Human Errors that Contribute to Altitude Deviations

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Altitude Busts:
The View from ATC & the Flight Deck
Royal Aeronautical Society
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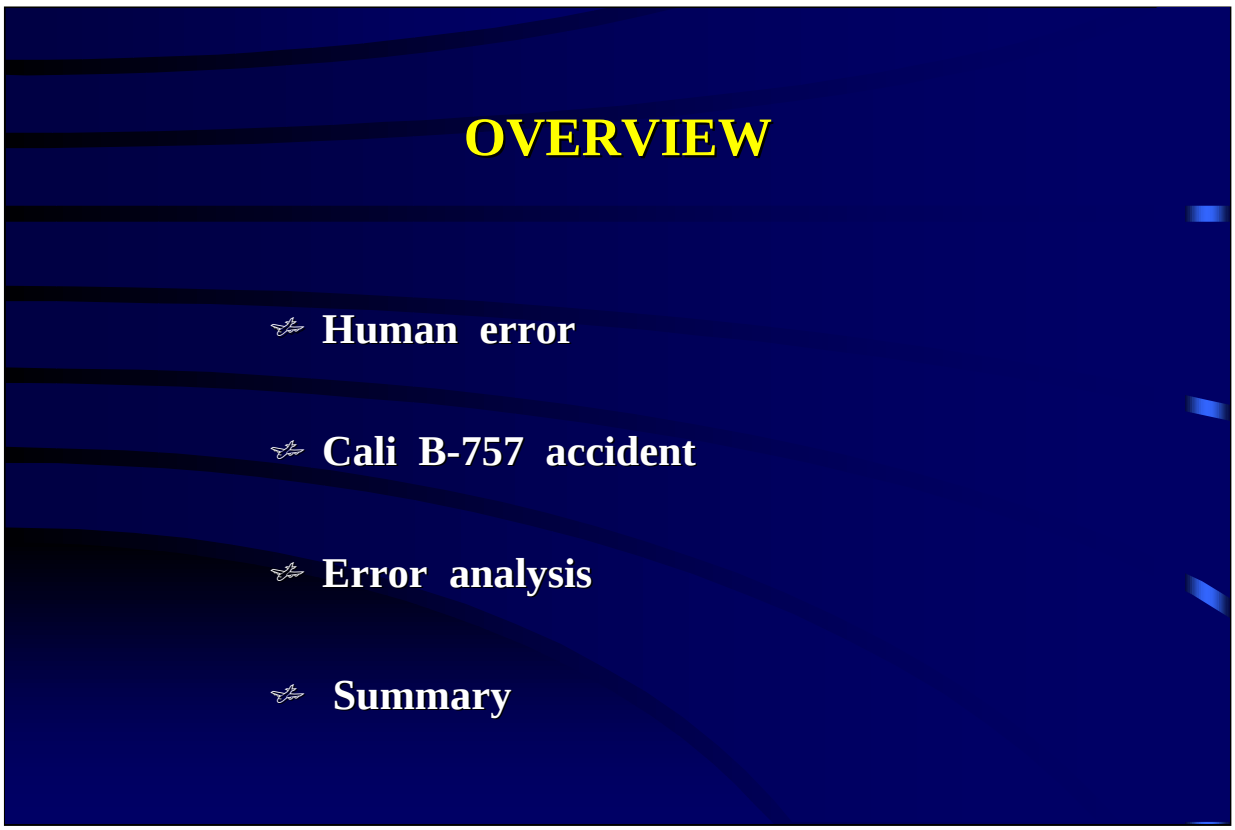
Good morning, I am pleased to be here today to share with you some thoughts about altitude busts.

This morning I will focus on some specific errors that can contribute to altitude busts or altitude deviations -- as they are called in my country.

In the afternoon session, I will discuss some of the skills and strategies that can be used to reduce the probability of altitude busts.

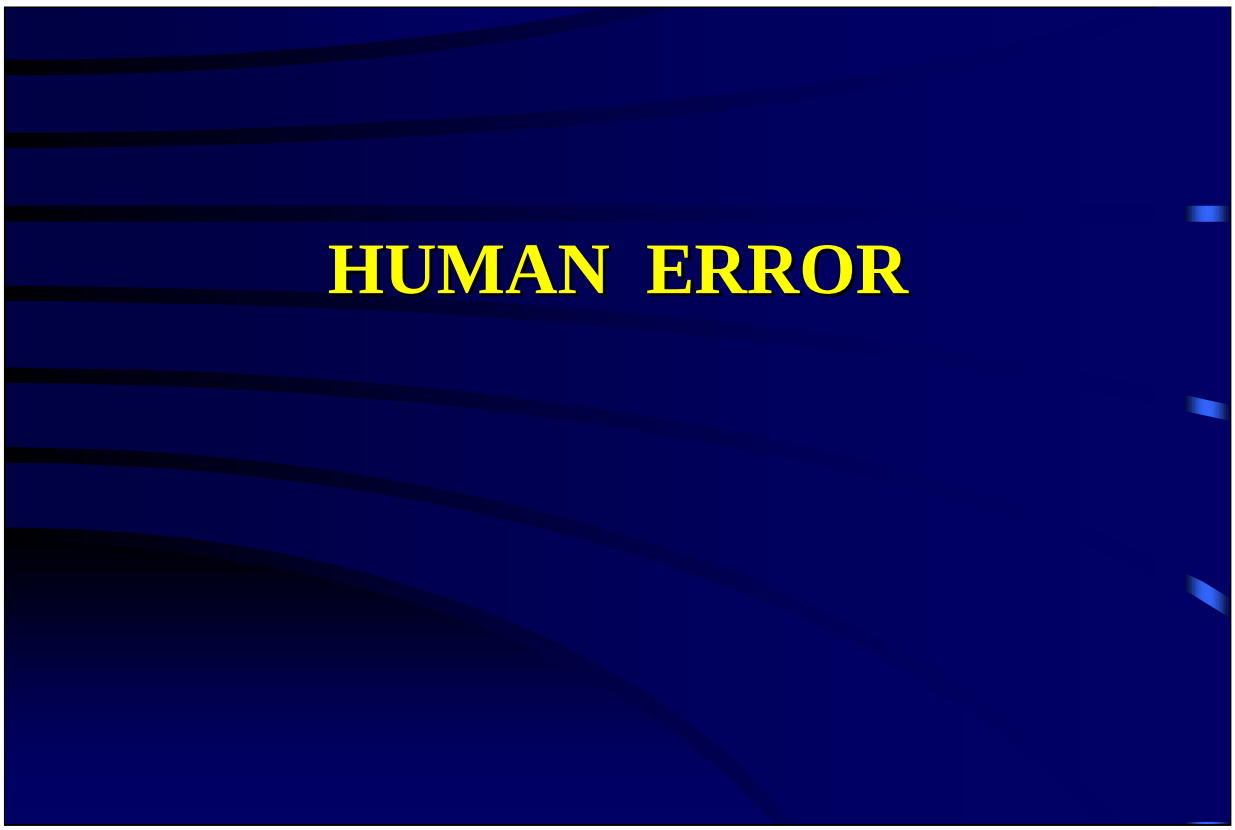


I will begin this morning's session with a brief discussion about several aspects of human error.

Next, I will review the American Airlines Boeing 757 accident that occurred at Cali, Columbia on December 20, 1995. This accident is a very important accident from a human factors viewpoint. I think you will be surprised by the large number of errors and lessons that can be learned from Cali.

After reviewing the Cali accident, I will briefly analyze the errors to surface some of the common elements.

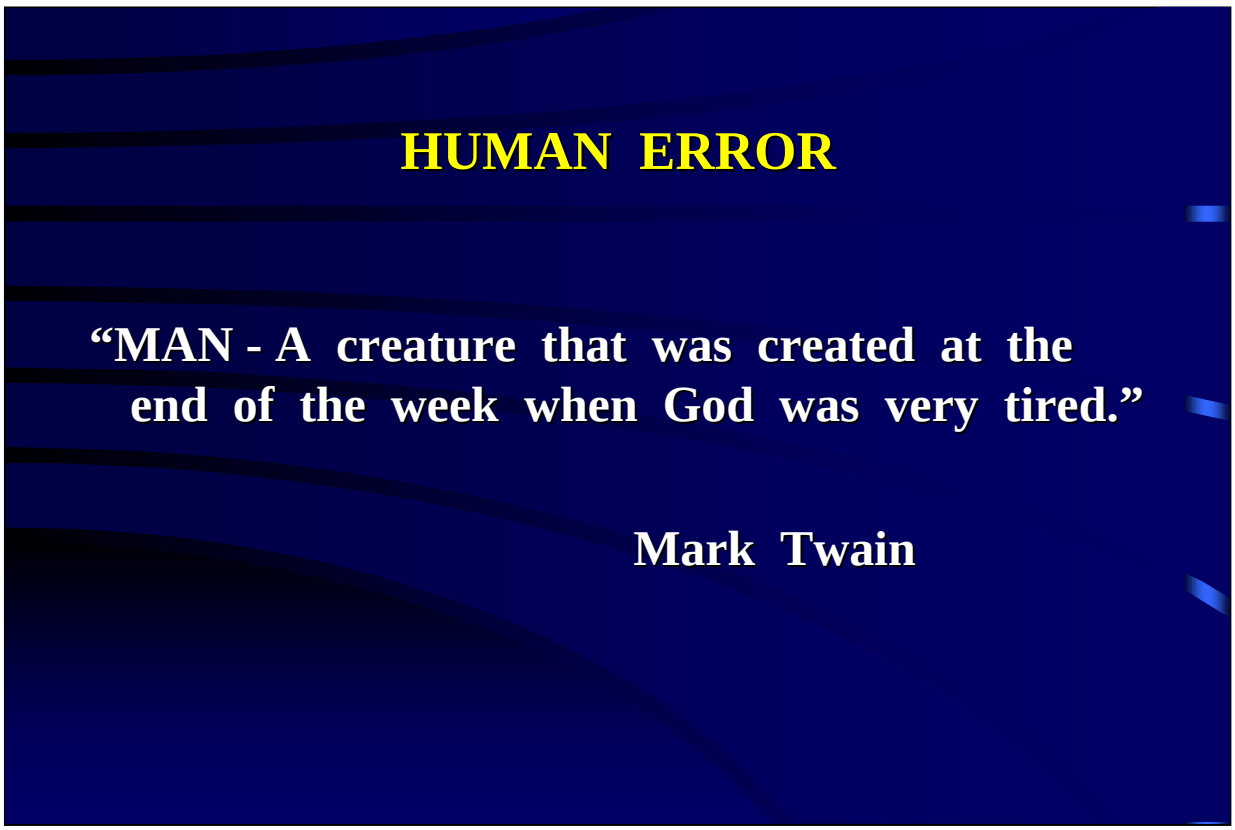
And finally, I will pose some provocative questions and make a few summary remarks.



I always like to begin any discussion about the causes of accidents with a few comments about human error in general.

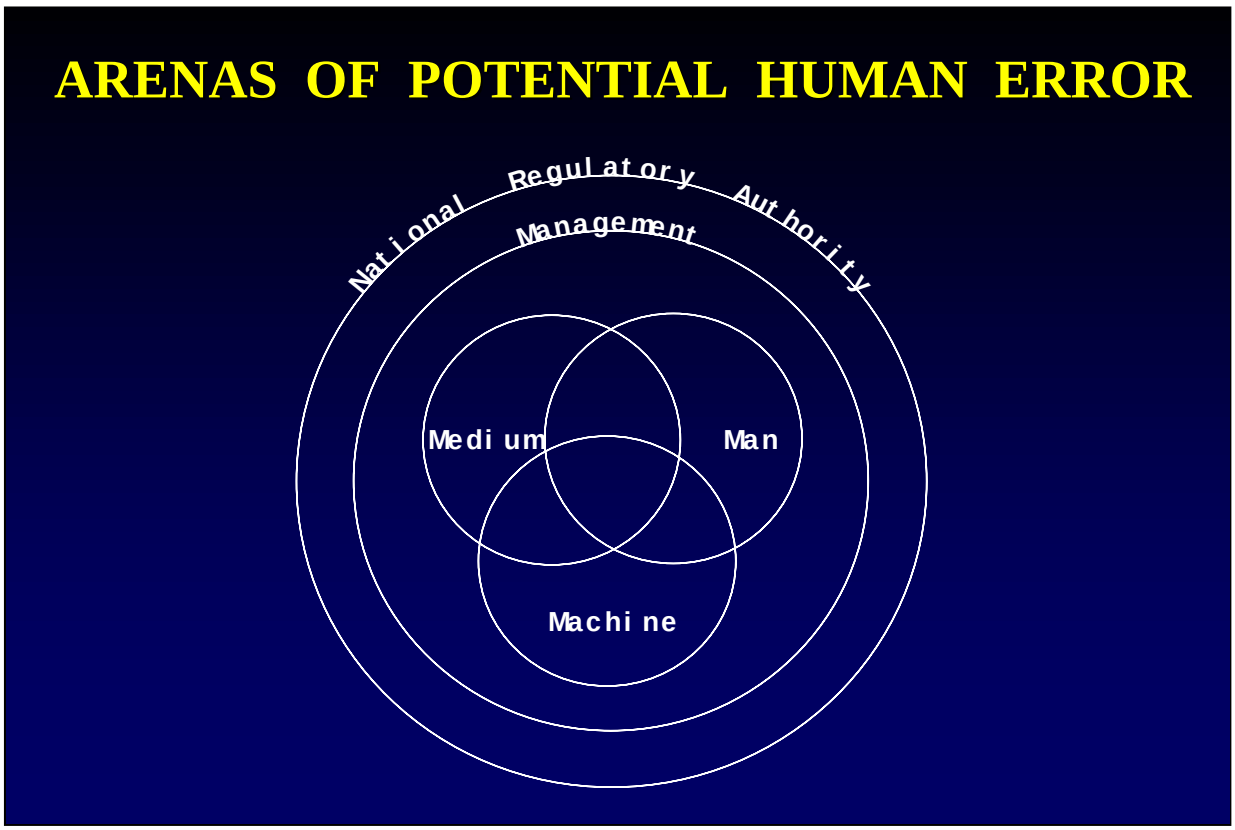
Over three centuries ago, William Shakespeare said, “To err is human.”

A similar statement was made by an author in my country who said, in a humorous vain:



I included this slide because it represents the appropriate approach to human error.

We need to look at our own susceptibility to error with openness and humor.



This slide is important because it identifies the different sources of human error.

Man is, of course, the operator. Man is used in the generic sense so it includes women as well as men.

Machine refers to the design, manufacturing and maintenance of aircraft.

Medium refers to the environment in which the aircraft flies. ATC, National Weather Service and Aerodrome services are part of this category.

Management includes training, checking, quality control, safety assurance, and policies of the organization. This area is frequently overlooked in accident investigation.

National Regulatory Authorities also have a overview responsibility.

In the Cali accident, there were multiple errors. Many of these errors could also have been prevented by more effective management and/or national regulatory authority actions.

All of these arenas are, of course, important and should be included as part of any accident investigation.

