







GEA Tianjin / 中国民航大学中欧航空工程师学院

Presented by

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Airbus

HUMAN FACTORS








Content

- Introduction, tests & concepts
- Involvement of human factors in accidents
 - Some figures
 - Accident studies
- How to address human factor problematic ?

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Introduction, tests & concepts

- **Awareness test :**



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Introduction, tests & concepts

- **Instructions :**

- ▶ There is a black point in the next picture. Stare at it for at least 30 sec without moving the eyes

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Introduction, tests & concepts

•The Aristotle Illusion

- Try by yourself...

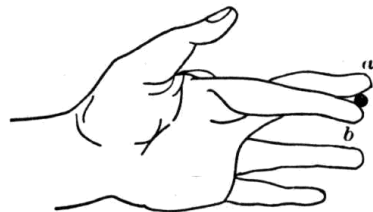


FIG. 48.

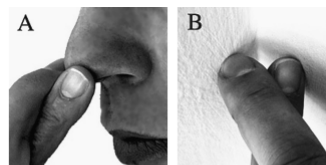
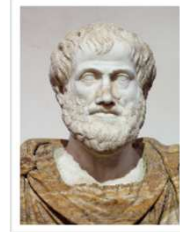


Fig. 1. The classic "Aristotle illusion" demonstration involves touching a pea. (A) Fingers are crossed and the nose is touched instead. One should feel two noses. Try different places. (B) The reverse illusion can be experienced by touching an inside corner with finger crossed. One should feel one surface, not two.

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Introduction, tests & concepts

•How many « F » ?

- Count the number of « F » letters in the text that will appear. You have 10 sec

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++++++
 FINISHED FILES ARE THE RE-
 SULT OF YEARS OF SCIENTIF-
 IC STUDY COMBINED WITH THE
 EXPERIENCE OF YEARS IN THE
 FUN OF THE EXPERIMENT.
 ++++++

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Introduction, tests & concepts

- Instructions :**
 - 8 is the right answer
 - Often, people find only 4, or more scarcely between 5 and 7
- Explanation :**
 - While reading quickly eyes are performing small jerks, eyes are focused by lexical words, jumping over grammatical words (article, conjunction...).
 - The 3 “F” of “OF” into the text are not directly identified.

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If yuo can raed tihs txet , it's bceuase yuo hvae aslo a good brian. Not all teh poelpe are albe to undrestnda tihs txet . Flolownig a sudty form Unievristy of Cmabridge, the odrer of the lteters is not so mcuh imotprante. The fisrt and the lsat leteters are imotprante.

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Introduction, tests & concepts

• Explanation :

- Your brain will automatically perform corrections / misspelling provided the word is not too much altered
- You cannot prevent the this process !

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Introduction, tests & concepts

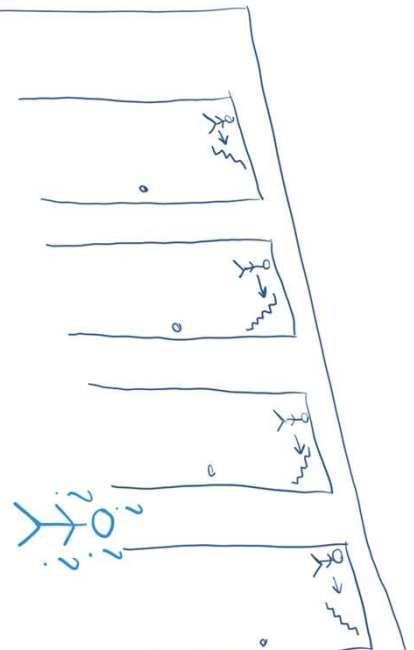
- **Some common human tendencies involved in human factor issues :**

- ▶ Sensory illusion (cf. previous test)
- ▶ Focalisation/tunneling of attention (cf. previous test)
- ▶ Error persistence
- ▶ Long time habit / automatic gesture

