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THE DRAGON IN THE COCKPIT

How Western Aviation Concepts Conflict with Chinese Value Systems

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List of Figures

List of Tables

Preface

In the past 30 years, China has slipped the surly bonds of its imperial past and joined the modern world economy, building sophisticated industries in electronics, pharmaceuticals, information technology, and most recently commercial aircraft. The COMAC C119, China's bid to join the United States and the European Union as exporters of wide-body commercial aircraft, is but the most recent of three decades of bold moves where China is re-asserting itself as *Chung Kuo*, the Middle Kingdom. However, in today's world of large technological systems such as air transport, global supply chains, and the internet, this creates challenges that would have been unfamiliar to travelers in the past, whether Marco Polo in 1271 or Lord Macartney in 1793.

The Dragon in the Cockpit examines one of these challenges, the inevitable and sometimes disastrous collisions of technology, language, and cosmology created when an advanced technology created in the West is adopted in the East. The consequences of these collisions are well known: In North America and Europe, there are fewer than one fatal accident per million flight departures, whereas in China there are 3.8 fatal accidents per million departures. Despite the fact that Chinese history is marked by many of the technological advances that shook the world, including gunpowder and the compass, this mismatch between East and West takes on a new aspect when embodied in large-scale, high-performance technologies. Nor is this simply a matter of China "catching up" with the West: the relentless, geometric acceleration of technological advance creates a Malthusian race between technological invention and technological adoption around the world, which will assure that there are always global mismatches between technology and culture, often with tragic consequences (Batteau 2010).

In this book we provide a new perspective on the differential successes of Chinese and Western civil aviation, in the contrasting cosmologies and value systems of China and the West. The Western cultures that invented the airplane and created global air transport networks are individualistic, egalitarian, and linear in their thinking. By contrast, Chinese culture is relationship-oriented, hierarchic, and figurative. These differences at times have tragic consequences. As currently designed, a modern airliner is a crew-served device, and flying it safely depends on a high degree of coordination among the flight crew. This is so important that an entire training discipline, "Crew Resource Management" teaches assertiveness, task-sharing and other communication skills to flight crews (Chapter 6). Assertiveness, however, is a foreign concept in a hierarchic culture, and several accidents have resulted from junior officers failing to correct obvious errors by their seniors (Chapters 1 and 2).

The situation becomes even more complicated with the addition of flight management systems to virtually all modern airliners. These systems are essentially computers that fly the airplane, and their programming embodies the logic of the Western engineers who designed them (Chapter 3). The complexities created by these "third crew members" have been implicated in several accidents among European and North American airlines; when one adds the cultural and linguistic differences between East and West, the sources of misunderstanding skyrocket.

This book had its origin in the decision by Jing Hung-Sying in the 1990s to dedicate his career to interpreting Western technology in the Chinese context, and to a very specific event in September, 2001. Jing, his wife, and Batteau were having dinner in a restaurant in Tainan when they received word of an event halfway around the world. It was evening in Tainan, but it was morning of the same day in New York City, where an airliner had just flown into the World Trade Center. Jing and Batteau had been discussing flight safety, and it slowly dawned that the unfolding events of September 11, 2001 were not the sort of aviation accidents that they had been discussing. Over the next few days, while waiting for flights into North American airspace to resume, Jing and Batteau had several opportunities to reflect on and discuss the meaning of these events for the world and for aviation. When Jing asked Batteau to assist with the English translation of his original 龍在座艙 published (in Chinese) in 2009, Batteau readily agreed.

Hung-Sying Jing would like to express his sincere appreciations to Dr. Kay Yong, former director of the Aviation Safety Council for his support of the research project which the present book is based, and to his colleague, Professor P.-J. Lu as the principal investigator of this research, and Thomas Wang for his full involvement in the survey work, and to his former student First Officer Casper Wang in China Airline providing valuable insight about CRM, and Shirley Tzeng for her assistance. Special thanks also go to his daughter Catherine Jing, a Columbia University graduate for helping translating the book. Also, without the help from many respected figures in the Taiwanese aviation community, this book would not be possible. They deserve deep appreciations from the authors.

Allen Batteau would like to extend his thanks to Dr. Kay Yong, formerly of the Aviation Safety Council, introducing him to the world of Chinese civil aviation, and to Capt. Rafael Alejandro Pérez Chávez and Dr. Carolyn Psenka, for their involvement in the survey of CRM attitudes among Chinese pilots, and to Suzanne Walsh, for her valuable comments on the final manuscript, and to Dr. Maria Roti for assistance with the bibliography.

