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ACCIDENT REPORT

Unstabilised approach, hard landing

Aircraft	Embraer ERJ 145 MP registration F-GUBF
Time and date	1.07 p.m.(1) on Monday 24 May 2010
Operator	Regional CAE
Location	Ljubljana aerodrome (Slovenia), runway 31
Nature of the flight	Scheduled public transport of passengers
(Flight) crew	Pilot-in-command, co-pilot
Consequences	Damage to landing gear and structural components

(1) Unless otherwise stated, the times contained in this report are expressed in Coordinated Universal Time (UTC).

PROGRESS OF THE FLIGHT

NB: For this section, unless otherwise stated, the heights represent the height in relation to the threshold of the runway in operation. The altitude values are those of the recorded parameter.

The crew of the Embraer ERJ 145 took off from Paris Charles de Gaulle bound for Ljubljana with two members of flight crew, one member of cabin crew and 49 passengers. The flight progressed without incident until the descent. The crew was under radar vectoring for an ILS approach to runway 31 in operation.

Descending to an altitude of 7,000 ft, on heading 110, the co-pilot (PF) agreed to the suggestion of the pilot-in-command (PNF) to change to a visual approach. The approach controller agreed to the request from the crew and authorised them to change to a visual approach with a clearance limit of 4,000 ft. The runway was to the left of the aircraft and the meteorological conditions made a visual approach possible, with turbulence deemed moderate by the crew.

The PF turned base leg. At this point the aircraft was at an altitude of 6,500 ft and was approximately 4.5 NM from the threshold of runway 31. The clearance limit was lifted as the aircraft descended through 5,500 ft. The PF, who could not see the runway from his right-hand seat position, turned towards final on the basis of information from the pilot-in-command. The aircraft was established for final at a distance of 2.8 NM from the runway threshold and at an altitude of 2,900 ft, i.e. a height of 1,709 ft. Following the triggering of a "SINKRATE" EGPWS Alert, the co-pilot announced that he was struggling to control the aircraft. The controls were therefore transferred to the pilot-in-command who continued the approach. At between 1 and 1.5 NM from the runway threshold, the pilot-in-command levelled off the aircraft at a height of approximately 800 ft to reduce the aircraft speed and set the flaps to an angle of 45 degrees. At 0.9 NM from the threshold and still at a height of 800 ft, the pilot-in-command restarted the aircraft descent. A "SINKRATE" EGPWS Alert was triggered for 6 seconds, followed by a "PULL-UP" Warning for 11 seconds. At this point the aircraft was at a height of 100 ft and the pilot-in-command began the touch-down:

- his nose-up action caused a significant and rapid variation in the pitch attitude;
- at a height of 10 ft, the thrust levers were pushed half-way forward and then immediately brought back to the idle position.

These two actions aimed at reducing the rate of descent were not sufficient to prevent the hard landing.

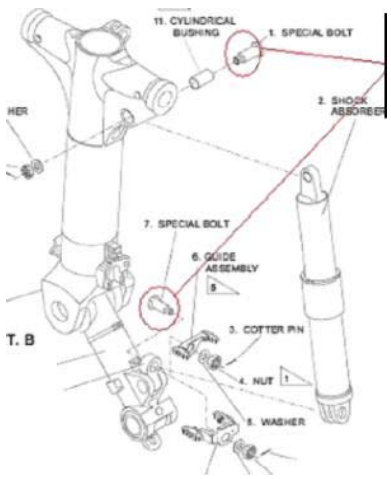
Contact with the ground was made with a load factor[(2)] in excess of 4 G and with a vertical speed calculated at -1,300 ft/min. The aircraft bounced and the load factor on the second contact with the runway was 2.26 G. The pilot-in-command controlled the aircraft's track on the runway and proceeded to the apron.

[(2)] Nz, load factor normal to the aircraft horizontal plane

ADDITIONAL INFORMATION

Damage to the aircraft

The shock-absorbers of the left and right main landing gear were found to be distorted. The landing gear had to be changed.