As we review the Cali accident, look specifically at training and ask yourself how many of the errors could have been prevented by more effective training.

HUMAN ERROR PRINCIPLES

- **Applicable to everyone**
- **Separate error from consequences or blame**
- **Develop a scientific understanding of error**
- **Identify & adopt coping skills & strategies**

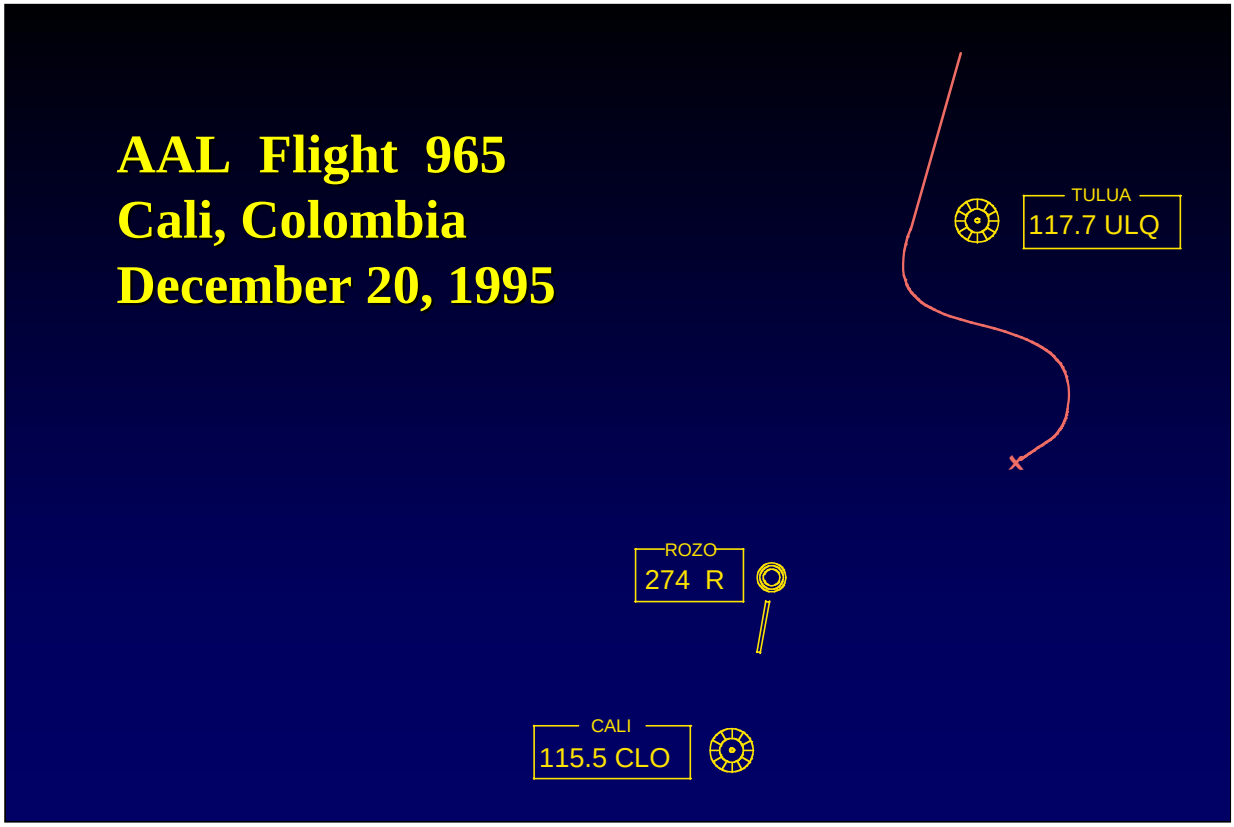
Here are four principles that are important to understanding and reducing human error.

• Error is applicable to everyone! -- regardless of age, race, height, sex, native language or national origin.

• The first step in understanding error is to consider error apart from its consequences. This is important so we can look at the error without emotion and defensiveness.

• This approach attempts to enlist the crewmember as a scientist in the understanding of his own mental processes by encouraging openness within himself.

• And finally, once the defining characteristics of any error type are determined, counteracting strategies can be developed.



Now let's look at Cali.

First, let me describe the situation. AAL 965, a regularly scheduled flight from Miami, Florida to Cali, Colombia was approaching from the North. The crew was flying direct to TULUA, a VOR 33 miles North of the airport and anticipated an ILS to runway 01. This plan would require them to continue past Tulua to the Cali VOR, located 8 NM South of the airport, make a teardrop penetration, and then fly an ILS to runway 01. Cali is located in a valley with mountainous terrain to the East and West. The flight was about 200 North of Cali when the cockpit voice recordings began.

About six and a half minutes before the crash, the flight was cleared to Cali. Several minutes later, the flight made a turn to the East, deviated nine miles off course, descended below the published MEA and crashed into a mountain. Why did this accident happen?

The following is a chronological reconstruction of the errors. As previously discussed, I look at the errors without regard to the consequences of the error. Some of the errors had little or no adverse consequences, some had minor consequences, and some had major consequences.

Before beginning, let me point out that those errors that could relate to altitude busts are color coded white while other errors are color coded gray.

CALI ERRORS

1. Crew read back wrong transponder code
2. ATC did not pass on flight information to Cali
3. Adequate approach review not accomplished
4. Adequate approach briefing not accomplished
5. Descent checklist not accomplished

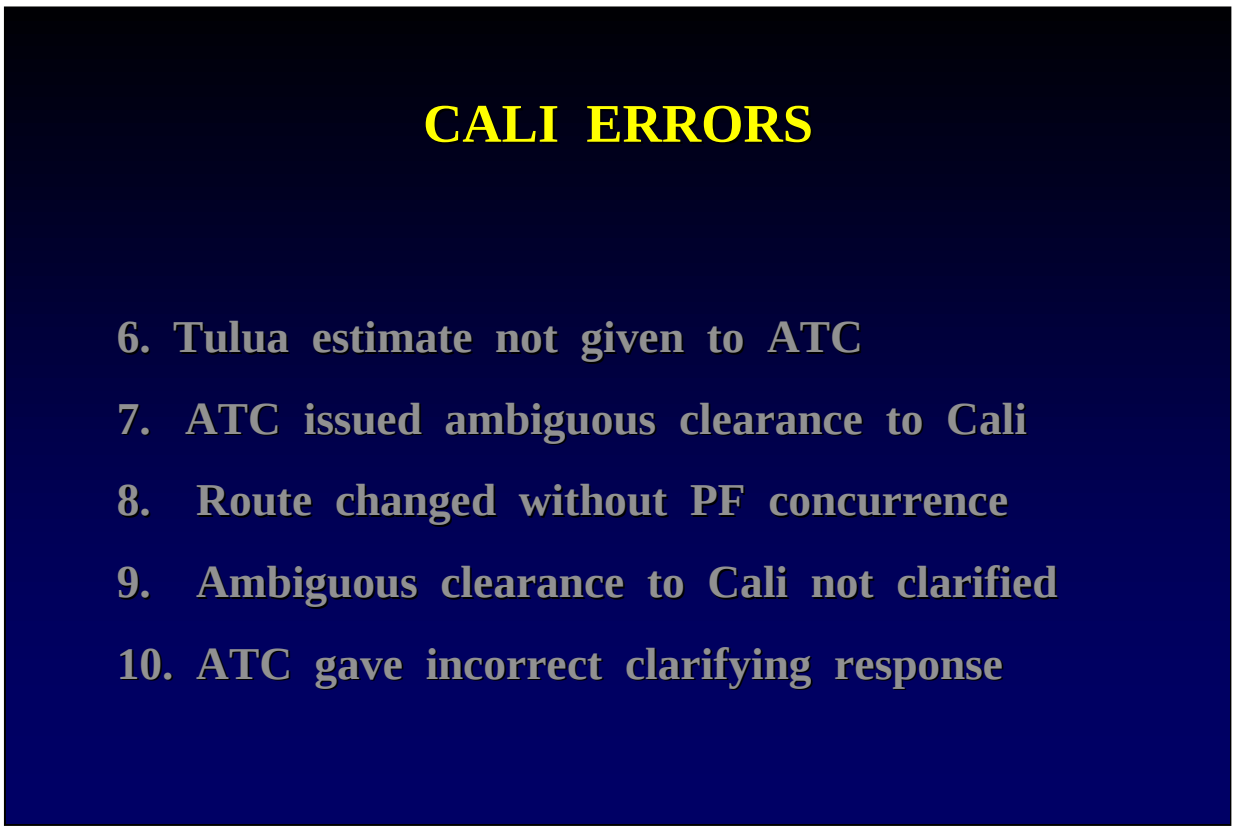
Error number one occurred when the crew read back the wrong transponder code. This minor lapse, however, had no bearing on the accident because the controller changed the transponder code to coincide with the code acknowledged by the crew.

The second error occurred when the Bogota controller failed to advise the Cali controller that AAL 965 was proceeding on a direct route to the Tulua VOR. This omission contributed to the subsequent misunderstanding of the "cleared to Cali clearance.

Although one of the crew members did build a preliminary arrival path to runway 01, the crew was **not knowledgeable enough about the various approaches or physical features of the Cali area**. This error - number three - created a major problem that will become more obvious in a few minutes.

The briefing was also inadequate. The only recorded briefing was the captain's request, "when you want descent let me know a few minutes early in case there is a language problem, O.K." and the first officer's reply, "well let's see, we got a hundred and thirty six miles to the VOR and thirty two thousand feet to loose and slow down to boot so we might as well get started."

Although the switches were in the correct position, there was not any recorded checklist conversation during the final thirty minutes of the flight. **No one asked for the descent checklist or reported it completed**.



These five errors concern the clearance to Cali.

The crew failed to give ATC their Tulua estimate in accordance with PANS-RAC procedures. The omission of the Tulua estimate also contributed to the misunderstanding of the "cleared to Cali" clearance.

This omission caused ATC to restate the clearance, "roger is cleared to Cali VOR ah descend and maintain one five thousand feet …. report TULUA VOR". This clearance was ambiguous since it did not specify whether the flight should proceed direct to Cali or to Cali <u>via</u> Tulua.

The captain who anticipated a direct route to Cali for the approach to runway 01, <u>assumed</u> the clearance was direct to Cali and executed the change before the sentence was completed and without obtaining concurrence from the pilot-flying.

The captain tried but was unable to clarify the ambiguous clearance - error number nine - despite the presence of the words, "report Tulua".

ATC's response to the Captain's question was incorrect - error number ten -. The captain had added the word "direct (to Cali)" in his readback. ATC did not recognize this change and repeated "affirmative, report Tulua".

The effect of these five errors was that the flight was now proceeding on a direct route to Cali. While this was not a problem in itself, it did cause TULUA to be dropped from the active LEGS page. This became a significant factor as soon as the flight was cleared for the approach to runway 19.

CALI ERRORS

11. **Accepted rushed approach to runway 19**
12. **ATC did not issue approach altitude**
13. **Ambiguous clearance altitude not clarified**
14. **Requested improper clearance to Rozo**
15. **ATC's response was incorrect**
16. **Ambiguous clearance to Rozo not clarified**

ATC then called the flight and said, "… sir the wind is calm. Are you able to approach runway one niner"? Without determining the feasibility of the situation, (error #11) the captain replied, "yes sir, we'll need a lower altitude right away though." **At this time, the flight was 41 miles from the field, was indicating over 300 knots and had 16 thousand feet to loose**.

ATC replied, "roger. American nine six five is cleared to VOR DME approach one niner". ATC did not specify the altitude, however (error #12). Even though the first officer questioned the clearance the crew was unable to clarify the clearance with respect to altitude (error #13).

At this time the captain says, "we have time to pull that out?" after which the CVR records the sound of pages turning. Eighteen seconds later, he requested an improper clearance direct to ROZO. (error #14)

ATC replied, "affirmative" (error #15) take the Rozo one and runway one niner, the wind is calm." The crew did not clarify (error #16) **the difference between the ROZO one arrival and proceeding direct to ROZO**.

CALI ERRORS

17. Select Desired WPT screen difficult to use
18. Latitude/longitude not verified
19. Charted & FMS data bases were different
20. New path to "R" not verified on map
21. New path not confirmed by pilot-flying
22. Did not detect A/C deviation from course

The captain then entered "R" - the ROZO identifier - into the direct intercept page and the FMS responded with 12 different "R's". The only way to differentiate was to compare the latitude/longitude coordinates. (error # 17)

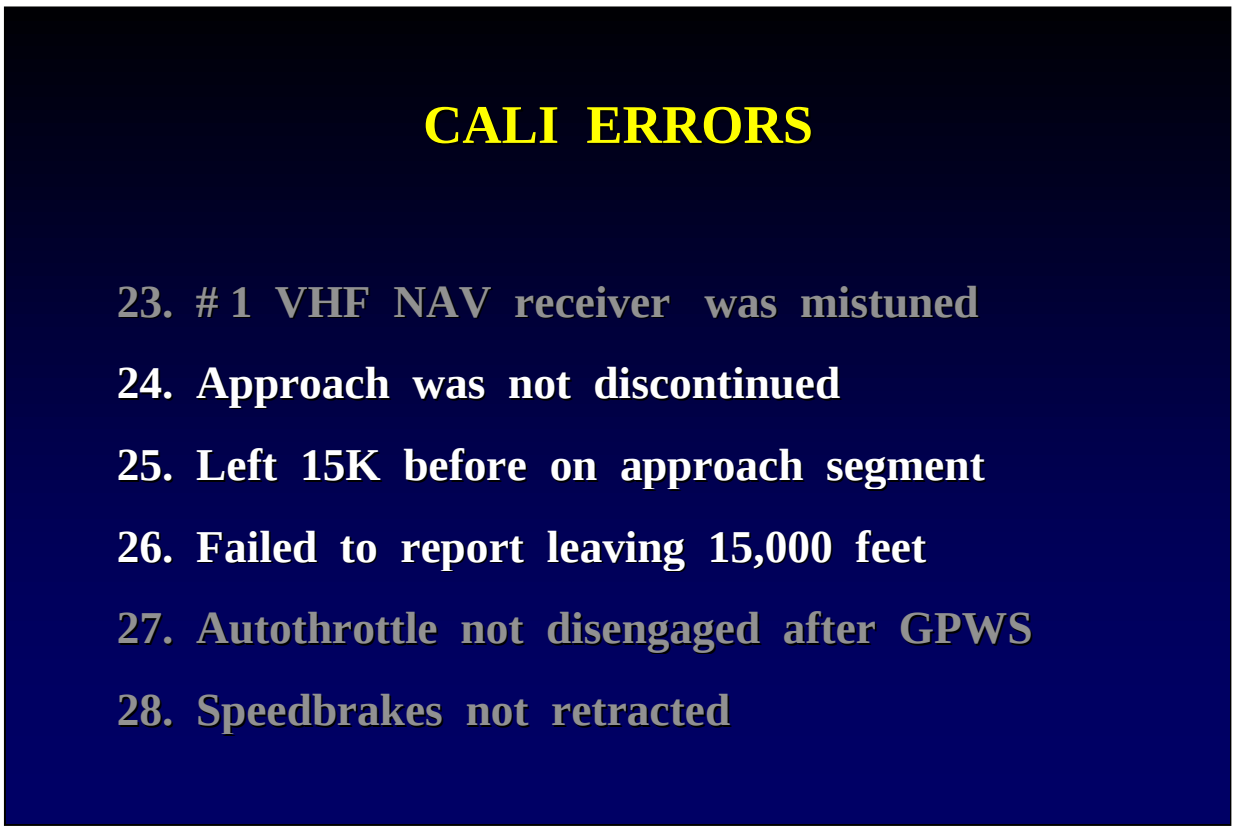
The captain assumed, incorrectly, that ROZO was the first "R". (error # 18)

Unknown to the crew, the "R" selected was for the ROMEO ADF at Bogota - not for the ROZO ADF at Cali. **The charted and FMS data bases were different due to an AIRNC 424/ICAO naming convention rule**. (error #19)

The captain did not verify, before executing the change, that the modified route was the intended route. (error # 20)

And he did not ask the first officer to confirm the new path prior to executing the new route. (error # 21)

67 seconds later the first officer said, "uh, where are we?" He had not detected and corrected in a timely manner the aircraft deviation from the cleared path (error # 22). At that time, the crew had two minutes and 39 seconds to live.



