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Air France Flight 447 Accident investigation

1.Background

Air France flight 447 took off from Rio de Janeiro Galeão on 31 May 2009 and was planned to be in Paris Charles de Gaulle after 10 h 43 min flight. The airplane Airbus A330-203 carrying 216 passengers crashed into the Atlantic Ocean, killing all 216 passengers and 12 aircrew. The path between Brazil and France was the airspace which was managed by Senegal , Cape Verde, Spain (Canary Islands), Morocco , Spain(Madrid)and France.

The aircraft at 22:03(UTC) on May 31 and planned to land at Paris at 9:10. When it was 1:33, aircraft reported that the aircraft would enter the air control area of Senegal within 50 minutes (latitude and longitude: 4 ° 0'18 "N 29 ° 59'24" W / 4.005, -29.99). At that time, the aircraft was 565 km away over the northeast coast of Brazil (Coordinates: 1 ° 21'39 "S 32 ° 49 '53 "W / -1.36083, -32.83139). Its cruising altitude was 35,000 feet (10,670 meters) and its speed was 467 knots (840 kilometers per hour). At 1:48, the aircraft left Brazil's air control area of Atlantic. At 2:10, the ground control station received the automatic failure code from the Aircraft Communication Addressing and Reporting System (ACARS) for the first time. The failure code pointed out that there were troubles with the pitot tubes and the first aircraft flight control system. Because of the failure of Air Data Inertial Reference Unit, the Autopilot System and Auto-thrust System shut down. Meanwhile, the Traffic Collision Avoidance System (TCAS) switched to fault mode, and Fly by Wire Flight Control System changed to standby mode. After 1 minute, the aircraft send failure code which means the Integrated Sensor Structure in backing navigation system and the inertial reference component of flight management system had failed. At 2:13, the aircraft emit a warning, pointing out that two separate air data analysis system were working abnormally. At the same time, alert from the flight management system referred to the first and second flight electronic control system's malfunction. At 2:14, the ground control station received a final piece of information referred to the failure of cabin pressurization system. At that time, the aircraft was in latitude and longitude 3 ° 34'40 "N 30 ° 22'28" W / 3.5777, -30.3744. Generally we thought that the aircraft entered a strong storm area and encountered strong turbulence. Subsequently the aircraft lost contact with the ground control station.

2.Review of the authors´ statements and conclusions

2.1Accident Scenario

We are not going through the whole scenario but we highlight some parts which we think that they are the main causes for the accident. Basically the author divide the accident scenario into three parts:

1) From the beginning of the CVR(Cockpit Voice Recorder) recording until the autopilot disconnect.

2) From the autopilot disconnection to triggering of the stall warning

3) From the triggering of the stall warning until the end of the flight.

The Airbus 330 is designed to be flown by a crew of two pilots but because it was a long fight it was crewed by three pilots. So each of them can take rest in the flight and there is a rest cabin in the plane. When the captain goes to rest at 02:01:46 UTC. At 02:06 UTC, the pilot warned the cabin crew that they were about to enter an area of turbulence. Two minutes later, the pilots turned the aircraft slightly to the left and decreased its speed from Mach 0.82 to Mach 0.8 because of the increased turbulence. At 02:10:05 UTC the autopilot disengaged as did the engines' auto-thrust systems three seconds later. The author refer that “The captain appeared very unresponsive to the concerns expressed by the PF about ITCZ”(168). It seems that captain take the situation as a common condition. In the report we read that “When the PNF replaced the captain, he noticed that the gain on the weather was set to calibrated. It was thus likely that it was already the case before the captains departure”.(169)One reason could be that turbulence which was never the case for AF447.

The roles of the pilots were not defined by Captain before leaving for the rest. They also did not discuss about the problem .The risk of loss of speed information related to crossing a high density of ice crystal was never mentioned. “The Captain did not explicitly designate his relief in the presence of the two co-pilots, nor did he leave specific instructions for the ITCZ crossing”. (170)

After Autopilot disconnects the crew figured out that there is a problem since the speed was very low compare to the autopilot connection time. But they did not understand that the problem is with the airspeed indications. “Following the autopilot disconnect, the PF very quickly applied nose-up side stick inputs. The PF’s inputs may be classified as abrupt and excessive”(173). Although it is understandable that PF decide to nose up reaction but persisting on it cause deviation in the flight, the reason can be effect of stress or surprise.

There is also problem with speed indication, The ECAM shows no information that is likely to point this problem. “The ECAM mentions a maximum speed that should not be

exceeded but does not mention a minimum speed. This could lead crews to suppose that the main risk is over speed". (174) When the PNF says, "we've lost the speeds" it can be a clue to show that they loss of indicated airspeed information or the loss of characteristics of speed.

The pilot tries to control the plane manually but nose-up input caused the increase in the angle of attack and triggered the stall warning .In fact the situation, with a high workload and multiple visual prompts, corresponds to a threshold in terms of being able to take into account an unusual aural warning. In an aural environment that was already saturated by the C-chord warning, there is a possibility that the crew did not identify the stall warning.