MLG damper axes found deformed

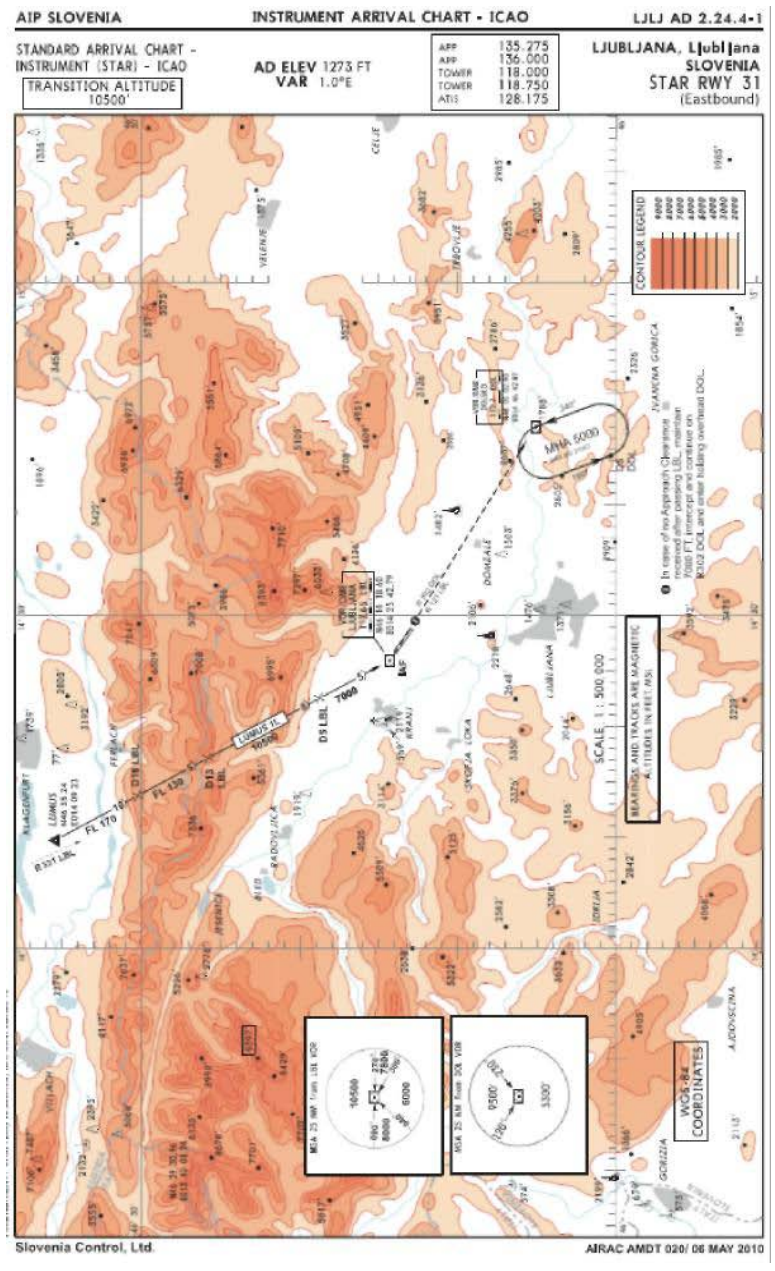
Deformation to the damper axes of the main landing gear

The reinforcing plate between the fuselage and the wing at the fairings was bent and some of its rivets were broken.

Meteorological information

Meteorological conditions observed at Ljubljana aerodrome: wind from the north-westerly at 8 kt, visibility more than 10 km, Broken Stratocumulus at FL60, QNH 1013.

Aerodrome information



Ljubljana aerodrome is located at the foot of the Julian Alps, at the entrance to a valley which runs north-west/south-east. This valley, closed to the north and west by a mountain chain, the highest summits of which reach almost 7,000 ft, is open to the south-east towards the plain and the town of Ljubljana.

Owing to the topographical environment of Ljubljana aerodrome, Regional's Operations Manual states that all members of flight crew must conform that they have familiarised themselves with the instructions set out in Part C of the Manual. In particular, these instructions draw the crews' attention to the prevailing winds at altitude to the west and to the immediate proximity of terrain which could lead to turbulence during the approach phase when the wind has a northerly component.

The final descent of the ILS approach to runway 31 is performed with an angle of descent of 3 degrees and begins at 4,000 ft, at a FAP (BASTA) which is located at 8.9 NM on the ILS DME. Runway 31 is equipped with a PAPI.

Operator's procedures

Visual approaches

The arrival briefing must take into account the special characteristics of the approach, in particular if there is any change to the general plan of action which was initially adopted when the arrival was briefed. A visual approach requires the crew to build a flight path, unlike instrument approaches which are already built onto a published flight path. A specific briefing is therefore necessary.

Regional's operating manual indicates that the briefing for a visual approach must be "*short and concise*". It must cover the following elements:

- □ runway;
- □ flight path adapted to the environment;
- □ minimum stabilisation height;
- □ flight path in the event of a loss of visual references;
- □ flight path in the event of a visual go-around if different from that described during the arrival briefing.