The captain attempted to tune the #1 VHF NAV to the Tulua frequency of 117.7 but inadvertently tuned it to 116.7 (error #23). While this did not affect the navigation of the aircraft, it did consume valuable time.

The crew did not discontinue the approach and stay above the MEA even though they were rushed, disoriented, and confused. (error #24)

The flight left 15,000 feet before they were on a segment of the approach path that authorized a lower altitude (error 25). That was the altitude bust. But recognize that there were 24 errors that led up to it.

The PNF did not report out of 15,000 feet as required by ATC procedures. (error #26). If he had, ATC might have issued a clearance to maintain 15,000 until established on the Tulua 202° radial.

Thirteen seconds before the crash the GPWS sounded. Although the crew advanced the throttles and increased pitch, they did not disengage the autothrottle according to SOP. (error #27). The crew also forgot to retract the speed brakes after the GPWS alert. (error #28)

ERROR ANALYSIS

- **Flight Crew - 21/28 (75%)**
- **ATC - 5/28 (18%)**
- **Design - 2/28 (7%)**
- **Management - ?**
- **National Regulatory Authority - ?**

This slide shows the errors by the man-machine-medium paradigm.

Notice that correspondence between the 75% of errors due to actions or omissions of the flight crew and the 74% of hull losses accidents that have been attributed to the flight crew by Boeing statistics over the last 36 years.

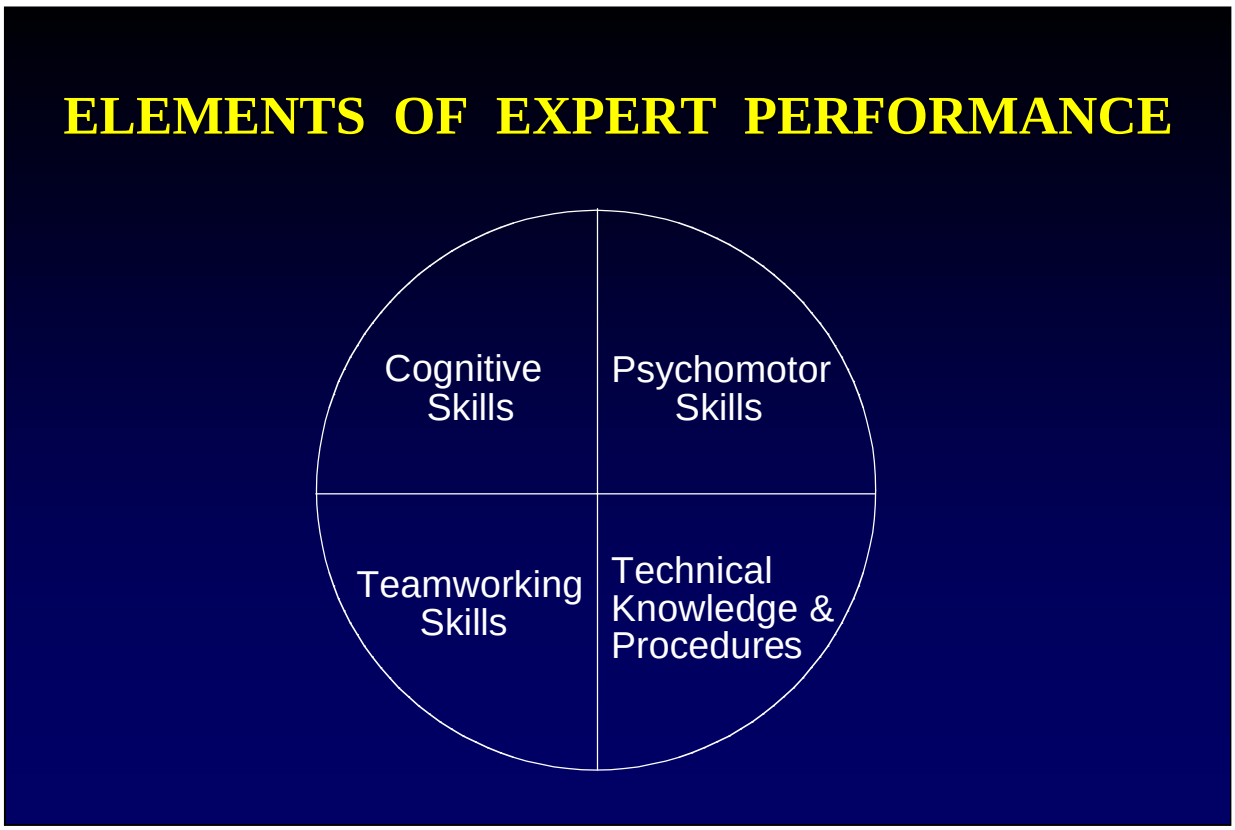
I will leave it to your good judgement to determine what percentage of the errors were due to inadequate management, or FAA oversight.

ERROR ANALYSIS

- **Lapses - 5 (18%)**
- **Slips - 3 (11%)**
- **Knowledge bases mistakes - 16 (57%)**
- **Rule based mistakes - 4 (14%)**

This slide shows the type errors in the Cali accident.

While slips and lapses are usually due to distraction, inattention or inadequate association, mistakes are related to knowledge deficiencies that can often be corrected **by more effective training**.



Now, let's look at the errors from the perspective of expert performance.

Psychomotor skills, called flying skills by pilots, are essential to all professions. No errors were from this area.

Technical knowledge and procedures are very important and include operational procedures plus a vast amount of technical knowledge about aviation's infrastructure. I believe there were nine of these errors.

Teamworking skills, usually called CRM, are needed to ensure that the valuable perspective of each crewmember is considered. I counted six errors that could be classified in the teamworking area.

Cognitive skills, the thinking, planning, preparing, and strategizing parts of flying are, of course, an essential part of expert performance. This area contained the largest number of errors -- 13 by my analysis.

Now let's look at the left side of this graphic from two very different perspectives.

<u>This is the most important slide in my presentation</u>!

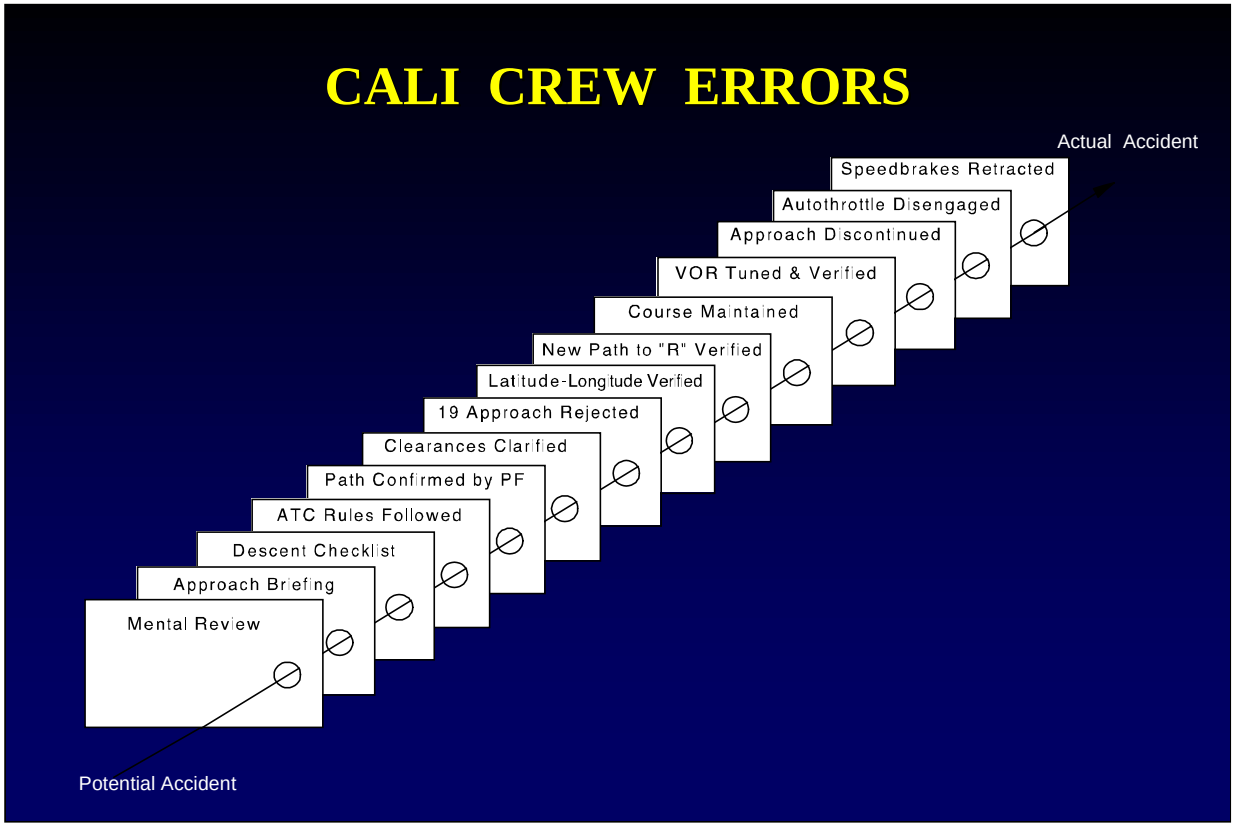
The intrapersonal perspective holds that the key to successful crew performance is to emphasize intrapersonal skills that involve the capabilities of the human mind. This perspective is generally advocated by cognitive psychologists. **<u>It is important to recognize that the intrapersonal perspective can be applied to either cognitive or teamworking skills</u>**.

In contrast, the interpersonal perspective holds that the key to successful crew performance is to emphasize interpersonal skills that involve crew interaction and small group dynamics. This perspective is generally advocated by social psychologists. Most of the current CRM training in the United States is interpersonal, social training.

The intrapersonal perspective appears to be better for aviation since the skills are more detailed and operational. In addition, they can be quantified, taught, learned and assessed more easily.

The errors in the Cali accident can be analyzed from these perspectives. That is, does the error represent a failure of group interaction skills or does it represent a failure of individual intrapersonal skills.

All five ATC errors were intrapersonal. Nineteen of the 21 crew errors were intrapersonal. **<u>This implies a significant dichotomy - while most of the CRM training was interpersonal, most of the errors were intrapersonal</u>**.

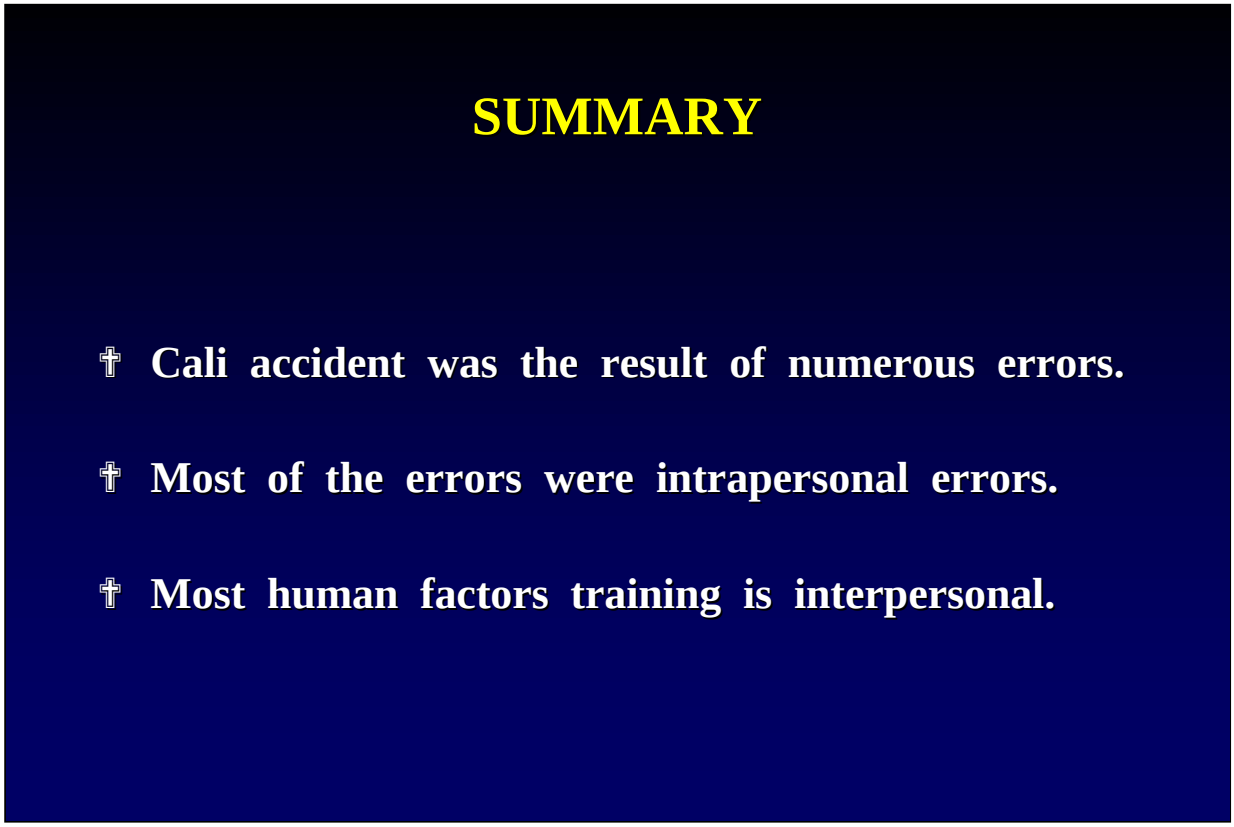


This slide was adapted from James Reason's swiss cheese graphic and shows the relationship of accidents and the error defense system.

Think of each card as a defense system that could prevent an accident. Unfortunately, most defenses are not perfect and sometimes contain flaws or holes as they are shown here. If the imperfections of any one of these defenses could have been been eliminated, this accident could have been prevented.

For example, if the first card - the mental review - had been accomplished properly, the crew would have determined that they could not leave the last cleared altitude until they were established on the 202° radial of Tulua. This would have prevented this accident.