Orange Blue Green Pink Orange Purple Pink
Purple Yellow Green Blue Green Blue Purple
Yellow Orange Gray Red White Red Pink
Blue Gray Red Blue Orange Red Blue
Purple Red Purple Orange Gray Red Green
Blue Purple Pink Yellow Pink Green Yellow
Orange Yellow Red Yellow Pink Orange Green
Purple Gray Red Orange Green Blue Green
Pink Gray Red Yellow Purple Blue White
Pink Blue Green Purple Yellow Gray Yellow



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Introduction, tests & concepts

- **Some common human tendencies involved in human factor issues :**

- ▶ Sensory illusion (cf. previous test)
- ▶ Focalisation/tunneling of attention (cf. previous test)
- ▶ Error persistence
- ▶ Long time habit / automatic gesture
- ▶ ...

Strongly influenced
by stress, fatigue,
conflicts...

- **Some designs are prone to raise human factor issues**

- ▶ Absence of information
- ▶ Too much information / Overloaded
- ▶ Lack of information hierarchy
- ▶ Contradictory information
- ▶ Ambiguous information / missing conventions
- ▶ ...

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Involvement of human factors in accidents

- **Study case 1:** Tenerife airport disaster (March 27, 1977)



Computer-generated portrayal of collision between both Boeing 747



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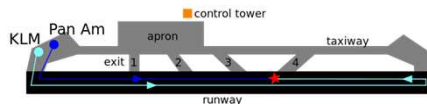
Involvement of human factors in accidents

• Study case 1: Tenerife airport disaster (March 27th, 1977)

- **Overview:** 2 Boeing 747 (KLM / Pan Am) collided on ground, one was taking off, the other one was rolling out to take off just after it. 583 fatalities, 61 survivors.

► Detailed facts

- Bomb explosion at Gran Canaria Airport, the threat of a second bomb → many aircraft to be diverted to Los Rodeos Airport (small airport with 1 runway)
- Apron was saturated, need to use the runway instead of the taxiway
- Poor visibility (<100m) on part of the runway
- Pan Am Aircraft misses the third exit he was supposed to take
- KLM completes its rollout, perform U-turn and prepares for taking off
- Without being really cleared for taking off, KLM captain applies TO power and release the brakes
- Interferences prevented the 2 aircraft and the tower to communicate properly
- The 2 aircraft collided at the level of the 4th exit



Source : Wikipedia

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Involvement of human factors in accidents

• Study case 1: Tenerife airport disaster (March 27th, 1977)

► Investigation conclusion:

- **Main cause of the accident :**
 - Captain Veldhuyzen van Zanten (KLM 747) took off without proper clearance.
 - desire to leave as soon as possible in order to comply with KLM's duty-time regulations?
 - before the weather deteriorated further?
- Other major factors contributing to the accident were:
 - The sudden fog greatly limited visibility. The control tower and the crews of both planes were unable to see one another.
 - Interference from simultaneous radio transmissions, with the result that it was difficult to hear the message.
- The following factors were considered contributing but not critical:
 - Use of ambiguous non-standard phrases by the KLM co-pilot ("We're at take off") and the Tenerife control tower ("OK").
 - The Pan Am aircraft had not exited the runway at C-3.
 - The airport was forced to accommodate a great number of large aircraft due to rerouting from the bomb threat, resulting in disruption of the normal use of taxiways

Source : Wikipedia

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Involvement of human factors in accidents

• Study case 2: Überlingen mid-air collision (July 1st, 2002)

► **Overview:** A Tupolev Tu-154 passenger jet; and DHL Flight 611, a Boeing 757 cargo jet; collided in mid-air over the southern German town of Überlingen. 71 Fatalities. 0 Survivor.

► Detailed Facts

- Controller Peter Nielsen working on 2 workstation at the same time
- He realized the trajectory of the A/C was conflicting about 1 minute before the crash
- He contacted the Russian pilot, instructing to descend by a 1000ft
- TCAS order were contradictory with control instructions
- Both A/C were descending at approx. The same rate
- Unaware of the TCAS instructions, the controller maintained its demand to descend and provided wrong information about traffic position
- The 2 aircraft collided in the air at a right angle, the 757 VTP sliced the Tupolev fuselage.