Once authorised to perform a visual approach, the crew did not do a specific briefing and did not update their initial arrival briefing. They not use the means at their disposal (for example, radio navigation, approach charts) to help them specify and validate this change of approach, in a mountainous environment which can change the judgement of a visual flight approach path. The crew therefore found themselves on final approach at a steep angle because of an imprecise assessment of the situation before the turn onto base leg.

Approach stabilisation

Regional's Operations Manual sets out the statutory definitions, the airline's policy and its guidelines concerning approach stabilisation criteria.

Stabilisation criteria

The aircraft is stabilised during final approach when the following conditions are met:

- □ *the final approach is being made on the prescribed slope (a standard 3 degrees or as otherwise defined in the procedure plate of the QFU in question);*
- □ *the aircraft is on the extended runway centreline or on the published flight path;*
- □ *the speed is equal to the calculated Vapp;*
- □ *the landing gear is down and the flaps are set to an approved landing configuration (45 or 22 degrees);*
- □ *approach thrust is set;*
- □ *the landing checklist is complete.*

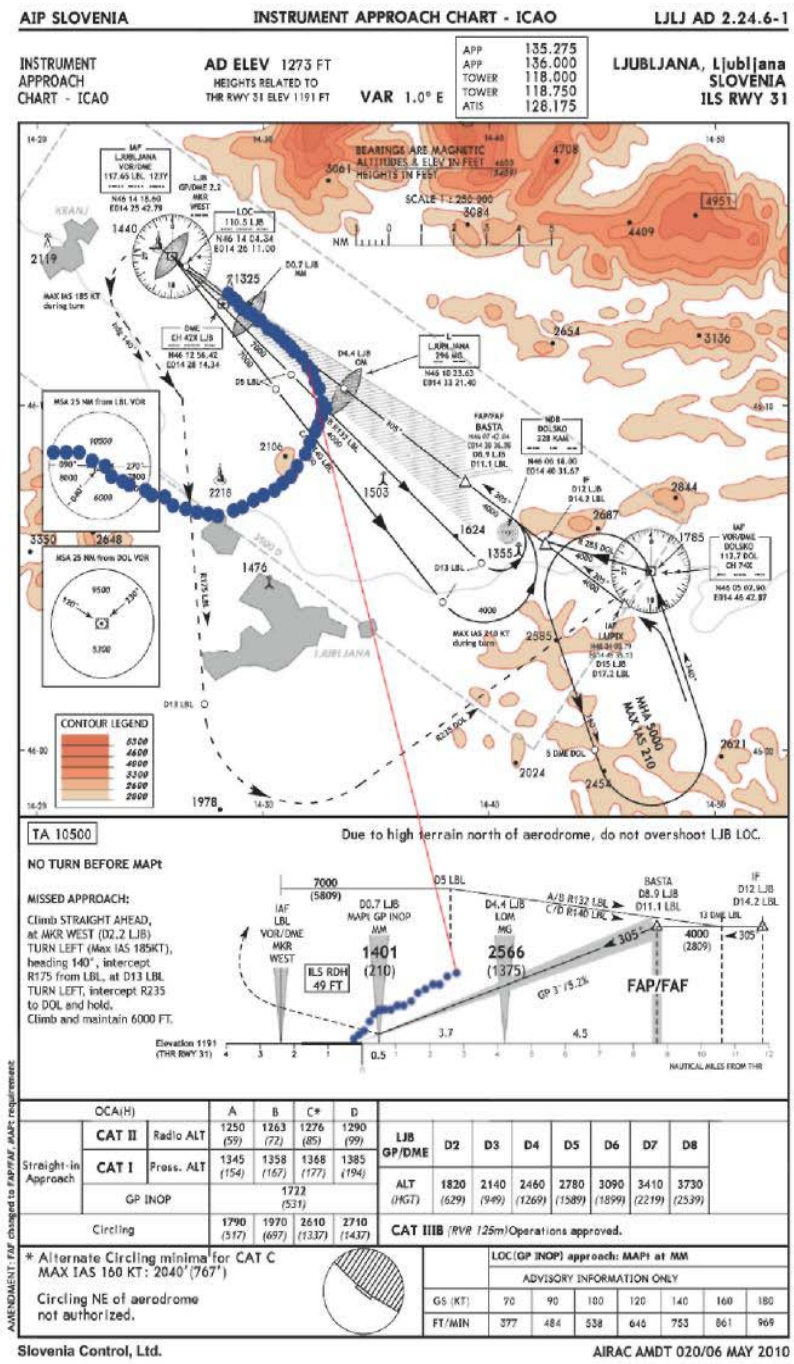
If these stabilisation criteria are not met at the minimum stabilisation height or if after this stabilisation level a wing oscillation is detected, a go-around or rejected landing must be carried out.