This graphic only shows the crew errors. A similar graphic could be made for the ATC errors. The reason why there are only 14 cards for the 21 separate crew errors is that some errors occurred more than once. For example, there were three ATC procedural errors and three times that the crew was unable to clarify an ambiguous clearance.



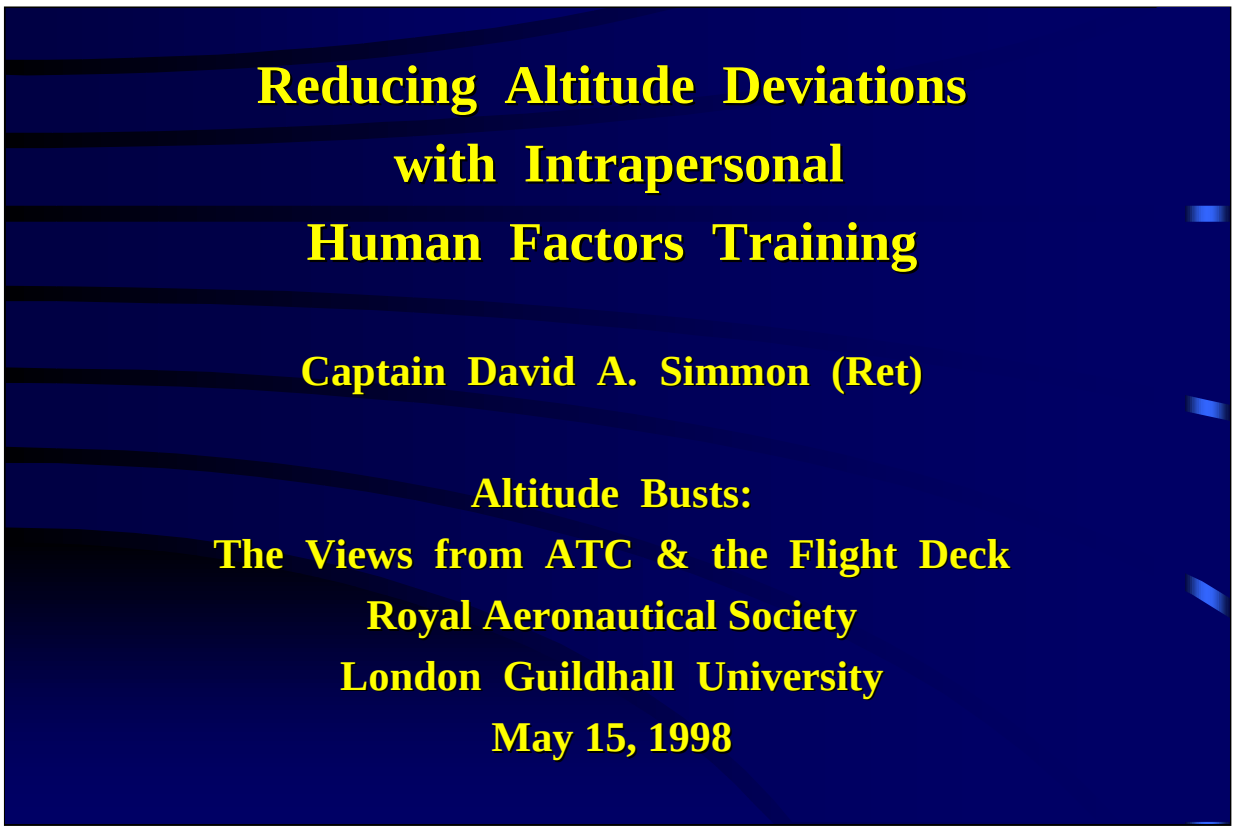
Here are my conclusions for this morning's presentation.

Clearly **this accident was the result of multiple errors**. If we attribute it to a single probable cause, many opportunities for improving aviation safety will be overlooked.

Most of the errors were intrapersonal errors while most of the human factors training was interpersonal. This is, in my opinion, a very important finding and explains why traditional CRM has not been an effective accident prevention program.

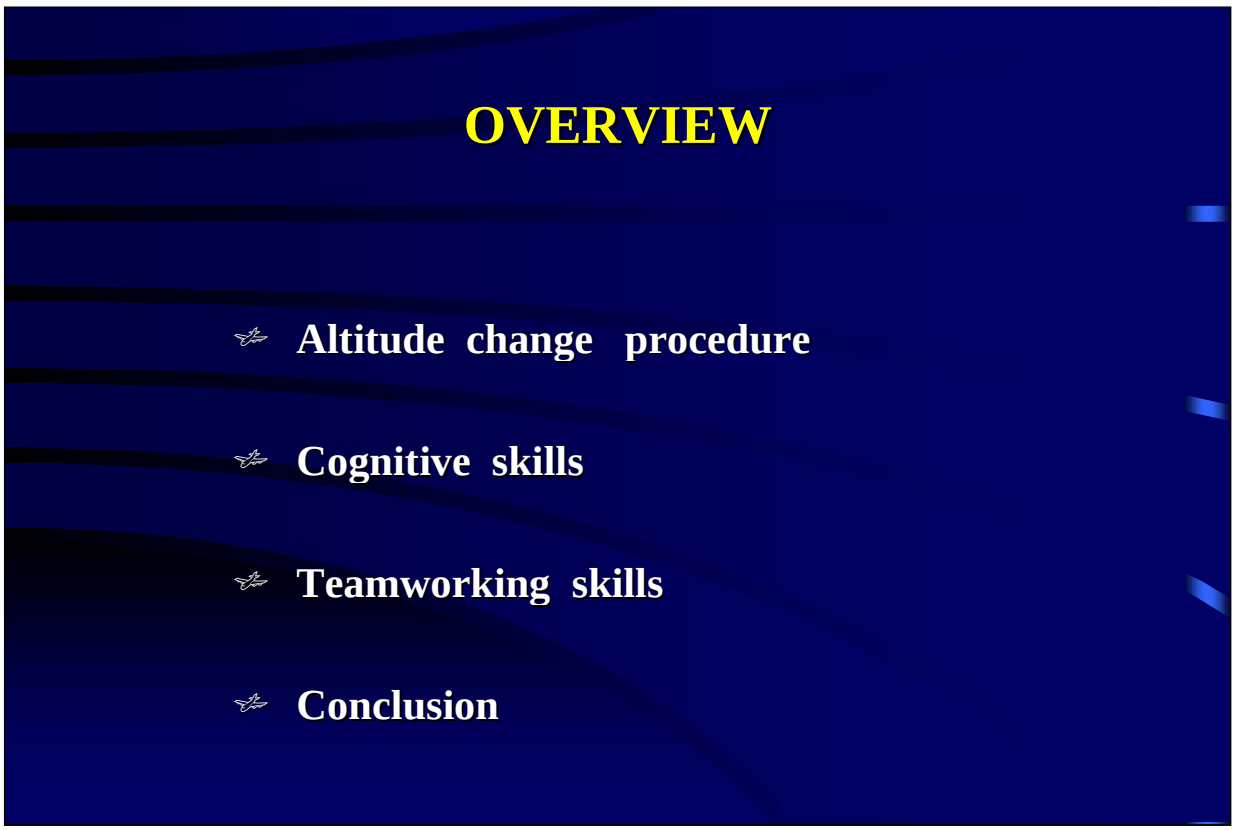
This afternoon I will focus on the kind of intrapersonal skills and strategies that could have prevented this catastrophic altitude bust.

Thank you.



Good afternoon, I would now like to share with you some thoughts about ways to reduce human error.

Before I begin, I would like to give credit to two other people, Dr. Alan Pope of NASA Langley Research Center and Dr. Charlotte Freeman of Samford University in Birmingham, Alabama. Dr. Pope is a cognitive psychologist and Dr. Freeman is a social psychologist. Many of the ideas that I will present here today came from the CRM Curriculum Advisory Manual that the three of prepared for Transport Canada several years ago.

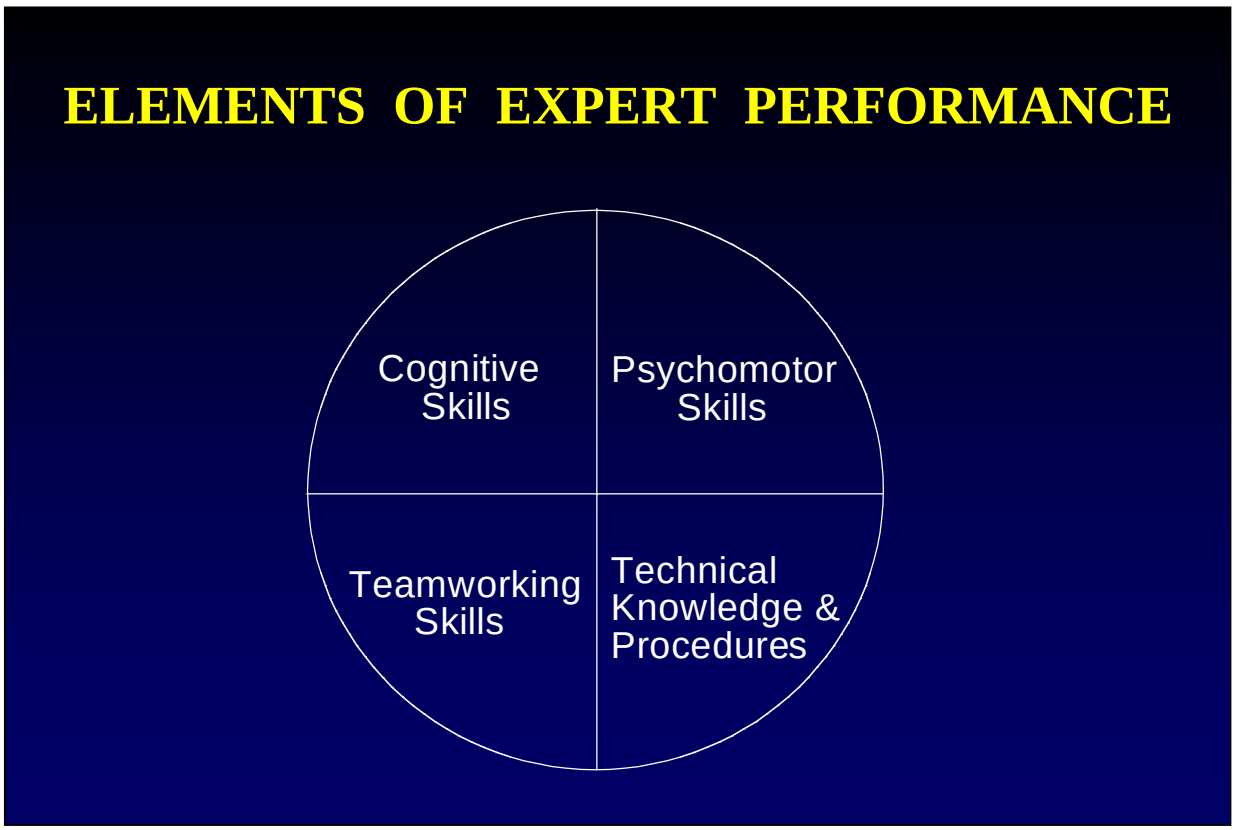


I will first present an altitude change procedure that may help to reduce altitude busts.

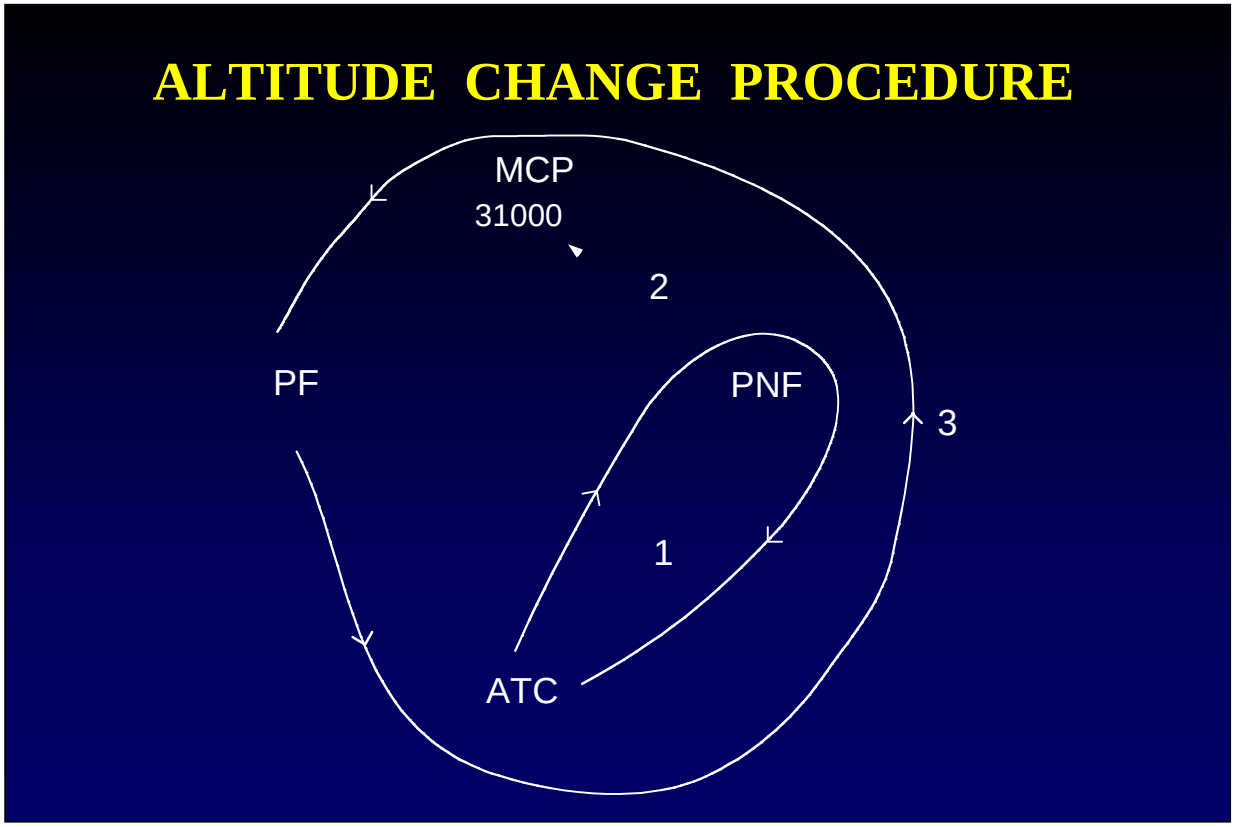
Next I will cover some intrapersonal skills that can be used to reduce the probability of human errors and accidents. **Note that both cognitive and teamworking skills are included**. If either is omitted, safety will be compromised.

It is important to recognize that most pilots will develop these intrapersonal skills over time without any training or outside help. But therein lies the problem. Most is not good enough! With over 15 million commercial flights a year, this industry cannot afford for even one percent of the flights to be at risk.

Individual intrapersonal training is necessary to ensure that all crews master these skills early in their careers.