It seems that there are some wrong perception by the crew. Some of the PF's actions may be interpreted as indicative of a perception of a risk or of a diagnosis of over speed instead of the low speed. Another example is that when the crews frequently mentioned their doubts regarding the relevance of the stall warning.

As the author mention there are some factors which cause that pilot get wrong perception .The flight director displays, the doubt regarding the relevancy of the aural stall warning and the identification of the possibility of an over speed situation did not allow the PF to make a correct diagnosis. He therefore implemented a combination of opposite actions to respond to both an over speed situation (reduction in thrust, nose-up inputs) and to a stall situation (application of maximum thrust). "The stall warning became intermittent and interwoven with the C-chord alert. These two warnings, combined with the ambient noise and the voices of his colleagues, made a saturated aural environment, which was difficult for the Captain to understand, especially since some of his attention was certainly focused on reading and analyzing the instruments"(182). The stop and start of the stall warning make the pilot confuse and finally the crew lost control of the situation.

In the report there are also some analysis about the training, ergonomics and some technical feedback. For instance it is mentioned that the crew are trained but they are good with
a known scenario but they did not have chance to be in a real situation and consider the consequences of the startle effect on their individual behaviour. The other problem which is mentioned in ergonomics part is that no failure message received by the crew in the other word the crew is only informed of triggering of these monitoring by seeing the consequences. " Disconnection of the Ap and of the AtHR , transition to alter law etc"(187).Crew could not use the messages receiving from the ECAM .

2.2 Conclusion

- The blockage of the Pitot probes by ice crystals in cruise was a phenomenon that was known but misunderstood by the aviation community at the time of the accident.
- The apparent difficulties in handling the aeroplane in turbulence at high altitude resulted in over-handling in roll and a sharp nose-up input by the PF. The destabilisation that resulted from the climbing flight path and changes in pitch attitude and vertical speed therefore added to the incorrect airspeed indications and ECAM messages
- Disruption of crew cooperation had a multiplying effect, inducing total loss of cognitive control of the situation. The behavioral assumptions underlying the classification of a loss of airspeed information as major were not validated in the context of this accident
- The airplane went into a sustained stall but the crew did not understand the stall warning and they are in stall condition.
- A review of pilot training did not provide convincing evidence that the associated skills had been correctly developed and maintained.

3.Our analysis

3.1 How can the pilot behaviors and errors be explained?

At the first point there was a communication problem but I think the captain did not take the ITCZ serious like what we read in human contribution book , when skilled person think that they are invulnerable. It is one of the reasons for violation. If we talk about the pilot and copilot it would be considered as knowledge based skill when the user is in a situation that does not have any information about it and it is totally novel. We can also consider the perception of the crew from different warning like stall warning. They do not believe the warning. It seems to be a skill based error. They thought that they know how to cope with the situation but they did not have comprehensive knowledge about the situation.

We do not know if there was a procedure for the long time flights to define the role of the captain, but it seems that if there was any the captain did not take it serious or did not follow it , on the other hand, it could be some problems in the procedure which can be categorized in the rule based errors. The same situation is about the rules and procedures when the crew does not care about the warnings it can be either bad procedure or bad performance. There is also another problem that the pilots were not in the right place. The copilot was more experienced in those situation compare with the PF.

When the AP disconnected and they have to manage to control the airplane manually there is also skilled-based problem, which means that they are not trained enough for those situation. Another problem with humans in the event is that when they have to control the plane they were kind of stressed so the pilot made an abrupt nose-up input on the side-stick. The action was unnecessary and excessive under the circumstances.

However, we believe that if some other pilots face with the same situation, they are very likely to make the same errors. Even if they have the same training and use the same system. The pilots in this accident are just normal guys, so it is understandable that they are stressed and fail to understand the situation according to the information they got at present. The idea got from the book “The Human Contribution” that “similar situations provoke similar types of errors and recurrent accident patterns involving different people” may help to explain this. So more emphasis should be put on “identifying error-provoking situations rather than error-prone people to indicate where remedial efforts must be directed”.

Although the captain's absence is also something to be blamed for the accident, operating the airplane in turn is just a daily activity of pilots. As it is said in the book "Proactive Risk Management", "their daily activities may not be coupled in any functional way, only the accident as observed after the fact connects their performance into a particular coupled pattern", so what we are looking for is not the decision errors of this certain accident but all the organizational bodies that contributed to the creation of the accident scenario.

3.2 What role does the technical systems play?

The technical systems can be viewed as latent conditions but not immediate triggers for the accident because they cannot discriminate between normal states and accidents. Chances are that some pilots may be able to overcome these unusual situations and thus prevent the disaster from happening. But this doesn’t mean that the technical systems have nothing to do with the accident. Emphasis should still be put on identifying and rectifying the latent problems of the system so as to improve safety.

In this accident, the first technical problem is that when the pitot was covered by the ice crystal there was no information about that for the pilot. Another main problem is the way that system shows the speed. The pilot did not know that the speed is less than minimum . There is a sign for the pilot when the speed is more than maximum but there is no sign to show that the speed is less than minimum.