The stubborn facts of higher accident rates among Chinese carriers, both in the Peoples Republic of China and the Republic of China (Taiwan), indicate that transplanting this modern technology into the Chinese context faces some challenges. At the same time, the ascent of Chinese civil aviation into a global sky is an expectable step in the technological evolution of the human race, with potentially mutually beneficial results for East and West. Although the equipment is the same, the cultures are different. Examining this cultural difference from the perspective of 6,000 years of history is the objective of this book.

Contents

Chapter 1
Tragedy in Nagoya

"Be careful! Guard and cover the memorial tablet! The souls cannot be touched by the sunlight!"

A high and clear voice appeared in Taipei Chiang-Kai-Shek (CKS) International Airport (CKS), as airport officials brought along a group of big black umbrellas (*United Daily News*, April 29, 1994). It was 3 o'clock in the afternoon, the sun dazzled in the sky. There was one victim each covered under the Each victim was covered by a big black umbrella, and with a heartbroken family behind. Just a few days earlier, a plane crashed in Nagoya Airport, Japan. The cremated remains of 67 victims were carried back to Taipei together with 30 coffins, and the reception site for the dead was set up right in the airport. Airline company staff held high a white long cloth, waving to and fro against the wind, written on it with large black characters: "China Airlines staff begged for forgiveness from victims' families," bowed and apologized with deep sorrow and regret again and again ...

On April 26, 1994, two Taiwanese pilots flew an Airbus A300-600R automatic airplane from CKS International Airport to Nagoya, Japan. There were 256 passengers, 13 cabin members and two pilots, 271 people in total on the plane. The plane took off smoothly from CKS Airport on schedule; two pilots followed the designated route according to the plan, heading to Nagoya Airport, Japan.

At 8:07pm (20:07), the airplane prepared to land on runway 34 under guidance from the approach tower and the instrument landing system (ILS). At 8:12pm, the plane passed the outer beacon with altitude roughly above 2,000 feet. The plane followed the three-degree glide path marked by the ILS to execute the standard landing procedure. Everything was normal. Two minutes later, when the plane was flying just below 1,000 feet, it started to level off, as if it didn't want to land. Yet, no additional sign showed that the plane was starting to climb to go around, which is a standard maneuver in a missed landing. After 15 seconds of level flight, the plane started to descend. At this moment, the plane was only 800 feet above the ground, and the speed was only 146 knots, yet well above the stall speed of 110 knots.

The plane descended steadily again, and everything seemed back to normal. At 8:15pm, the plane continued descending for about 30 seconds, reaching 350 feet above the ground. It looked like the giant was about to land. Yet suddenly, a deep and loud roar came out from the engine, the thrust was suddenly elevated to the maximum. The nose started to level off, and the plane surprisingly started to climb with increasing speed. It happens once in a while that a plane cannot land smoothly in the very final stage of landing, and has to execute a "go-around," a standard maneuver. However, it did not look like this plane was going around, because the pitch of the plane was still increasing, eventually to 50 degrees!

The wing stalled, the lift dropped drastically, and the drag increased significantly. Unfortunately, the thrust from the engines was not enough to raise the plane by itself. A chain of abnormal events combined and pushed the altitude back to 1,500 feet, with the speed suddenly declining to only 87 knots. The speed was already significantly lower than the stall speed. The plane started to fall out of the sky.

In less than one and half minutes, the situation facing the plane evolved from a three-degree steady descent on landing procedure to an irreversible situation beyond human control. The aircraft lost lift, its drag increased, its thrust was less than normal, its altitude increased, and its speed dropped. The entire situation made the plane totally out of control.

Two years later, the Japanese authority released the accident report (Aircraft Accident Investigation Commission, Ministry of Transport, Japan, 1996). The report pointed out that there was no clear sign of mechanical malfunction or special meteorological factors. In other words, the accident could only be attributed to human factors of the flight crew.