Source : Wikipedia

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Involvement of human factors in accidents

• Study case 2: Überlingen mid-air collision (July 1st, 2002)

► Investigation conclusion:

- **Main cause of the accident :**
 - Air traffic controller gave inappropriate instruction to Tupolev pilot
 - TCAS orders were disregarded
- The investigations mentions that:
 - Only one controller supervising the airspace, the other one on duty was resting (against regulation)
 - Several radars and warning systems were switched off or deactivated for maintenance but the controller was not aware of this

Source : Wikipedia

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Involvement of human factors in accidents

• Study case 3: Flight 236 Air Transat (August 24th 2001)



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Involvement of human factors in accidents

• Study case 3: Flight 236 Air Transat (August 24th 2001)

► Overview: Airbus A330 flying from Toronto to Lisbon.

Total engine flame out over the Atlantic ocean then emergency landing on the Azores.
No fatality, only light injuries.



► Detailed Facts

- During the cruise, the crew got an oil low temp alert which is not common in flight
- The crew contacts Air Transat technical team on ground, unable to explain it → A spurious warning is then suspected
- 20 minutes after that first alarm, another warning is triggered concerning a fuel imbalance
- As per procedure, the crew proceeds with fuel transfer from one wing to the other one which is almost empty without
- As the imbalance persists, the crew starts suspecting a possible fuel leak
- As the fuel leak cannot be confirmed visually by the cabin crew (night)
- One hour after the first alert the first engine stops running out of fuel, then the other one 15 min later
- The crew managed to glide up to a military runway on the Azores
- With limited braking capacity and a very high ground speed, the 3km runway was not oversized

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Involvement of human factors in accidents

• Study case 3: Flight 236 Air Transat (August 24th 2001)

► Investigation conclusion:

- As suspected, the imbalance was caused by a leak in the engine #2 feed line
- Engine #2 had been replaced recently by a spare one but the maintenance operations were not performed in total respect of the rules
- Some parts were missing with the new engine, had been taken from another engine and were adapted by the maintenance team
- The appropriate clearance between fuel and hydraulic lines was not respected, causing chafing between them and finally rupture of the fuel one
- The first alert was not spurious, but a first symptom of the fuel line failure (impossible to guess for the crew)
- The crew made an error not checking rigorously enough the presence of a fuel leak before opening the crossfeed valves

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Involvement of human factors in accidents

• Study case 4: Flight 235 Trans Asia Airways (FEB 4th 2015)



- **Overview:** 2 minutes after having taken off from Taipei, an ATR 72-600 crashed into Keelung river after one engine failure and the crew shutting down the other one by error

► Detailed Facts

- Right after taking off, the right engine fails
- Pilots sends a Mayday indicating the failure of the left engine
- Pilots perform the restart procedure on the wrong engine which is the last running
- The crew attempts to restart the engine but too late
- With 2 engines out in climb so close to the ground, the aircraft stalls instantly then crashes

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Involvement of human factors in accidents

• Study case 4: Flight 235 Trans Asia Airways (FEB 4th 2015)



► Investigation conclusion:

- Maintenance had been performed on one engine prior to flight
- When the engine failed, the appropriate alert was triggered after the engine failure and the engine was auto feathered
- The pilot shut the wrong engine by mistake, CVR data study reveals he realized he made this mistake a few seconds before the crash.
- **Note:** After the accident, Trans Asia pilots have gone through a test on how to react to an engine failure. All of them passed it except one. All Taiwan airlines have done the same. 10 pilots have been suspended.

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Involvement of human factors in accidents

• Study case 5: Flight 148 Air Inter Mount Saint Odile (JAN 6th 1991)



- **Overview:** An A320 crashes on Mount Saint Odile during final approach approx. 20km away from the runway threshold. 87 fatalities 9 survivors.