There is also another problem about the signs. There’s no instinctive and natural sign to show that the mode of FMA have been changed when the flight director became active again.

The crew did not get the stall warning. Maybe it is a technical problem and the crew really cannot get it in all situations. It seems that there was another aural warning at the moment, which cause kind of ambiguity. As it said in the report, a dedicated visual indication of stall is needed to help the pilots understand the situation.

What happens in the system and the errors by the pilot is associated with Swiss cheese model. For instance pilot is not trained to control the plane manually and at the same time autopilot is disconnected so we end up with hazard.

3.3 What can be done in order to avoid a similar accident?

We used the cause-consequence-chart to show the causes. You can see that the combination of some causes result in a wrong outcome or an accident. We got the idea from the part 3.2 in the report by Rasmussen & Svedung . Figure 3.1 in the report shows two consequence events in different diagrams. In our diagram in the figure 1, you can also see the condition and situation, which could happen in another order to prevent accident. The Rectangular show the event and we also have some condition boxes in the chart.

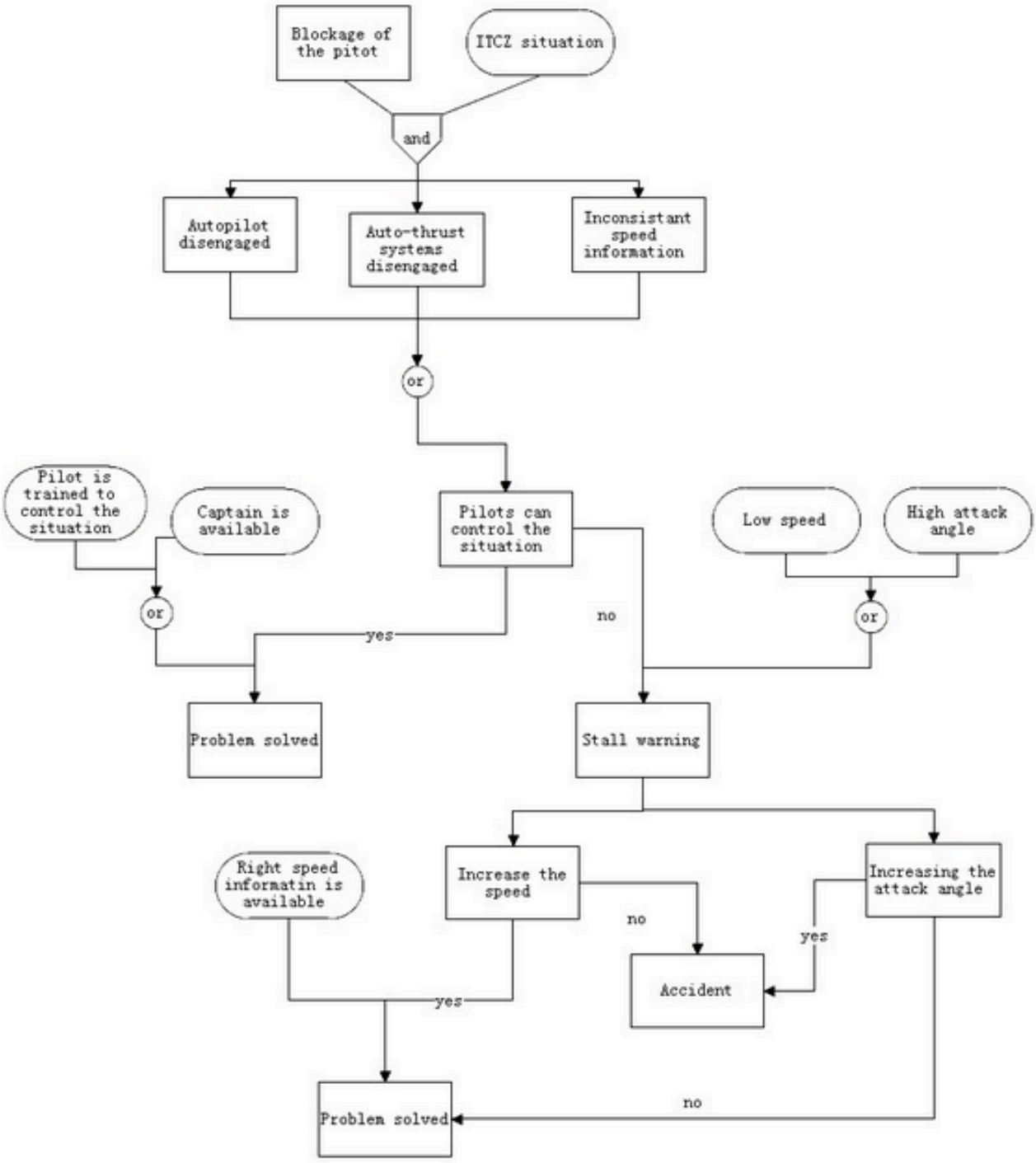

Figure one: CCC for Air France 447 Accident