Extract from Regional's Operations Manual

The Operations Manual states that visual approaches must be stabilised "*at the latest by the MDA[3] of the visual procedure and aligned with the extended centreline of the runway in the event of a visual approach not so aligned (made from the visual traffic circuit or by an (alternative) procedure*".

[3]The MDA for runway 31 at Ljubljana is 2,610 ft, i.e. a height of 1,337 ft.

The approach carried out by the crew was not stabilised at any point. At a height of 1,337 ft, the angle of descent being followed was 4°, the configuration was flaps 22° with the landing gear down with the speed 170 kt compared to a Vapp calculated for this configuration of 134 kt. At a height of 800 ft, the pilot-in-command levelled off the aircraft to set the flaps at 45°.



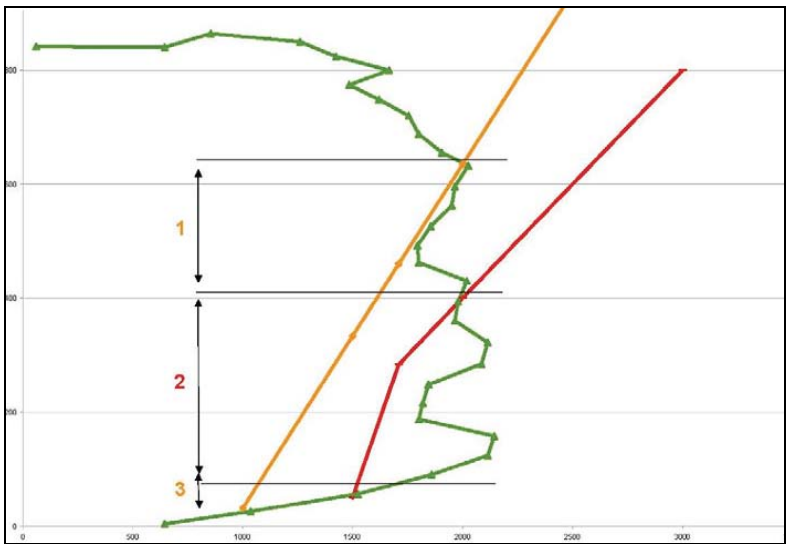
In the event of an unstabilised approach, the decision to abandon the approach may be taken by the pilot-in-command or the co-pilot, whether PF or PNF. Moreover, the Manual specifies that "*independently of the stabilisation criteria, the pilot-in-command or the co-pilot has the power and the duty to seek to abandon an approach or a landing […] if one or other of them feels that the approach or landing is compromised, or there is a danger in continuing the approach*". The transfer of the controls during the approach certainly placed the co-pilot in a difficult situation. He gradually found himself taking a back seat with regard to the progress of the flight and the seeming ease with which the pilot-in-command took over the controls probably reassured him in his role as an observer.

EGPWS activations

In the event of a "PULL-UP" EGPWS Warning, the emergency procedure described obliges the crew to react boldly, without hesitation and without trying to analyse the situation, whatever the conditions (day, night, in VMC or IMC). Regional's Operations Manual also explains that if an EGPWS Alert triggers without a PULL-UP message during flight in day VMC, the crew has the option either to correct the flight path to stop the alert, or to abandon the approach. In the event of an unstabilised approach, the crew must perform a go-around.

The Operations Manual states that "*if the pilot-in-command does not respond to the EGPWS activations, the co-pilot must assume that he/she is incapacitated and must take control of the aircraft in order to carry out the appropriate procedure*".
The following graph shows the activation envelope for the "excessive rate of descent" mode (Mode 1). The area between the yellow curve and the red curve corresponds to the SINK RATE Alert. The area under the red curve is that in which the PULL-UP Warning is triggered. The green curve is derived from the parameters of the aircraft[4]

[4] The descent rate was calculated on the basis of altitude. Moreover, these low values do not correspond to the exact values owing to the hysteresis effect.



Vertical axis shows height in ft /Horizontal axis shows vertical speed in ft/min

During the final approach, several EGPWS activation occurred. Despite a PULL-UP Warning alarm lasting 11 seconds, the crew did not commence a go-around. When the pilot-in-command took over the controls for the final approach, his experience as a glider pilot and aerobatic pilot reassured him in his decision to continue to land, and thus not to respond to the EGPWS calls.