► Detailed facts:

- Arriving near Strasbourg (destination) : Bad weather conditions, no visibility
- The control ask the crew to perform a loop over the runway to let some Aircraft take off
- To avoid the long VOR/DME procedure the control suggest a shorter radar guided one
- The control guides the A/C along the procedure
- The final turn they performed is a bit too tight : The A/C is aligned with the axis but on the left.
- The steep descent (3300ft/min) with AP engaged is engaged 45 sec before the crash

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Source : Aviation safety network / Wikipedia / BEA

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Involvement of human factors in accidents



• Study case 5: Flight 148 Air Inter Mount Saint Odile (JAN 6th 1991)

► Investigation conclusion:

- Main causes of the accident :
 - Crew is focused on the lateral trajectory
 - The captain suggest to be careful about the descent rate, and gets interrupted by the FO
 - Probable confusion made during AP mode tuning between:
 - 3.3° (Flight Path Angle)
 - 3300 ft/min (Vertical Speed)
- Other contributing factors:
 - Lack of announcement and control of the tuning performed between CAP and FO
 - Suspicion of VOR misbehaviour
 - Ambiguous guidance orders from controller
 - No GPWS (Air Inter choice, for fear of spurious activation)

Source : Aviation safety network / Wikipedia / BEA

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Involvement of human factors in accidents



• Study case 6: Flight 604 Flash Airlines Sharm el-Sheikh (JAN 3rd 2004)

- **Overview:** A Boeing 737-300 crashed into the red sea shortly after take-off at Sharm el-Sheikh. 148 fatalities.

► Detailed facts:

- Perfect weather with excellent visibility
- After take-off, the plane climbed and performed a procedural left turn to intercept a radial
- FO engaged the AP, the CAP expressed its surprise and AP got manually disconnected almost immediately (approx. 3 sec)
- The bank angle was increasing up to 40° : FO warned the pilot
- The crew did not stabilize the bank angle (reached up to 111°) and let the pitch go down to 43°
- The crew attempt to recover too close to the ground
- The Boeing crashed into the red sea at 770km/h with a 24° nose down attitude

Source : Aviation safety network / Wikipedia

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Involvement of human factors in accidents

• Study case 6: Flight 604 Flash Airlines Sharm el-Sheikh (JAN 3rd 2004)



► Investigation conclusion:

- Report conclusions are still controversial but highlight that human factors played a role in the accident.
- Debris examination allowed to dismiss terrorism hypothesis
- **NTSB (USA) and BEA (FR) pointed at several factors:**
 - Distraction may be involved : Captain ask repeatedly for AP 30 sec before the crash whereas the A/C attitude is abnormal,
 - The captain seems focused on AP engagement whereas the priority is to stabilize the A/C
 - Something the captain did not understand about AP behaviour « See what the A/C did » from CVR transcript
 - Spatial disorientation was involved:
 - The Captain repeats several time « Autopilot » probably to urge the FO to engage it whereas the excessive attitude of the A/C clearly prevents it
 - Fear from the co-pilot to challenge his superior authority:
 - Several warning from the FO about the roll angle but no corrective action from the pilot
- Egyptian authorities do not agree and blame technical issue

Source : Aviation safety network / Wikipedia

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Involvement of human factors in accidents

• Study case 7: Afriqiyah Airways Flight 771 Tripoli (MAY 12th 2012)



► **Overview:** An A330-200 flying from Johannesburg to Tripoli crashed approx. 1km before the runway it was supposed to land on. 103 fatalities, 1 survivor.

► Detailed facts:

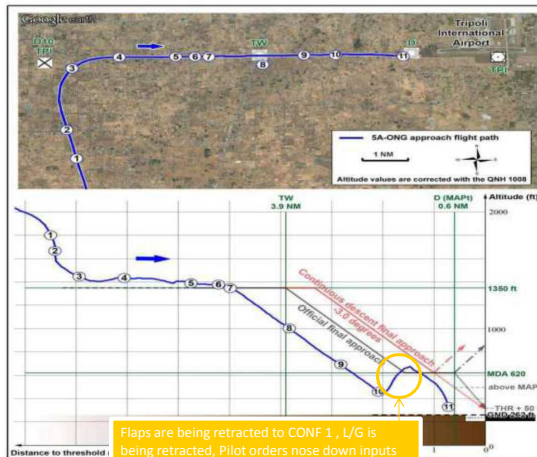
- No visual reference before approach was started
- Final descent for landing started too early
- Terrain awareness warning as the A/C is 280 ft AGL
- Manual AP disconnection, then go around
- A/C pitches up to +12° then L/G and flaps retraction
- The co-pilot orders nose down, down to -3.5°
- Flaps are progressively retracted by the crew as the A/C increases
- The ground proximity warning system sounded as the aircraft lost more height and the co-pilot responded with a sharp nose-down input
- Two seconds before impact (180 ft AGL), Both captain and FO pulling on the side stick fully back
→ aware of the aircraft's impending collision with the ground

Source: LYCAA/BEA report ; Wikipedia

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Involvement of human factors in accidents

• Study case 7: Afriqiyah Airways Flight 771 Tripoli (MAY 12th 2012):



1. At 03 h 57 min 35, the Captain asked the co-pilot, who agreed, to carry out the approach in "Nav approach".
2. At 03 h 57 min 51, the Captain called out "Track FPA" and the co-pilot replied "I will do it [when] establish".
3. At 03 h 58 min 25, the aircraft altitude was 1,400 ft, NAV and ALT modes were engaged and the aircraft route was 089 degrees.
4. At 03 h 58 min 46, the Captain asked the co-pilot "Give it to the approach now or this". Then AP engagement.
5. At 03 h 59 min 14, the aircraft was in landing configuration. Its speed was 144 knots and its altitude 1,400 feet. The co-pilot called for the landing checklist.
6. At 03 h 59 min 24, the FPA mode was engaged on the FMA after the crew had selected descent angle of -3.0 degrees on the FCU.
7. At 03 h 59 min 32, the co-pilot called out "Minus three degrees Sir". At the same time, the Captain of the preceding aircraft that had just landed called the Captain by his first name on the approach frequency to warn him about the presence of low stratus cloud.
8. At 04 h 00 min 01, the co-pilot called out passage over Locator TW. The aircraft altitude was 980 feet and its speed 128 knots. One second later, the Captain told the approach controller that he was on final approach and would call again when they had the runway in sight.
9. At 04 h 00 min 24, when approaching the MDA of 620 feet, and following the "HUNDRED ABOVE" callout by the synthetic voice, the Captain called out "Continue".
10. At 04 h 00 min 42, at a height of 280 feet (AGL), the TAWS "TOO LOW TERRAIN" warning sounded and the Captain reacted by calling out "Go around go around go around".
11. End of recording

Source: LYCAA/BEA report ; Wikipedia

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Involvement of human factors in accidents

• Study case 7: Afriqiyah Airways Flight 771 Tripoli (MAY 12th 2012)



► Investigation conclusion:

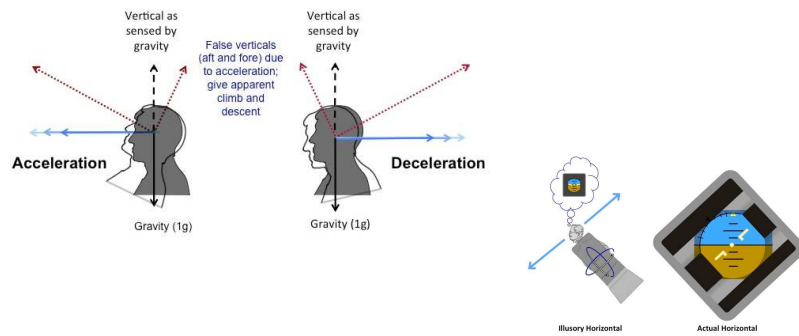
- The co-pilot could have been focused on the aircraft's speed, rather than its altitude (fatigue could have played a role in causing the first officer to focus solely on the airspeed, flight duration = 8h)
- go-around pitch attitude was not maintained and the instructions from the flight director were not followed
- The captain and the first officer were making inputs to the aircraft's side stick at the same time
- confusion on who was flying the aircraft : shortly before the crash the captain took control and maintained the nose-down input, while the first officer was simultaneously pulling back on his own side stick.
- pilots' lack of a common action plan during the approach
- inappropriate application of flight control inputs during the go-around, focus on the conf retraction to avoid overspeed
- flight crew's lack of monitoring and controlling of the flight path, and not responding to terrain awareness warnings
- **Sensory illusions** and the first officer inputs to the aircraft side stick were a contributing factor in the crash