The altitude change procedure falls under the Technical Knowledge and Procedures part of this graphic while the cognitive skills comes from this area and the teamworking skills from this area.

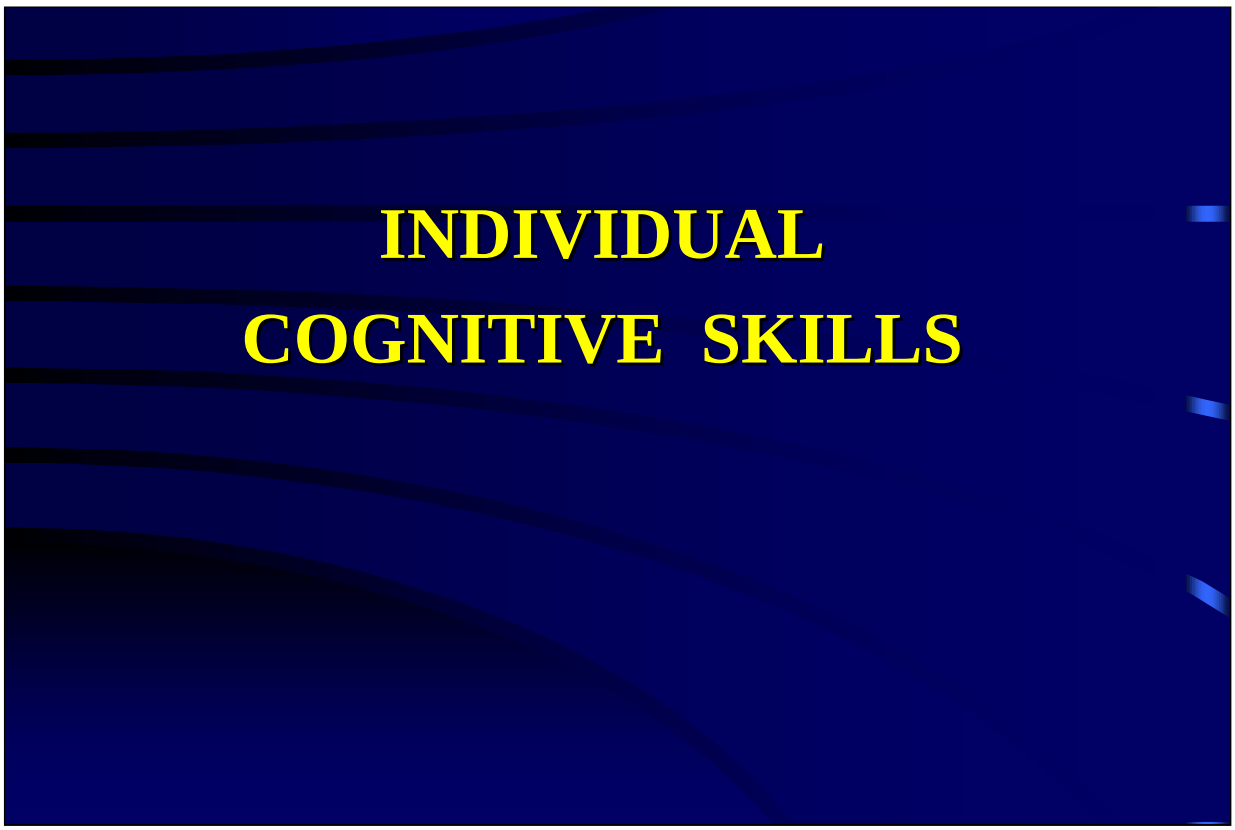


Several years ago we did an altitude deviation study at United and found that about a third of the altitude deviations were due to communication errors. Another third occurred when the PNF put the wrong altitude in the mode control panel. And finally, about a third of the deviations were due to execution errors during the altitude change. This procedure was developed to reduce the probability of first two areas. **The key is to develop a redundant, double loop procedure**.

Let's assume that the captain is the pilot-flying (PF) and the first officer is the pilot-not-flying (PNF). ATC issues a clearance. The first officer receives the clearance and then reads it back to ATC. He then places the new altitude in the mode control panel. This is the inner loop. Correct phraseology and terminology are, of course, essential. ATC must be alert for incorrect read-backs by the PNF.

The captain then compares what he heard from ATC over the radio with what he sees in the mode control panel. If they are the same he states "altitude confirmed" or words to that effect. This is the outer loop which is independent of the inner loop. If the probability of a single pilot error is 1/100, this procedure will reduce the probability of an altitude bust to 1/10, 000.

Some airlines require the PNF to point to the mode control panel. This increases awareness but is not the essential factor. **The key is for the PF to independently determine the correct altitude**.



Lack of awareness has been identified as a contributing factor in many accidents and incidents. We cannot just stop here, however. If we are to reduce human error, we must look underneath awareness.

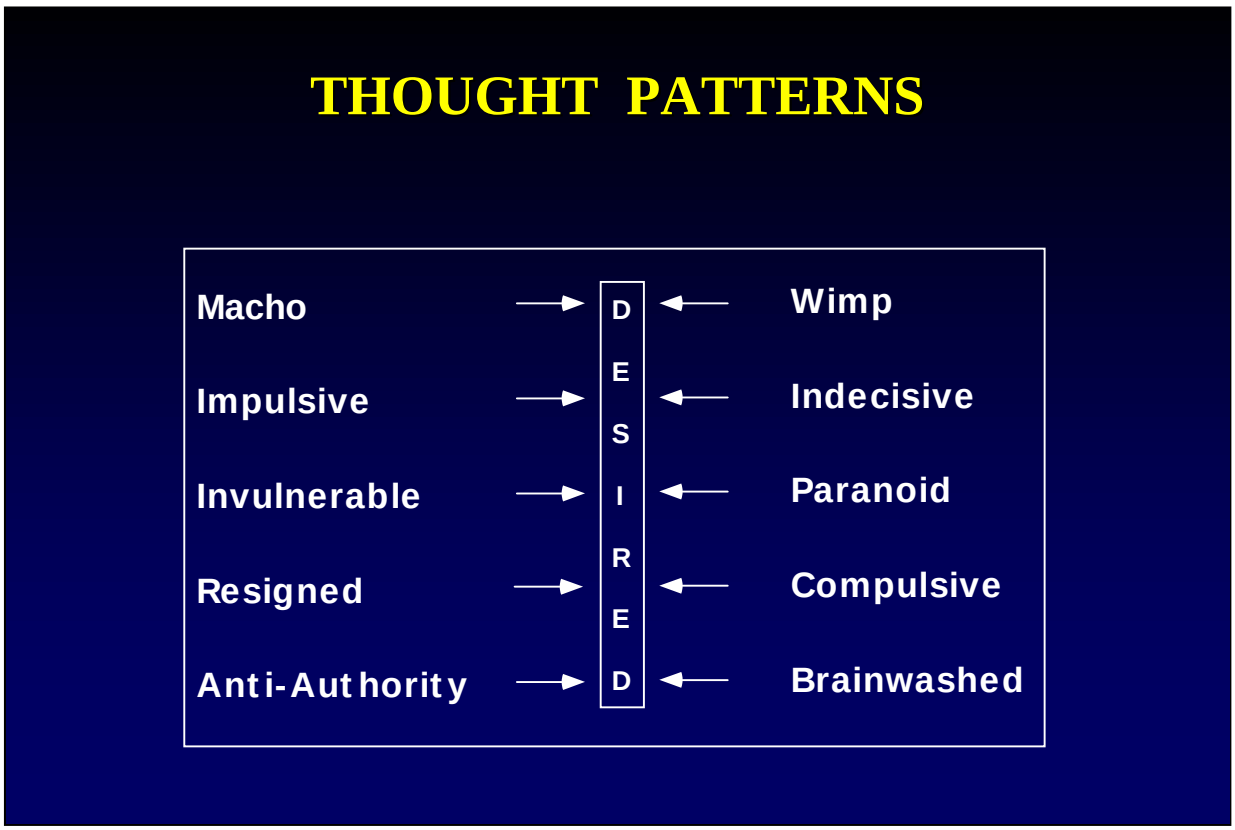
Since awareness emerges from processes of the mind, it is necessary to examine and enhance the underlying processes of memory, thought patterns, attention, reasoning, and physiological functions that affect mental state.

The intrapersonal training approach emphasizes that improving the capabilities of the individual mind is the key to improving operational performance.

It is important to recognize that many crews are exhibiting expert cognitive skills today. In fact, every skill discussed today has originated from an active airline crewmember. While the psychological words may be different from the words flight crews use, the underlying skills are the same.

The objectives are to reinforce these skills, to make crews aware of relevant psychological knowledge about those skills, and to share those skills across the aircrew population. **In other words, to bring aircrews closer to exhibiting all of the skills all of the time**.

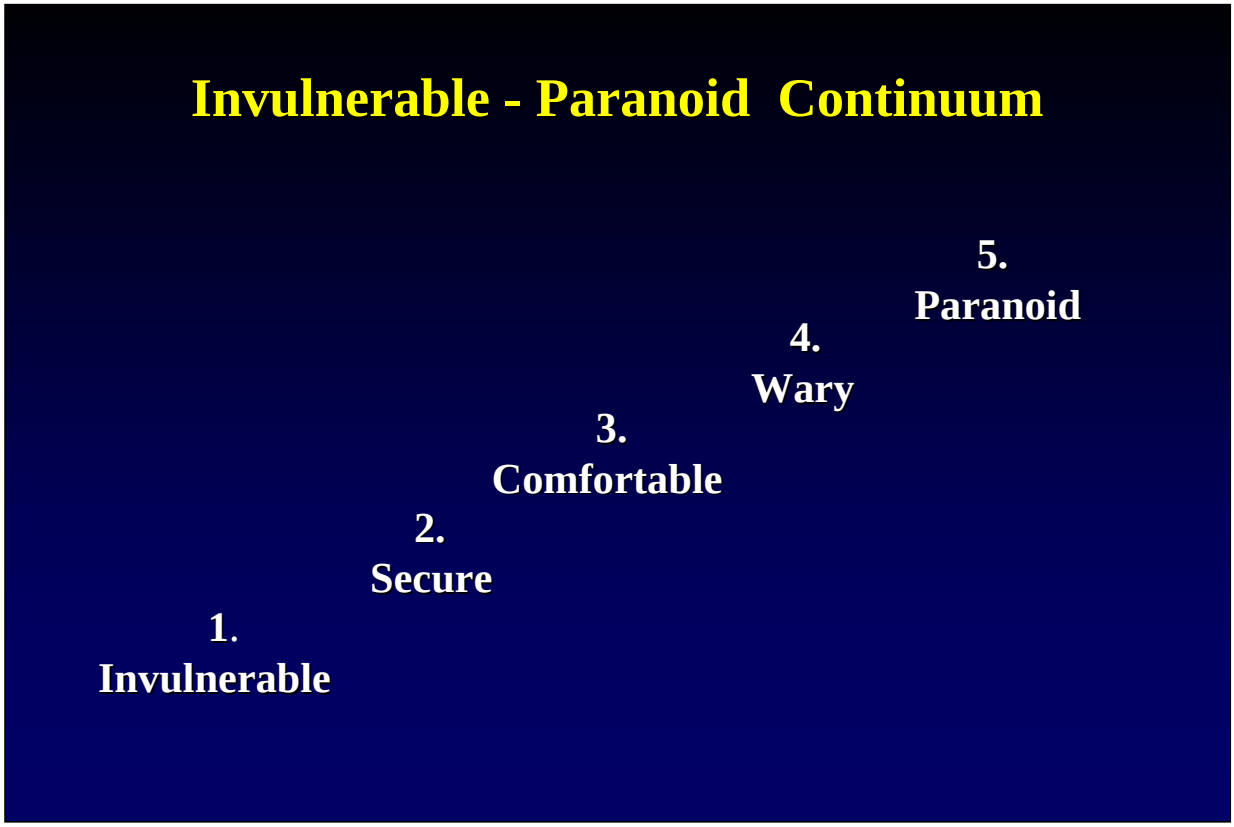
Now, let's look at some specific cognitive skills.



Thought patterns are very important because they are the building blocks of our attitudes and strongly influence the functioning of both attention and memory.

Most of you have already seen the 5 hazardous thought patterns on the left. What we have done here is to identify the 5 polar extremes on the right that are equally undesirable. The desired range is in the middle - between the 40 yard lines, so to speak.

Now, let's look at the invulnerable - paranoid continuum in more detail.



It's easy to rule out the two extreme thought patterns. But how about the middle three? What do **you** think? Which is the appropriate attitude for a commercial airline pilot as he or she approaches the various risks of aviation.

If your wife and children were flying tomorrow, how would you want the pilots to feel about the possibility of altitude busts? Invulnerable? Secure that it won't happen? Comfortable with the current system? Wary and suspicious? or Paranoid about the possibility that it might happen. I believe that most of you will choose the WARY category. It is better for operational personnel, who are entrusted with the safety of the public, to be a little suspicious rather than to be too secure.

Accident can and should be analyzed by these thought patterns. This kind of analysis makes excellent human factor training exercises. At Cali there is numerous evidence that the crew was too secure in their beliefs. Why didn't they feel a need to conduct a approach review or briefing? Why didn't they feel a need to challenge ATC's ambiguous clearances. Why did they accept, without careful analysis, ATC's suggestion to land on runway 19?

I believe that all expert pilots possess this cautious, wary, suspicious attitude. It is one of the hallmarks of expert performance.

THOUGHT PATTERNS

Pilots should consider ATC clearances with a healthy degree of skepticism and controllers should listen to pilot readbacks with equal suspicion.

Here is an example of the proper mindset.

I have heard this attitude expressed in various forms: For example,

Pilots should demonstrate a healthy degree of paranoia.

Pilots should approach the operational environment with an appropriate degree of skepticism.

After any clearance, the pilot should ask himself/herself, Is it appropriate for me to accept the clearance?