According to the accident chain theory from Boeing (Boeing Commercial Airplane Group, 1994), the Ministry of Transport of Japan listed every single link showing the evolving sequence in the accident:

1. The first officer (F/O) inadvertently triggered the go lever activating the go-around procedures.
2. The F/O continued pushing the control wheel in accordance with the instructions of the captain (CAP) in order to continue the approach.
3. The movement of the trimmable horizontal stabilizer (controlled by the computer) conflicted with that of the elevator (controlled by the crew), causing an abnormal out-of-trim situation.
4. There was no warning and recognition function to alert the crew directly and actively to the onset of the abnormal out-of-trim condition.
5. The CAP and F/O did not sufficiently understand the flight director mode change and the autopilot override function.
6. The CAP's judgment of the flight situation while continuing approach was inadequate, control takeover was delayed and appropriate actions were not taken.
7. The alpha-floor function was activated. This was incompatible with the abnormal out-of-trim situation, and generated a large pitch-up moment. This narrowed the range of selection for recovery operations and reduced the time allowance for such operations.
8. The CAP's and F/O's awareness of the flight conditions, after the CAP took over the controls and during their recovery operation, was inadequate respectively.
9. Crew coordination between the CAP and F/O was inadequate.

The alpha-floor function is an automatic protection to prevent the plane from stalling. When the angle of attack of the plane reaches 11.5 degrees, close to stall, the flight control system will automatically open the throttle to the limit and lock, pushing the thrust to the maximum and speeding up the plane, so as to escape from the danger of stall.

The accident report made some recommendations to Airbus and the airline:

To Airbus:

1. Improvement of the override function, out-of-trim prevention and warning and recognition functions for the trimmable horizontal stabilizer of the automatic flight system of the A300-600R is required.
2. The descriptions of override, disengagement of go-around mode and recovery procedures from out-of-trim in the Flight Crew Operation Manual of the A300-600R should be improved from the operational viewpoint.
3. In the event of an accident or serious incident, Airbus Industrie should promptly disseminate the systematic explanation of its technical background to each operator, and furthermore should positively and promptly develop modifications.

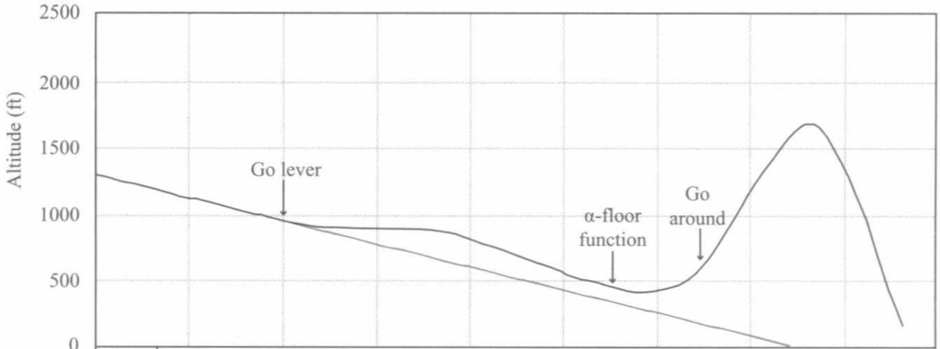
To the airline:

1. Reinforcement of education and training programs for flight crews;
2. Establishment of appropriate task sharing;
3. Improvement of crew coordination;
4. Establishment of standardization of flight.

Stated simply, this accident was caused by the conflict between the pilots and the automatic flight control system. The flight crew were fighting for control over the plane! In other words, the pilot pushed the plane to land, the computer managed to go around, and both wouldn't let go.

In fact, similar incidents had taken place before, incidents that weren't severe enough to cause planes to crash. Airbus has also released a notice, warning the pilots not to try to override the automatic flight control system. However, Airbus hasn't really made any change to the design of this protection system, apparently judging that this was not a serious matter. According to the experts at Airbus, the way out from such an abnormality is simply to release control of the airplane, so that the automatic flight control system can take over and execute the go-around procedure up to around 3,000 to 4,000 feet above ground level.

Figure 1.1 (below) shows the final flight profile of the Nagoya accident. According to the National Transportation Safety Board (NTSB), similar to what was pointed out by the Japanese accident report, there wasn't any problem with the machine, and the automatic flight control system did everything according to the order, rejecting the override from manual control and executing go-around. Almost everyone agreed that this accident was caused by human factors.



Time	13:50	14:05	14:20	14:35	14:50	15:05	15:20	15:35
Pitch		4.0	5.3	3.5	5.5	10.6	37.5	15.9
α		6.3	5.0	7.1	9.6	10.4	12.9	28.0
Elevator		0.3	3.5	8.5	9.9	14.1	14.1	0.6
THS		-5.3	-5.3	-12.3	-12.3	-12.3	-11.3	-7.2

Figure 1.1 The final flight profile of the Nagoya accident

For example, the F/O wrongly controlled the plane and the crew did not fully understand the functions of the automatic flight system. Hence, the corresponding solution is to emphasize the out-of-trim training to the pilots, just as suggested by the Transport Ministry of Japan.