Source: LYCAA/BEA report ; Wikipedia

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Involvement of human factors in accidents

• Study case 7: Afriqiyah Airways Flight 771 Tripoli (MAY 12th 2012)



Source: http://www.skybrary.aero/index.php/Spatial_Disorientation

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Involvement of human factors in accidents

• Study case 8: KD Avia B737 gear up landing (OCT 1st 2008)



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Involvement of human factors in accidents

• Study case 8: KD Avia B737 gear up landing (OCT 1st 2008)



- ▶ **Overview:** Boeing 737 from KD Avia landed at Kaliningrad with landing gear up. No fatalities, no injuries.

▶ Detailed facts

- During approach, trying to extend the flaps, the crew was faced with an alert concerning flaps dissymmetry which is a safety concern for landing
- They went through the failure procedure, performing a go around ending up with a decision to land with 2° flaps (attempt to extend to 5° failed on one side according to cockpit indications)
- The crew decided to prepare to high speed landing due to flap failure
- During the second approach, the crew does not extend the gear and switches off the alert
- They landed on the belly severely damaging the aircraft but without causing any injury
- The crew did not fully realize they had just landed on the belly : They announce to the control they will taxi to the apron on their own

Source: FlightGlobal, AVHerald

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Involvement of human factors in accidents

• Study case 8: KD Avia B737 gear up landing (OCT 1st 2008)



▶ Investigation conclusion:

- **Most probable cause of the accident:**
 - The crew having forgotten to deploy the landing gear
- **Element cited as the main contributors to this event:**
 - Night approach, poor weather conditions
 - No GPWS alert : turned off by the FO performing the procedure to cope with asymmetric flaps
 - ▶ Ambiguous asymmetric flaps procedure available in the cockpit : Not in line with actual cockpit layout
 - Landing checklist not correctly applied (item L/G extension was skipped)
 - The crew discarded the landing gear not down alert without checking the gear status
 - ▶ Pointed as a "negative stereotype", this alert may have routinely be silenced during landing
 - Poor crew organisation due to high level of stress in the cockpit

Note : the aileron asymmetry detection was spurious : flaps position sensors were faulty due to moisture in the circuits

Source: FlightGlobal, AVHerald

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How to address human factor problematic ?

- Multi-disciplinary approach:

Psychology

Automation
Decision making
Human errors
Cognitive resources
& workload
Situation awareness

Physiology

Workload
Anthropometry
Biomechanic

Linguistics

Terminology
Syntax
Abbreviations
Controlled language

Medical issues

Sociology

Human-human cooperation
Culture

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More on the web

- BEA study on loss of trajectory control (in French): <https://www.bea.aero/etudes/parg/etude.parg.pdf>
- BEA Report on Tripoli A330-200 accident: <https://www.bea.aero/les-enquetes/les-evenements-notifies/detail/event/ecart-de-trajectoire-poursuite-de-lapproche-sous-la-mds-remise-de-gaz-collision-avec-le-sol-incendie/>
<http://caa.ly/en/index.php/activities-of-interest/94-civil-aviation-authority-participate-in-the-session-of-the-37-in-icao-6.html>
- Flash Airlines accident: <http://www.tailstrike.com/030104.htm>
<https://www.bea.aero/docspa/2004/su-f040103a/pdf/su-f040103a.pdf>
- Air Inter Mount Saint Odile accident: <https://www.bea.aero/docspa/1992/f-ed920120/htm/f-ed920120.htm>

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