposite direction, the presented considerations have to be adapted.

Aircraft manufacturer, "*Bell Helicopter – Textron*" has published several articles related to this phenomenon, not only through Information Letters Nos. 206-84-41 and 206L- 84-27 and its "*Rotorbreeze*" magazine but only on seminars and other training & information material.

From such material we retrieved the information presented in the following presentations.

2.2.3 Unanticipated Right Yaw Contributing Factors

Four aircraft characteristics during low speed flight have been identified as contributing factors in unanticipated right yaw:

a) Weather cock stability;

b) Main rotor disc vortex interference;

c) Tail rotor vortex ring state;

d) Loss of translational lift.

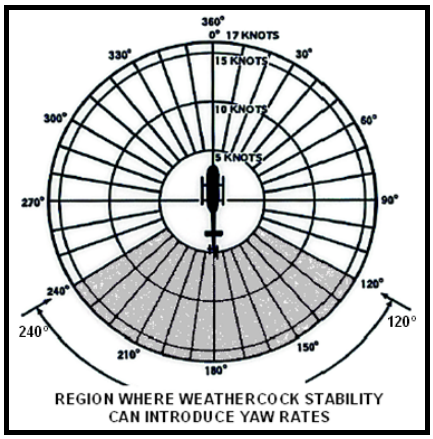
The following summary presentation of each one of these phenomenon is related to Bell 206 helicopter.

Wind directions referred in the pictures is not a geographical direction but a relative direction to helicopter longitudinal axle, considering 000º/360º on the nose and rotating clockwise.

2.2.3.1 Weather Cock Stability

Helicopter's fuselage and vertical fin configuration makes it to weathervane the nose into the relative wind, like a weather cock, rotating to the right or to the left, according wind relative direction.

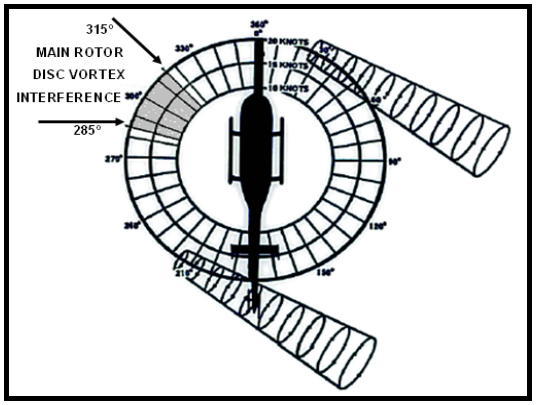
When the wind comes from the shaded area (*picture nr 12*) and a rotation is initiated to any side, that rotation will suffer an acceleration on the same direction, unless timely opposite pedal force is applied, to prevent high yaw rates.



Picture Nr. 12

2.2.3.2 Main Rotor Disc Vortex Interference

When the wind comes from 285º / 315º (*shaded area on picture nr 13*) the vortex generated by main rotor blades may be directed onto the tail rotor, changing its angle of attack.



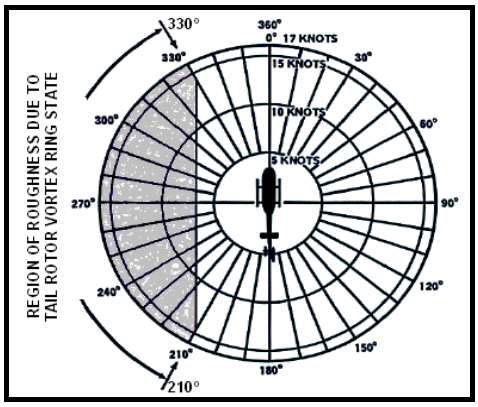
Picture Nr. 13

During a right turn, when tail rotor comes into the area of main rotor disc vortex, the angle of attack of tail rotor is initially increased, which requires the pilot to apply right pedal (reduce thrust) to maintain the same rate of turn.

As the main rotor vortex passes the tail rotor, its angle of attack is reduced, causing a reduction in thrust and a right yaw acceleration begins. This acceleration can be surprising, since the pilot was previously adding right pedal, to maintain the right turn rate. Even if tail rotor doesn't stall, the helicopter will exhibit a tendency to make a sudden, uncommanded right yaw, which, if uncorrected, will develop into a high right turn rate.