But is this a sufficient explanation? Will similar incidents be prevented from happening again after enough training?

The primary goal of accident investigation is to find the real causes behind an accident, make recommendations, and ideally prevent similar events from happening again. However, after the Nagoya accident, in less than four years, an almost identical accident took place. The same type of aircraft crashed in almost the same manner in Da-Yuang, Taiwan. It forced us to think: have we indeed found the real cause of the Nagoya accident? And have the suggestions from the accident investigation report really mitigated the conflict between the pilots and the computer?

Every single human behavior has its origin. Some are after deliberate consideration belonging to the decision-making behavior. Some are from a cultural heritage that is shared within a community, some are from the sub-consciousness, perhaps even instinct. Behavior that appears on the surface to be the same might originate from completely different sources. If we insist on looking at only what it appears to be, and do not dig deep and get at the real cause behind such a behavior, how can we recommend an effective solution? Obviously, the principal beliefs widely accepted by the international aviation community might very likely bring about a self-restricting situation, causing the truth to be buried.

The cockpit voice recorder (CVR) is an essential resource for finding human errors. Further, the CVR can supply hints about the psychological conditions, even cultural characteristics, of the crew. The sequence of the Nagoya accident clearly shows the disastrous interaction between the pilots and the machine. How could the interaction become so fatal? What was in the crew's mind? What were the pilots thinking during the process? The main part of the conversation of the crew was in Chinese. Hence, it requires a thorough knowledge of Chinese language and culture, preferably by one sharing a similar cultural background, in order to have a thorough understanding of the real meaning of the conversation.

After the F/O inadvertently triggered the go lever, at the same moment the CAP reminded the F/O of the situation.

20:14:10 CAP: You, you triggered the go lever.
20:14:11 F/O: Yes, yes, yes. I touched a little.

At that time, the automatic flight control system started to execute the go-around procedure, and the plane began to level off. Yet the crew still wanted to land, so the F/O continuously pushed the control yoke, hoping to lower the nose. The angle of the elevator increased.

The CAP acknowledged the situation and commanded the F/O to disengage it.

20:14:12 CAP: Disengage it!

Immediately, the cockpit voice recorder recorded the sound of a pitch trim maneuver. Obviously the F/O was pushing the yoke and trimming the pitch, trying to disengage the automatic go-around which was already in progress, so that the plane could continue to land. However, the order that the computer received was to go around, so in order to raise the nose, the angle of the trimmable horizontal stabilizer started to rotate, countering the effect from the increase of the angle of the elevator. The elevator and the horizontal stabilizer started to diverge and their angles differed even more. The two control surfaces of the tail that should cooperate to fly the airplane actually started to go against each other.

Two contradictory orders continued to take effect on the horizontal stabilizer. After 20 seconds had passed, the CAP reminded the F/O that the plane was still in go-around mode, indicating that both of the crew recognized the go-around mode was still on.

20:14:30 CAP: You, you are using the go-around mode.

20:14:34 CAP: It's OK, disengage again slowly, with your hand on.

Then, the sound of pitch trim is heard continuously without a break five times, indicating that the F/O was still trying to disengage the autopilot and continue descending. Unfortunately, he was continuously trying the same ineffective maneuver. And on the contrary, it caused the out-of-trim situation, i.e., the conflict between the elevator and the horizontal stabilizer, to become even worse.

Since the CAP reminded the F/O that the go lever was triggered, 24 seconds had passed. During this time, the F/O had tried six times to disengage, yet in vain. Strangely, he never tried to speak out that he could not resolve the problem. Nor did he express that he did not know how to do it. According to the accident report, obviously the F/O didn't know the correct procedure, yet he refused to speak out or to ask, just continued trying the same ineffective maneuvers.

Several seconds later:

20:14:41	CAP:	Push more, push more, push more.
20:14:41	F/O:	Yes.
20:14:43	CAP:	Push down more!

Of course it was still ineffective:

20:14:45	CAP:	It is now still in go-around mode.
	F/O:	Yes, sir.

The CAP reminded the F/O again that the plane was still in go-around mode. Several seconds later:

20:14:51	F/O:	Sir, I still cannot push it down.

Strangely, another several seconds passed without any response from the CAP.

20:14:58	CAP:	I, well, land mode?

Obviously, the CAP was asking the F/O if the go-around mode had been switched to the land mode, but the F/O remained silent. Another several seconds later:

20:15:01	CAP:	It's OK. Do it slowly.