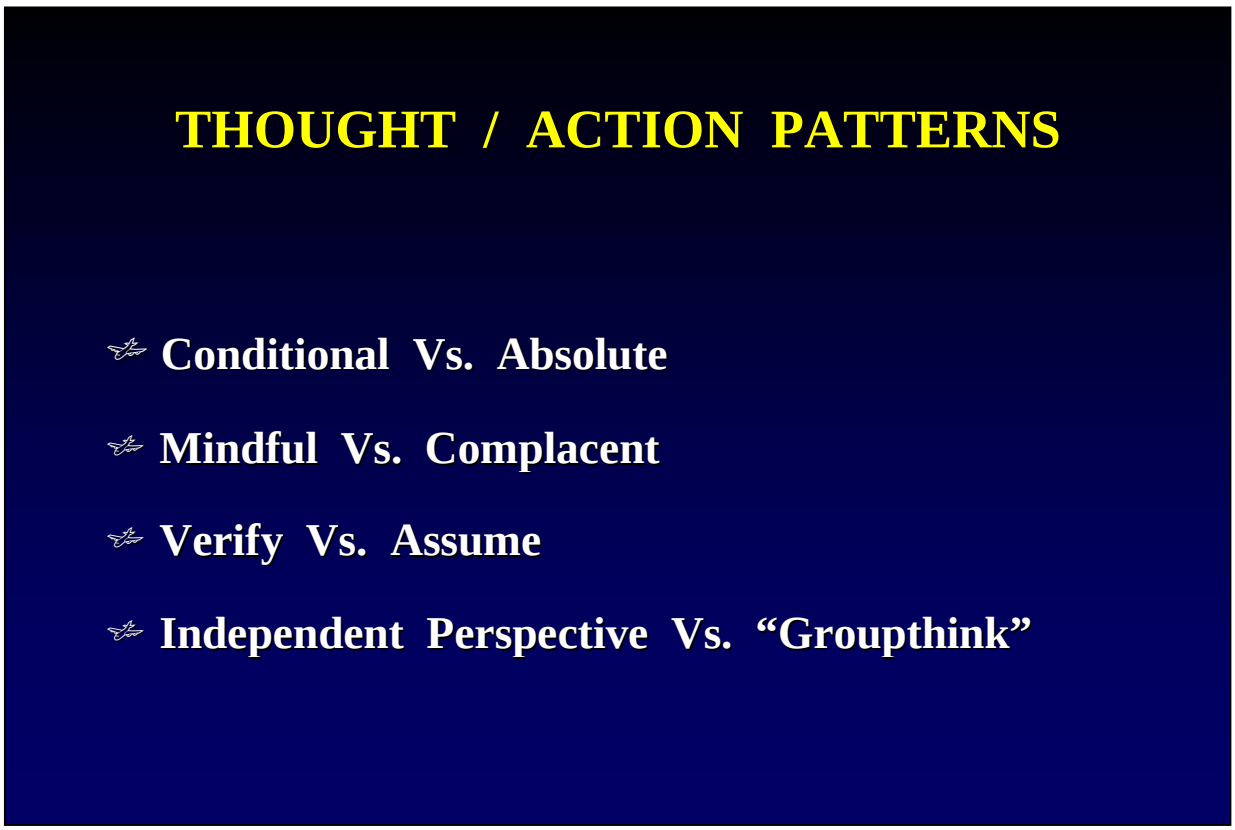
CFIT PRECURSORS

- Terrain-critical airport
- Night or IMC
- No radar
- Non-precision approach
- Non-English speaking pilots or controllers

Here are the well known precursors to a CFIT accident. When any of these precursors are observed increased vigilance is warranted.

It is interesting to note that all five were present on the evening of December 20, 1995 as AAL 965 began its approach into Cali.

This is the same approach that was used with windshear training. When any one of the precursors of windshear is detected, the crew is taught to search for other indications of windshear.



Here are some other beneficial thought patterns that can help your airline reduce errors.

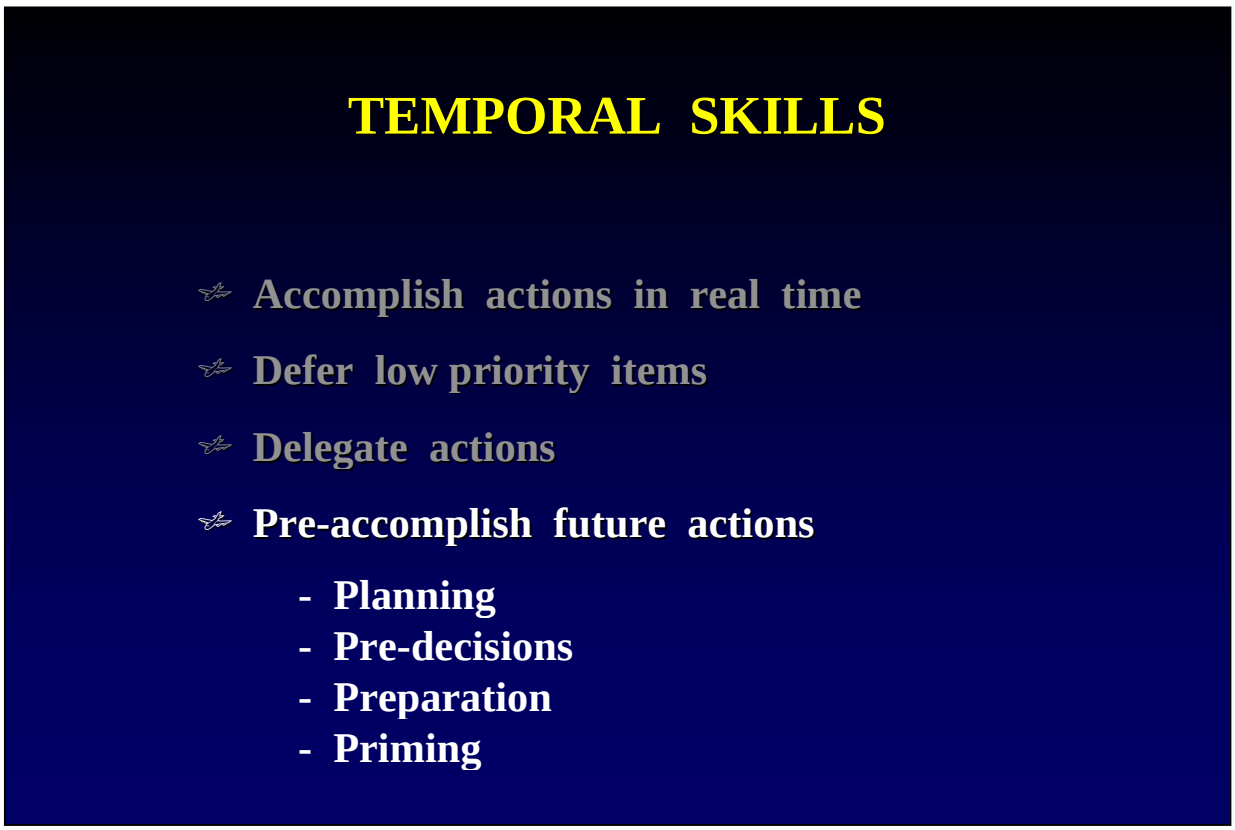
• **Conditional thinking** is superior to absolute thinking because it opens the door to additional possibilities and keeps you off the proverbial garden path. At Cali, the PNF could have listened conditionally to the approach clearances and tried to determine what was meant rather than assuming the meaning.

• A **mindful** thought pattern is more difficult but vastly superior to a complacent thought pattern. It is important to recognize that complacency is a normal side effect of atomization -- not a character deficiency. The good news is that it can be countered by experience or training.

• **Verification** is a third hallmark of expert crew members. Professionals verify - amateurs assume. Assuming can be dangerous. At Cali, the modified flight paths should have been verified before execution.

• Maintaining an **independent perspective** and avoiding "groupthink" is critical for all crewmembers. For example, consider the outcome if either crewmember had made an independent assessment of the proposed runway change.

It is important to recognize that the items on the right are the easy and normal thought patterns. **The items on the left are more difficult and take more time and effort, but are the hallmarks of elite performers**.



Most actions in life can be accomplished in real time. In aviation, however, heavy workload sometimes requires alternative strategies. We can defer low priority items to a later period, delegate actions to others, and pre-accomplish future actions during low-workload periods.

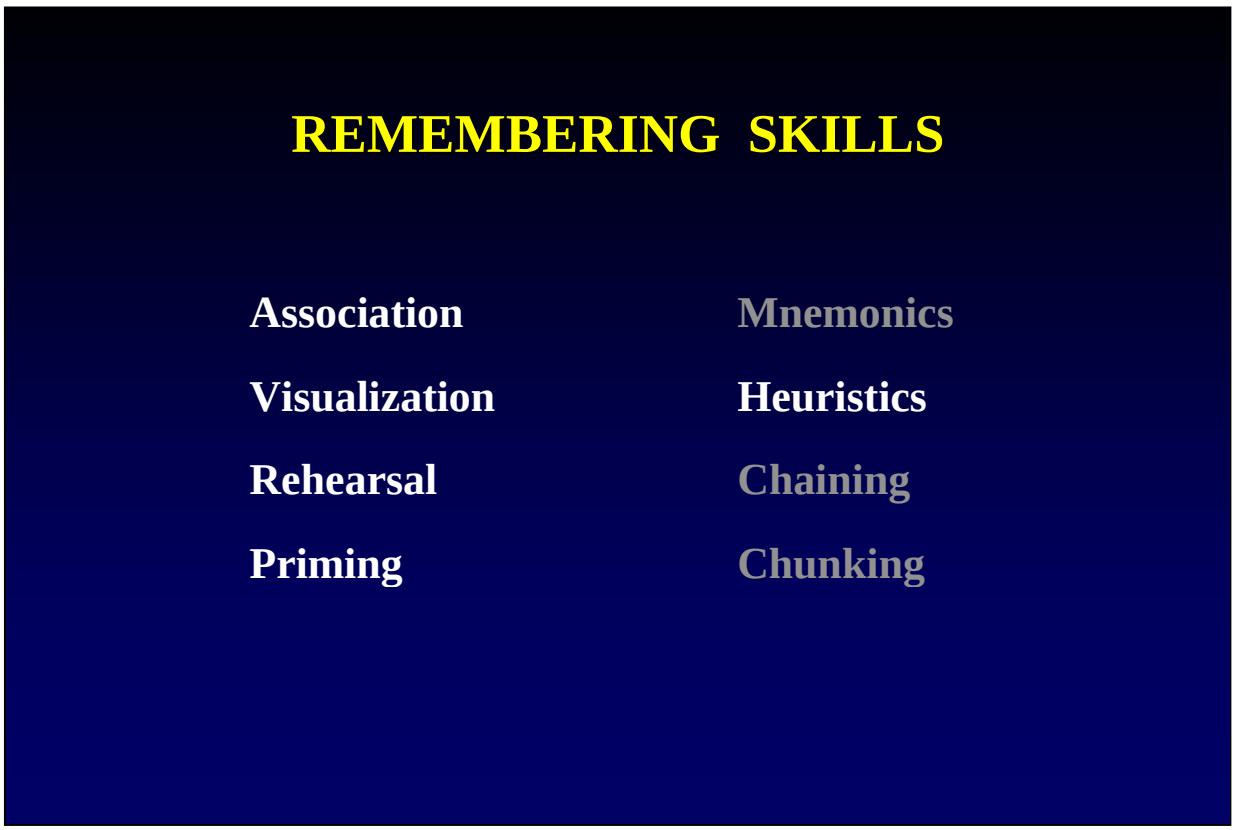
This last item - pre-accomplishment of future actions - is another way to identify expert performers. Planning, pre-decisions, preparation, and priming are specific skills.

Pre-accomplishing future actions not only frees-up valuable time, but also will result in improved decision making since the decisions will be made during calm, low workload periods that are free of stress and emotion.

At Cali, a thorough approach review and **plan** would have begun with a basic risk assessment of the situation and would have surfaced many of the approach problems before the fact. The crew could have made **pre-decisions** about the planned crossing altitude & airspeeds at Cali for the expected approach to runway 01 as well as for the possible approach to runway 19.

Both crewmembers should have mentally **prepared** themselves for the approach by pre tuning radios and rehearsing the predetermined procedures. **Priming** would have insured that critical altitudes would have been remembered.

This process will prepare you for the approach, arm you for future problem solving, and free up your mental time during the approach.



These skills are needed to remember task-relevant information and pre-decisions. Since time does not permit me to discuss each one, I will only discuss those that apply to altitude busts. They can be identified by the white color.

Association - a skill that dates back to the time of the Greek civilization - is the core process of remembering and could have been used to link the crossing altitudes and airspeeds to specific points in the approach. **Visualization** would have aided the pilots to maintain terrain awareness.

Rehearsal is needed to strengthen the trace of a particular item in our brain.

Heuristics or rules-of-thumb - such as a 3:1 descent ratio - would have been useful to determine how much distance was required to descend and make a stabilized approach.

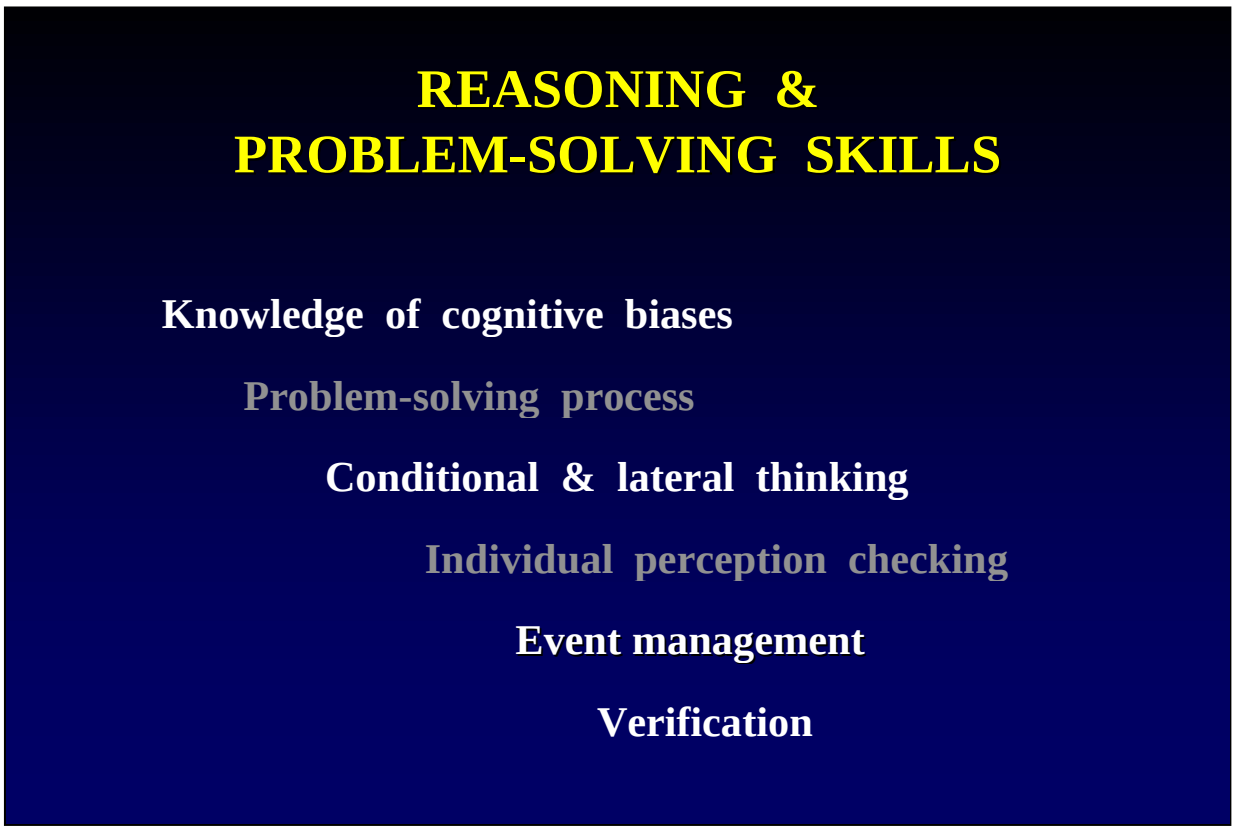
Priming - is a short term preparation skill that is very useful. At NASA, I use it frequently to train subjects and have found that it will reduce errors and improve reaction time by as much as 2 seconds. Think what 2 seconds would mean in a runway limited RTO situation!