2.2.3.3 Tail Rotor Vortex Ring State

If relative winds are blowing from 210º / 330º (*shaded area on picture nr 14*), there's the possibility of development of vortex ring state of tail rotor, which causes tail rotor thrust variations resulting in yaw rates. Having not a specific period, the pilot must make corrective pedal inputs as the changes in yaw accelerations are recognized. This resulting high pedal workload in tail rotor vortex ring state is routinely applied, as helicopters usually fly in this region.



Picture Nr. 14

Unless corrective action is not timely, this characteristic presents no significant problems. If a right yaw rate is allowed to build, the helicopter can rotate into the wind azimuth region where weather cock stability will then accelerate the right turn rate.

2.2.3.4 Loss of Translational Lift

The loss of translational lift results in increased power demand and additional anti-torque requirements. If this occurs when the aircraft is experiencing a right turn rate, the right turn will be accelerated as power is increased, unless corrective action is taken by the pilot. When operating at or near maximum power, this increased power demand could result in rotor RPM decay.

This characteristic is usually associated with unanticipated right yaw once the result of increased right yaw rate is the loss of relative wind, though loss of translational lift. Any reduction in translational lift will result in an increased power demand and anti-torque requirements.

2.2.4 Unanticipated Right Yaw Recovering Technique

Anticipation on left pedal application is the best way to avoid entering an unanticipated right yaw. If it can not be avoided it's necessary to react timely and efficiently using ***left pedal to its maximum extension*** and, ***simultaneously***, ***pushing cyclic forward*** to increase speed.

Once control has been recovered flight controls will be adjusted for normal forward flight.

Collective pitch reduction will aid in arresting the yaw rate but may cause an excessive rate of descent. The subsequent large, rapid increase in collective, to prevent ground or obstacle contact, may further increase the yaw rate and decrease rotor RPM. The decision to reduce collective must be based on the pilot's assessment of the altitude available for recovery.

If not possible to regain control it's recommended to execute an auto-rotation.

2.2.5 CS-HFB Tail Rotor Loss of Effectiveness

The aircraft was in pursuit of car nr 1 on an heading of 230º, flying at low speed (35kt) and close to maximum power.

When requested to proceed to car nr 2, which would be in a position near 360º heading, the pilot started a right turn, reducing left pedal force.

As the wind was blowing from west, when passing by 300º the *"tail rotor vortex ring state"* effect started to interfere with helicopter stability. Before the pilot could initiate corrective action, increasing left pedal displacement, the aircraft passed 315º and *"main rotor disc vortex"* effect increased right yaw acceleration reducing translational speed and corresponding translational lift.

At this point the pilot could only recover control with an increase on translational speed (***pushing cyclic forward***) or reducing main rotor pitch (***putting collective down***).

Both solutions implied considerable altitude loss, which the pilot couldn't afford at that moment.

3. CONCLUSIONS

3.1 Findings

Based on what has been exposed, we may conclude that:

1st The flight has been approved and all recommended safety measures have been considered;

2nd The pilot was duly qualified for the mission and he showed no signs of any incapacity for the job;

3rd Aircraft Certificate of Airworthiness was valid, maintenance approved programme has been complied with and there were no reports of system's malfunctions or limitations ;

4th Total Mass & Balance sheet showed normal values and well inside flight envelope;

5th During a right turn, at low speed and low altitude, the aircraft entered on an unanticipated right yaw condition, which caused the loss of control of the aircraft;

6th The pilot had no required altitude available for recovery of the situation and couldn't avoid aircraft collision with the ground;

7th Aircraft ground collision caused serious injuries to the occupants and substantial damage to the helicopter.

3.2 Causes of the Accident

3.2.1 Primary Cause

Primary cause of the accident was pilot loss of control of the aircraft, after it started an unanticipated right yaw.

3.2.2 Contributory Factors

The following were considered as Contributory factors:

1st Flying at low altitude above the ground;

2nd Flying at low translational speed;

3rd Flying with a Total Mass close to Maximum Mass for that altitude;

4th Flying at high engine power setting.

4. SAFETY RECOMMENDATIONS

There are no safety recommendations to address but, considering there are a great number of single rotor helicopters flying in the country and being this a typical single rotor helicopter's phenomenon, we remember all operators that they should include in their recurrent training programmes some material related to low speed flying characteristics and unanticipated yaw acceleration prevention & recovery procedures.

Lisbon, 11th of February 2010

The Investigator In Charge,