Yet right after he comforted the F/O, the CAP couldn't stand anymore and said:

20:15:03	CAP:	OK, I have got it, I have got it, I have got it.

The CAP finally took over the control without waiting for the F/O to complete the disengagement of go-around. Yet the alpha-floor protection function had been activated. The throttle of the engine had gradually increased to the maximum. Since the action line of the thrust passes under the wing, right beneath the center of gravity of the plane, the increase of the thrust force resulted in a positive pitching movement. The nose was raised quickly, causing the pitch of the plane to further increase.

What happened next was really frightening:

20:15:08 CAP: What's the matter with this?

The F/O also panicked:

20:15:09 F/O: Disengage, dis …

The nose continued to pitch up, and the plane climbed further up.

20:15:11 CAP: Go level.
Damn it, how come like this?

Surprisingly, the CAP also did not know how to disengage the go-around! Meanwhile, the CVR recorded the sound of pitch trim twice. The CAP was trying exactly the same ineffective action that the F/O had already tried six times.

The pitch angle of the plane had been raised up to 21.5 degrees now, and was still increasing. The signs of an unusual and dangerous situation were very clear, so the F/O immediately called to the tower to prepare to go around.

20:15:14 F/O: Nagoya Tower, Dynasty going around.

Seconds later, the sound of flap movement was heard, the ground proximity warning system alarmed at the same time, and the angle of the airplane pitched up to 36.2 degrees. Facing such a frightening situation they had never experienced before, both of the crewmembers froze.

20:15:21 CAP: If this goes on, it will stall.
20:15:25 CAP: Finish.

In Chinese, this word means, "We're screwed." The stall warning went off, and the pitch angle reached an unbelievable 52.2 degrees.

20:15:26 F/O: Quick, push nose down.

In the cockpit, the atmosphere was extremely chaotic, all kinds of warnings and operational sounds clashed all together.

20:15:31 F/O: Set, set, push nose down.

The plane started to fall after it peaked to the highest.

20:15:34 CAP: It's OK, it's OK!! Don't, don't hurry. Don't hurry.
F/O: Power!!

The plane started to fall faster and faster … the crew was obviously terrified.

20:15:37 CAP: Ah …!!
F/O: Power, power, power!!

Until the end of recording, the CVR was full of frightened screaming. The CVR recorded deadly silence at 20:15:45. The runway of Nagoya Airport was already covered by a stretch of raging fire.

In earlier ages, there was not much computer technology used in airplanes. How the airplane flew was mainly affected by the aerodynamic features of the corresponding mechanical system itself. Even if the pilots were not fully familiar with the aerodynamic features of the plane, it would not have been a big problem because the airplane was not going to do anything by itself. As airplanes became more and more complex, together with the rapid development of computer technology, the modern large airliners quickly became automated. In plain language, the airplane itself started to do something solely on its own, autonomously. According to the flight control software, gradually it has its own power to make decisions, just like a real human being. So the aviation community called such an automated flight control system the "electronic crewmember," "electronic pilot," or "artificial pilot." Because this artificial pilot was created by the software engineer, it is the engineer who grants the artificial pilot the ability to think, to analyze, to judge and to make decision, to help the crew to complete the flying mission.

However, once the electronic pilot had the ability to make decisions, it started to develop its own viewpoint and accumulate its own power. Of course, its viewpoints are in fact the viewpoints of the flight control software design engineers, and its power was given by these engineers too. So, some say that the people who are really flying the airplane are not the pilots in the cockpit, but the software engineers. This is of course a little bit exaggerated; yet, it is definitely true in some aspects. At least, we can say so: the pilots and the software engineers must cooperate to fly the plane!

As airplanes become more automated, the electronic pilots will have opinions on more and more aspects of flight, increasing their power to fly the plane. Yet, most of the software engineers do not seem to know how to fly, nor do they have much flying experience. They just design the software according to the physical laws, flight dynamics and control theory. It sounds a little bit scary at first. Some engineers who cannot even fly a plane are actually designing the flying software. But on second thought, it isn't that scary. As long as the electronic pilots express their viewpoints concerning physical phenomena, there won't be a problem. Unfortunately, as the plane evolved to be more complicated, the software engineers began to equip the electronic pilot with more power to make decisions about non-physical things. Consequently, the flight control software extends its influence into the category originally belonging to humans. The psychological features, value system, and cultural traditions of the software engineers then started to intrude into the automatic flight control system. Thereafter, gradually, the electronic pilot, in a manner of speaking, bears white skin, golden hair, and blue eyes. It is a Caucasian.