Crew testimonies

Pilot-in-command (54 years old, 12,812 hours of flight time, of which 5,900 on type)

The entire flight was performed without any time pressure or incident until the beginning of the approach. Taking into account the good meteorological conditions, a visual approach was requested of and approved by the approach controller. The pilot-in-command felt that the "high on the approach " position was due to the approach controller keeping the aircraft at 4,000 ft[(5)]. Since the co-pilot appeared to encounter problems managing the flight path, and owing to an initial EGPWS alert, he decided to take over the controls.

He did not feel he was on a particularly steep angle of approach. He remained confident while carrying out the approach until the landing despite the triggering of further EGPWS alerts/warnings. At the very end of the approach, he felt a significant sinking of the aircraft and recollected the landing to have been abrupt without any bounce.

Co-pilot (54 years old, 9,994 hours of flight time, of which 2,392 on type)

As the co-pilot exited the cloud layer, the pilot-in-command suggested performing a visual approach, which he accepted. The co-pilot mentioned a long period of "tail wind" whilst being held at 4,000 ft by the approach controller, which led to the aircraft being positioned high on the approach. He entered into an area of moderate to strong turbulence and had difficulty reducing speed. He heard an EGPWS alert and announced that he couldn't "feel" the aircraft very well. The pilot-in-command therefore took over the controls. The co-pilot deemed the approach steep, but despite further EGPWS activations, he did not regard the position as difficult. He mentioned that the pilot-in-command was clearly confident, which led him to think that the latter would reach the required descent vertical profile. At a height of approximately 200 ft, he felt a rapid sinking of the aircraft which the pilot-in-command attempted to counter, but the movement was too fast. It was a hard landing.

The crew mentioned moderate turbulence during the approach, from FL 100 until the landing. There was no reference to the PAPI at ant time during the approach.

Cabin crew

The cabin crew member declared that, shortly before landing, during turbulence, he had prepared for an abnormal situation since he did not hear the usual messages when at his workstation (in particular the "one hundred" announcement). He said he had heard another message which he could not identify. He described the landing as violent with a bounce, followed by normal taxiing.

[(5)] The clearance limit was in fact lifted when the aircraft descended through 5,500 ft..

CONCLUSION AND LESSONS LEARNT

The crew was authorised to perform a visual approach. The co-pilot decided to turn base leg too close to the runway taking into account the altitude, which positioned the aircraft on a final approach above the final approach profile and with a high indicated speed. Continuation of the unstabilised approach, in turbulent conditions, led to the hard landing.

Overconfidence on the part of the pilot-in-command in combination with the passive attitude of the co-pilot following the transfer of control during the final approach resulted in a (significant) authority gradient in the flight deck. In these circumstances, breaking off the approach was not envisaged by the crew despite awareness of several EGPWS activations and failure to meet stable approach conditions.

The following factors also contributed to the accident:

- the failure to update the arrival briefing after receiving clearance to make visual approach;
- during the visual approach, the assessment of the situation by the crew was without recourse to available information. This information is all the more useful in a mountainous environment where terrain can distort the perception of the vertical profile to follow;
- the distribution of tasks between the crew. It was in fact less convenient for the PF, sat on the right, to visually locate the ground during the turns onto base leg and final approach.

Arrival briefing

The purpose of the briefing is to align the crew on the plan of action and to identify any special features of or threats to the approach in order to reduce the risk of surprise effects. The identification of any special features of the approach during the arrival briefing is one of the recommendations of IATA and the Flight Safety Foundation.

Visual approach

The purpose of a visual approach is to reduce the flight track and therefore the flight time and fuel consumption. It should not be carried out to the detriment of safety, and does not mean that the crew can dispense with monitoring and checking the progress of the flight. This accident demonstrates that assessment can be considerably flawed and may not therefore allow the risk encountered to be identified.

Crew work

The co-pilot's testimony reveals that he was gradually excluded from the plan of action until he found himself more of an observer of the flight than an active participant. The suggestion of a visual approach seems to have been passively agreed to. During the approach, the co-pilot mentioned that he was struggling to control the aircraft, which led the pilot-in-command to take back the controls.

The apparent ease with which the pilot-in-command acted, owing to his confidence in the success of the approach, reassured the co-pilot in his role as an observer. The co-pilot gradually took a back seat with regard to the progress of the flight, which prevented him from intervening in respect of the non-stabilisation of the approach and the triggering of the EGPWS alarms.

Management of the alarms

In no case should a plan of action include the triggering of an alarm and lead the crew to judge the activation of an alarm normal. The emergency procedure required in response to the EGPWS PULL-UP Warning must be applied without equivocation. The precise purpose of this warning is to alert the crew to a severe situation which they have not recognised. Like TCAS activations, EGPWS activations must be considered as an unquestionable protection and must lead the crew to react. This reaction must be initiated by either the pilot-in-command or the co-pilot.