This slide shows 10 attention management skills. The column on the left contains skills for managing attention in the present time frame while the column on the right contains skills for managing attention in the future.

Knowledge of the **hazardous states of attention** - preoccupation, distraction fixation, and overload - and the attributes of **flexible attention** should have dissuaded the crew from accepting runway 19.

If the pilot-flying had been trained in the use of **attention tracking** and **attention steering** he would not have allow himself to become fixated for 67 seconds while the aircraft was descending and turning. If the captain had understood the consequences of fixation, he might have **monitored** the first officer's state of attention more closely.

If the pilot-flying had **pre-determined** the need for **attention flagging** when the aircraft approached 15,000 feet, he would have maintained 15,000 feet since the aircraft was not on the Tulua 202 degree radial. **Priming** 500 to 1,000 feet before the 15,000 cleared altitude would have virtually guaranteed a level off until the aircraft was established on the Tulua 202° radial.



Biases cause mistakes just as inattention causes slips and lapses.

Knowledge of the traps that come from biases will allow crewmembers to develop counteracting strategies. At Cali, the confirmation **bias** was evident on 3 different occasions. The appropriate counteracting strategies could have included the development of a cautious, wary **thought pattern** as well as the specific procedure for the crew to listen to what ATC says not what they expect ATC to say.

Conditional thinking would have caused the pilots of AAL 965 to question the meaning of each ATC clearance - not to just assume that ATC was confirming their expectation.

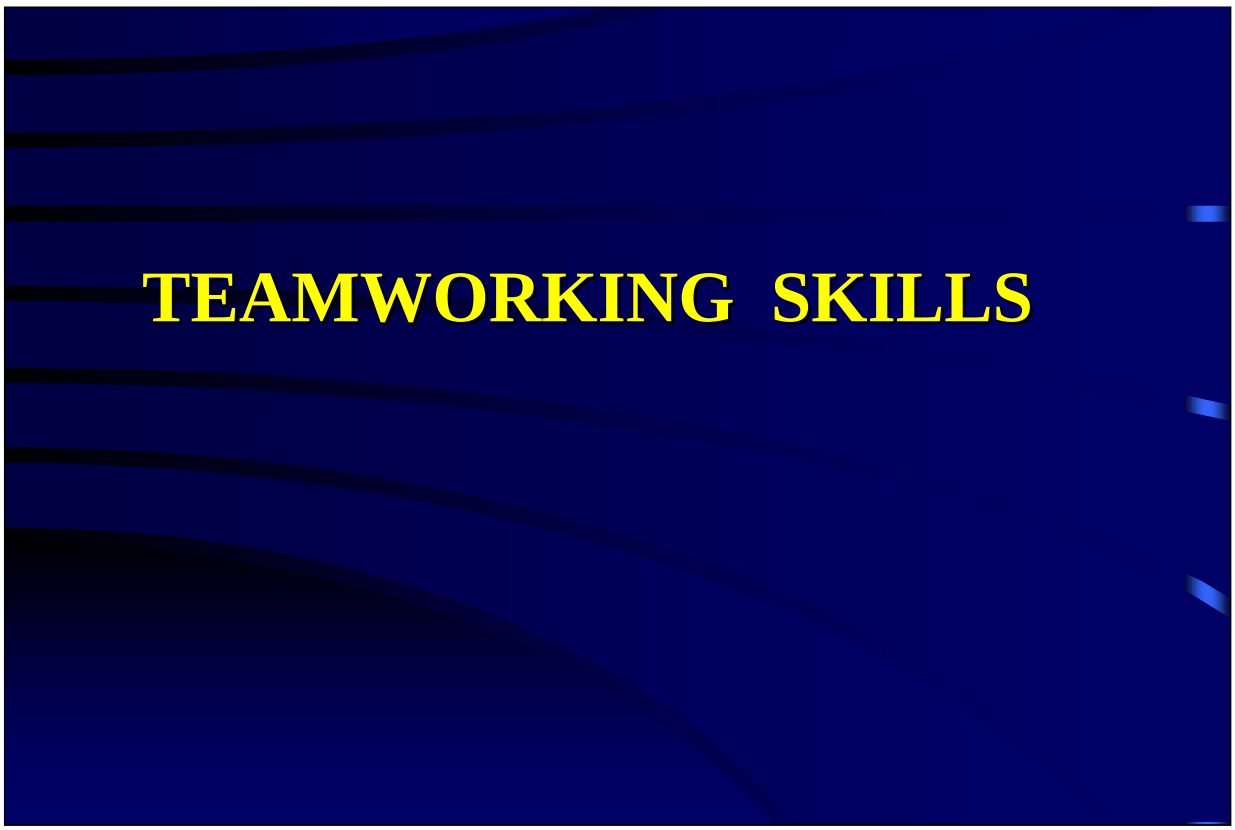
ATC requested a Tulua report at least 4 times. Proper **event management** should have become the catalyst for the crew to realize the significance of the request to "report, Tulua".

Verification, of the point on the chart at which 5,000 feet was authorized would have counteracted the crew's incorrect assumptions that they could descend immediately to 5,000 feet.

The expert crew member adopts the elite athlete's approach by managing physical factors that support the ideal mental state.

At Cali, the time-consuming decision to discontinue the approach would have been more likely and expedited if a pre-decision had been made about the factors and conditions that would cause the approach to be discontinued.

This action would have **mentally prepared** the pilots and **would have turned this time-consuming process into a quick attention task**.



Viewing events from different perspectives is a cognitive technique for increasing awareness. Since different members of a crew will naturally have different perspectives, the effectiveness and awareness of the crew can be dramatically increased through effective teamwork.

Teamwork can, therefore, be thought of as a form of cognitive redundancy in which each member of the crew is backed-up by the other team members.

Teamworking skills can be taught from either the interpersonal or intrapersonal perspective. The following teamworking skills are presented from the intrapersonal perspective.

These are three intrapersonal skills that enhance the team-building process.

I will skip briefing for now since I will cover it in detail in a few minutes.

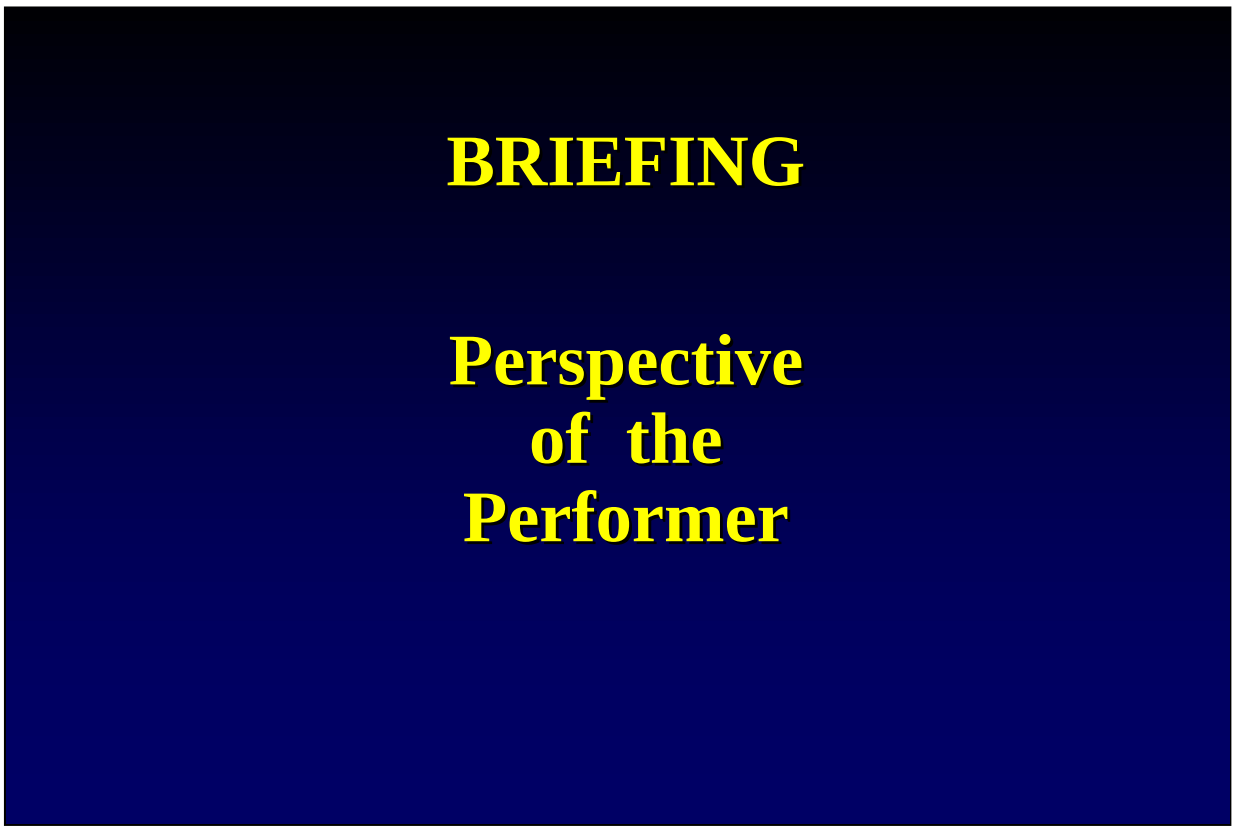
Here are four teamworking skills that could have made a difference at Cali.

Language clarity is essential to aviation safety. At Cali, there were three ambiguous ATC clearances that the crew was unable to clarify. The goal of aviation communicators should be to select specific words that define a single meaning.

Active listening is equally important. At Cali there was clear evidence that disconfirmed the crew's belief in each of the three ambiguous clearances. An effective strategy is to listen for **what is said** not what you **expect to be said**. This begins by developing an attitude with a healthy degree of skepticism.

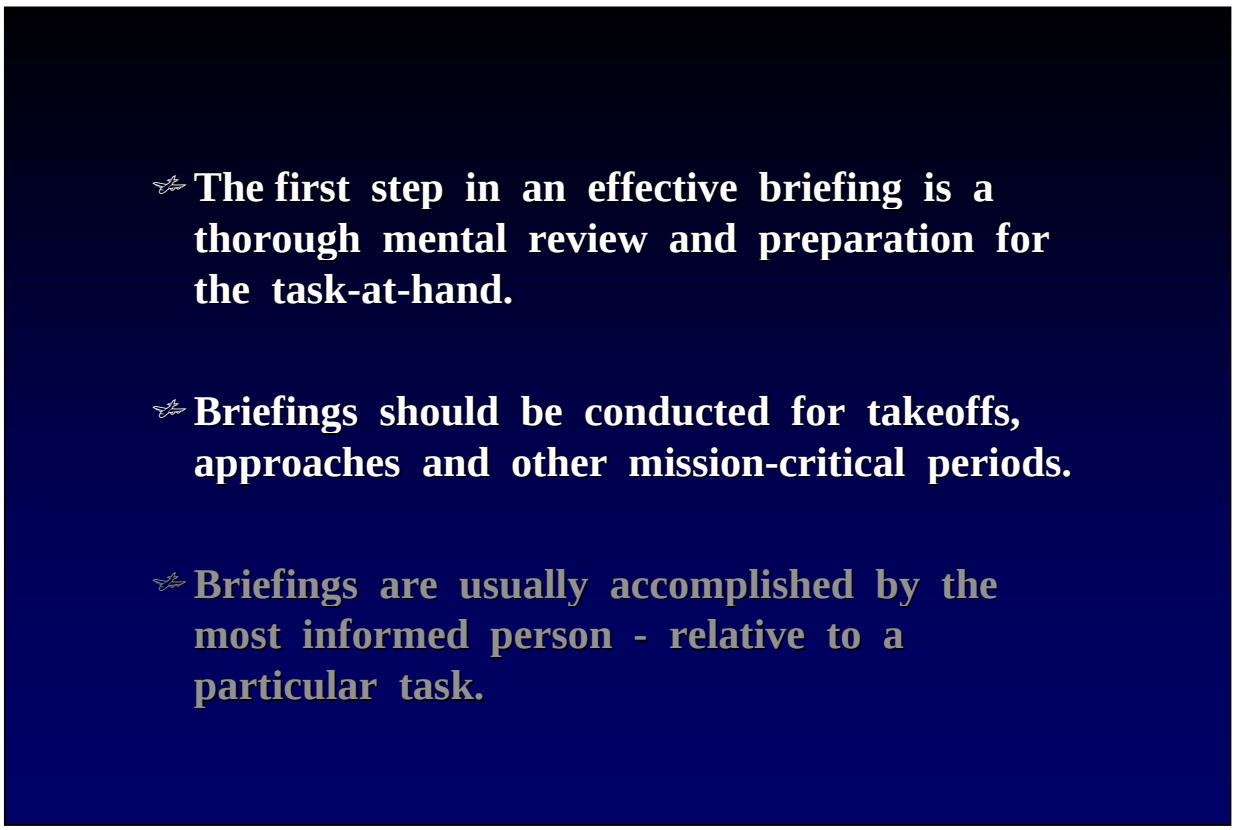
Effective **leadership** could have prevented this accident. The captain, as the pilot-in-command, should have seen to it that the approach briefing provided the necessary orientation and frame work for the approach into Cali. This would have included the fact that the flight was at night, in IMC conditions, at a terrain critical airport with non-precision approaches, without the benefit of radar, and where the controllers native language was other than English.

Effective **followership** could also have reduced the probability of this accident. As the pilot-not-flying, the captain should have **independently** determined if the approach to runway 19 could be safely made. He should also have verified on the approach chart the point where the flight could descend to 5,000 feet.



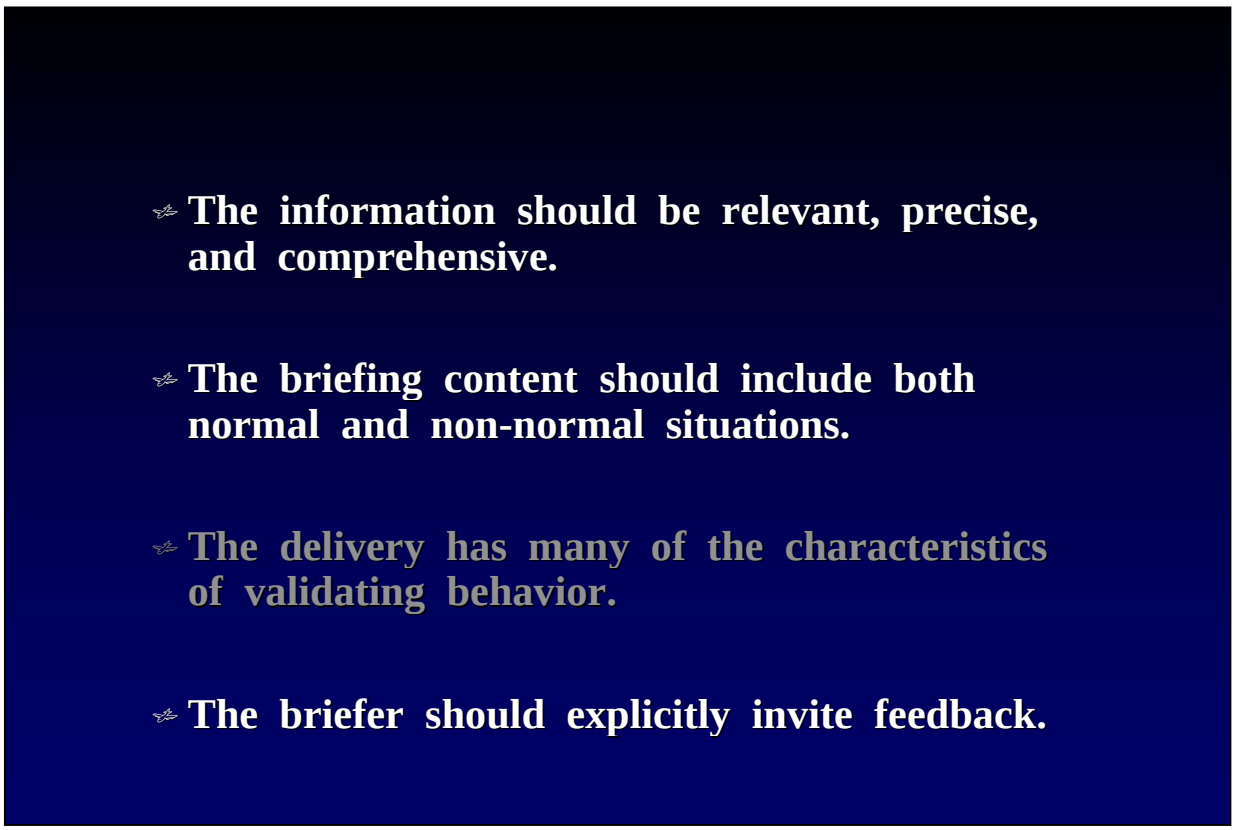
The next few slides show some of the detail that is available for intrapersonal training. The goal is to provide skills that can be quantified, taught, learned, and assessed -- practical skills that can be used on your next flight.

I will present the briefing skill from two different perspectives -- from the perspective of the performer of the skill and from the perspective of the other crewmembers.



Notice the first point. **An effective briefing cannot be accomplished unless it is preceded by a thorough mental review and mental preparation**.

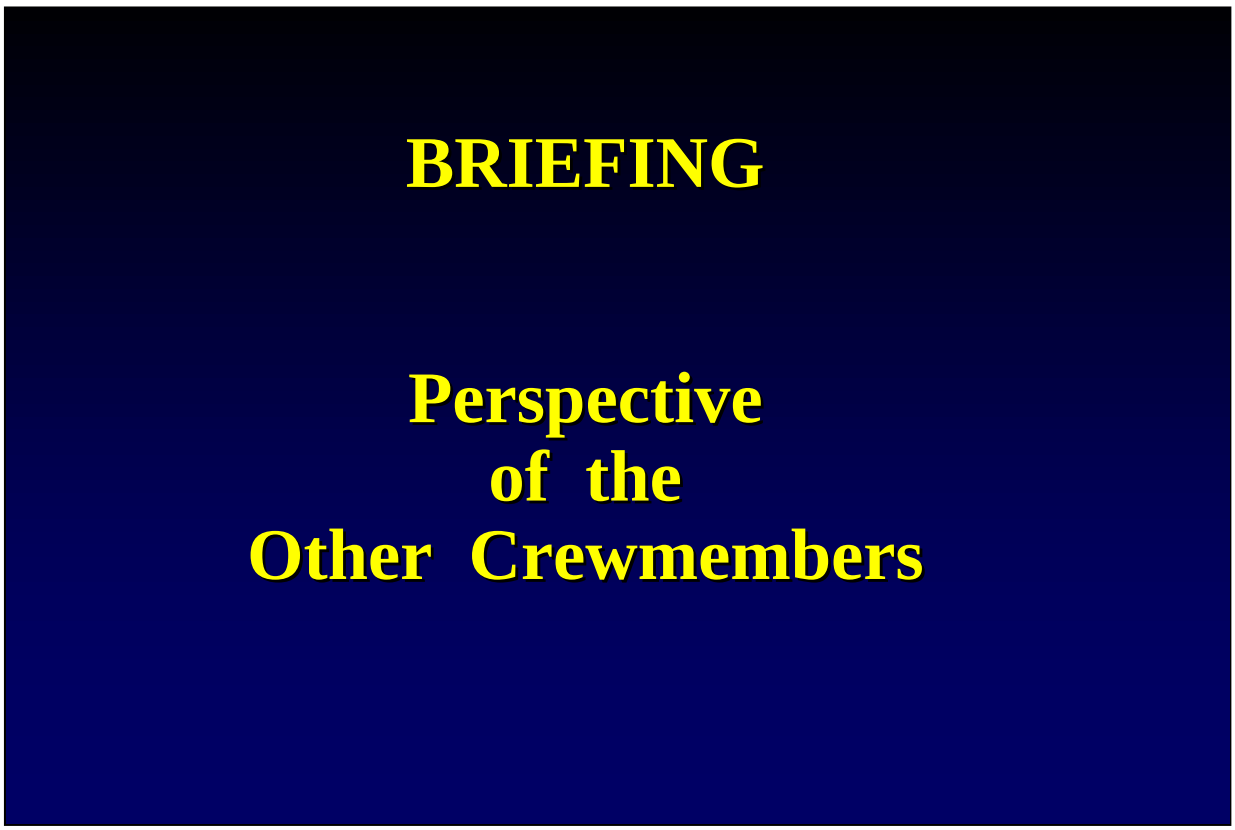
This was written about two years prior to Cali, by the way.



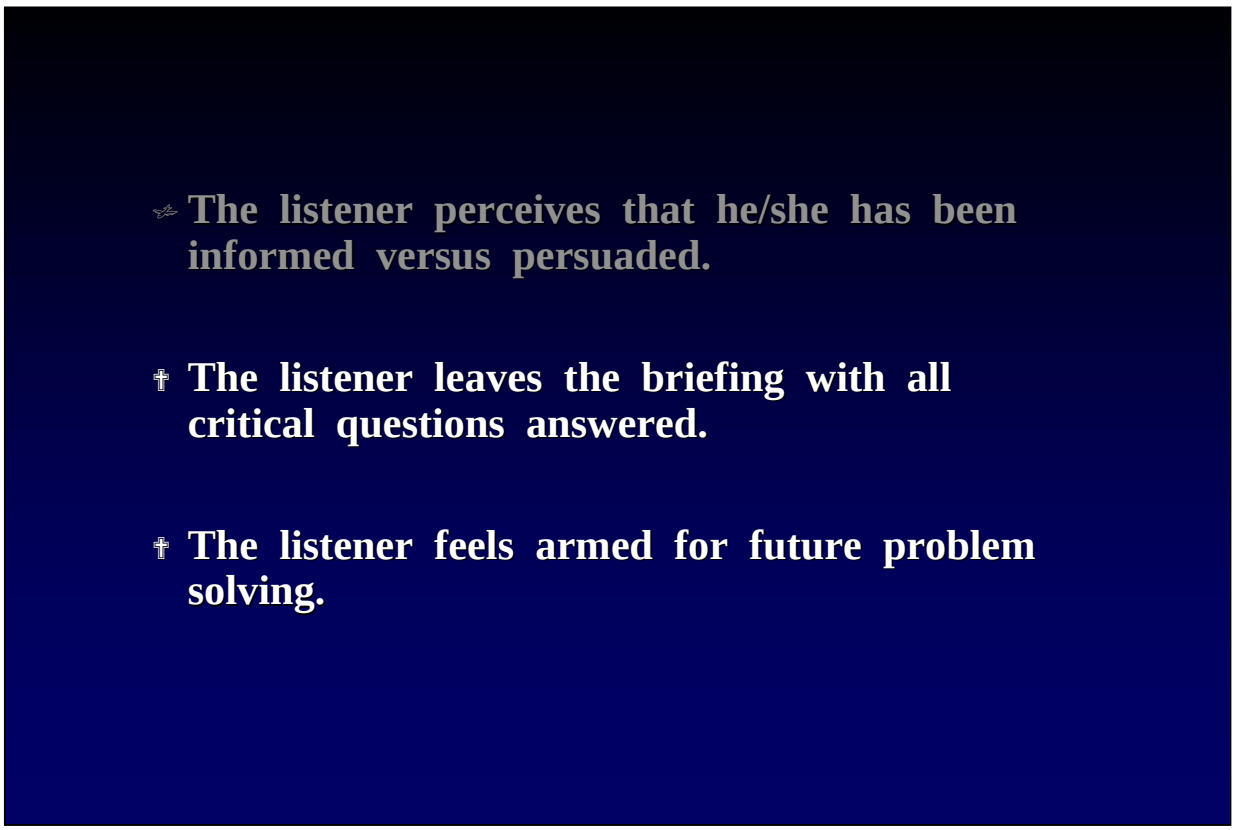
Clearly, the briefing at Cali was less than comprehensive. A comprehensive briefing that included crossing altitudes at both Cali and Tulua would have made a difference.

Notice the reference in the second point to **non-normal** situations. The time to consider the VOR approach to runway 19 is at cruise altitude - not in the middle of a descent. Human factors training must reinforce the fact that stereotype briefings can and do lead to complacency.

The briefer should **explicitly** invite feedback. This is a common mistake that is still occurring in cockpits. Most briefings are one sided. If you really believe in teamwork, you must try to pull the other pilot into the briefing to gain that person's valuable perspective and contribution.



Here is the briefing skill from the perspective of the other crew members.



Notice the last two points.

The listener leaves the briefing with all questions answered. The listener feels armed for future problem solving.

Did the pilots of AAL 965 feel armed for future problem solving after the approach briefing? I think not!

CONCLUSION

- **Intrapersonal skills can reduce altitude busts.**
- **Human factors training must emphasize intrapersonal skills.**
- **Intrapersonal human factors training can also reduce many other types of aviation accidents.**

And finally, the conclusion.

There is no question - at least in my mind - **that intrapersonal human factor training can reduce altitude busts and related accidents**.

While both interpersonal and intrapersonal training can compliment each other and be beneficial, **intrapersonal training must be emphasized for safety reasons**.

Some of the additional benefits of intrapersonal training is that it applies to multi-piloted aircraft **and to single-piloted aircraft** .

Additionally, crews that master a complete set of intrapersonal skills will be armed to avoid many of the other risks of aviation including, runway incursions & excursions, CFIT, turbulence, windshear, icing, volcanic dust, and RTO's.

Thank you.

ERROR REDUCTION METHODOLOGY

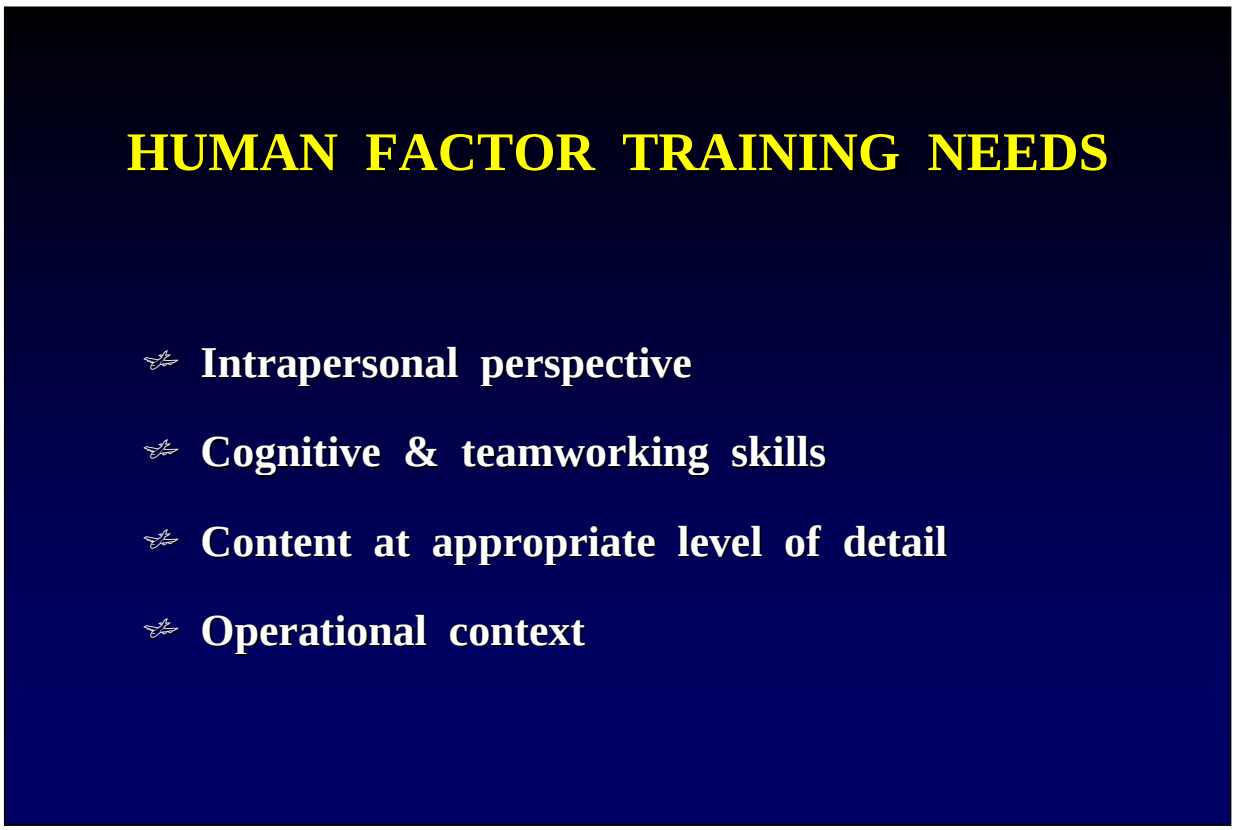
PROCESSES	PROBLEMS	REMEDIES
Reasoning & Problem Solving	Biases, Complacency Haste, Mindlessness	Reasoning & Problem Solving Skills
Belief Formation	Macho, Impulsive, Invulnerable, Resigned, Anti-Authority Thought Patterns	Effective Thought Patterns
Cooperative Behavior	Self-sufficiency Bystander Apathy Groupthink	Team Building Skills Team Participation Skills
Attention	Slips of Habit Mental Lapses, Absorption, Distraction, Preoccupation	Attention Management Skills
Memory	Mental Lapses	Remembering Skills
Physical Functioning	Stress & Fatigue	Stress & Fatigue Management, Diet, Nutrition, Rest

This slide illustrates the basic error reduction methodology.

The column on the left represent various human processes.

The middle column contains problems that interfere with these basic processes.

The column on the right contain the remedies that can be used to reduce human error.



While the interpersonal and intrapersonal perspectives are not mutually exclusive and can actually compliment each other, intrapersonal training must be **emphasized** for safety reasons.

Effective human factor training must include a comprehensive set of cognitive **and** teamworking skills.

Human factor training must be conducted at a deep enough level of detail to ensure that the desired behavior will be achieved.

And finally, all human factor training **must** be operational.