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The *Journal of Air Transport Studies* (JATS – ISSN: 1791-6771) is a peer reviewed journal aiming at publishing high quality research related to air transport. JATS is interested in publishing papers primarily focusing on economics, geography, policymaking, management, marketing, operations, technology, logistics/supply chain management and modelling.

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- Fragoudaki, A., Keramianakis, M. and Jancovich, S. (2005) The Greek PSO Experience. *4th International Forum on Air Transport in Remoter Regions*. Stockholm, May 24-26.
- Forsyth P. (2002a), 'Privatization and Regulation of Australian and New Zealand Airports', *Journal of Air Transport Management*, 8, 19-28.
- Papatheodorou, A. (2008) The Impact of Civil Aviation Regimes on Leisure Market. In Graham, A., Papatheodorou, A. and Forsyth, P. (ed) *Aviation and Tourism: Implications for Leisure Travel*, Aldershot: Ashgate, 49-57.
- Skycontrol (2007) *easyJet welcomes European Commission's decision to limit PSO abuse in Italy*. 23rd April. Available from: http://www.skycontrol.net/airlines/easyjet-welcomes-european-commissions-decision-to-limit-pso-abuse-in-italy/ (accessed on 22/08/2008).

Conference Reports should be between 1,000 and 1,500 words. They should provide factual information (e.g. conference venue, details of the conference organizers), present the various programme sessions and summarize the key research findings.

Book Reviews should be between 1,000 and 1,500 words. They should provide factual information (e.g. book publisher, number of pages and ISBN, price on the publisher's website) and critically discuss the contents of a book mainly in terms of its strengths and weaknesses.

Industry Perspectives should be up to 1,000 words and provide a practitioner's point of view on contemporary developments in the air transport industry. Contributors should explicitly specify whether their views are espoused by their organization or not.

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performance affects airlines flight safety in practice. Kirkpatrick's four-level training performance assessment method is used as the basis of this study, while factor analysis, t-test, ANOVA and SEM (Structural Equation Modelling) are used for data analysis. Most respondents agree that the training content can be clearly learned without language barriers if the airlines use domestic instructors. In addition, most respondents felt that airlines should improve the frequency with which they update the training material and that more practical drills and line training should be added to training syllabus, especially with regard to emergency evacuations. SEM method is used to assess the relationships among the training syllabus, skills learning, operational performance and flight safety performance. The results show that the training syllabus positively affects skills-learning, skills-learning positively affects operational performance and flight safety performance, and operational performance directly affects flight safety performance.

The aim of this paper is to describe the different uses of English phraseology and plain language within pilot-controller (or air-ground) communications via a comparative study between two collections of texts (corpora): one representing the prescribed norm and made up of examples of English from two phraseology manuals; the other consisting of the orthographic transcription of recordings of real air-ground communications. The comparative study is conducted at a lexical level. It focuses on the discrepancies observed in the distribution of the corpora lexicon. Our preliminary results indicate that, in real air-ground communications, pilots and controllers tend to use more "subjectivity" markers (pronouns, courtesy expressions) than prescribed by the linguistic norm. This observation reflects their needs to use the language in its social role. A description of the different markers introducing subjectivity in air-ground communication can help understand the use of a more natural language in radiotelephony. In the long run, the results from the comparative study can be used to improve English radiotelephony teaching.

Airspace control systems introduced automation into functions previously performed by human operators. This situation increased the dependence on the availability of

Editorial
Special Issue: Aviation Safety
Selected Papers from the 2011 ATRS Conference

The 15th Air Transport Research Society (ATRS) Conference took place in 2011 in Sydney, Australia. In the conference 217 paper presentations took place in the presence of 256 participants from 34 countries.

For this special issue of the Journal of Air Transport Studies we present seven papers from the Sydney Conference. The first two papers highlight the experiences of two captains to lead us into the practical aspects of safety. The rest of the papers cover safety from various orientations: safety training programs, communication skills, airspace control systems, and obstacle restriction and removal.

In the first paper of this special issue Ian Douglas summarizes the address given by Captain David Evans to the 2011 Air Transport Research Society World Conference in Sydney, Australia. The paper draws on the responses of the crew of Qantas flight QF32 to an inflight emergency to identify areas of weakness in simulator training. There are two significant issues that emerge from this paper. First, the lack of simulated training for actions to be taken after the aircraft is successfully landed by the crew; and second, the impact of a high workload on the crew's ability to hear audible warning signals.

Another important insight is provided by Captain John Gadzinski, who discusses overrun accidents that continue to occur despite the good intentions of those involved in identifying and managing risk. He explains how our ability to predict and prevent accidents that "can't happen" must depend on willingness to accept that no system is failure-proof. The paper focuses on the different ways risk can be measured as well as how the nature of randomness can influence perceptions of safety. He discusses the interrelated effects of probability modelling, safety assurance practices and current policies and regulations a new definition of safety hazards and mitigations.

Yu-Hern Chang, Meng-Yuan Liao, and Chien-Chen Kuo examine the impact of airlines' cabin crew training on safety performance. They use the Kirkpatrick's four-level training performance assessment method and a questionnaire survey. The responses indicate that training content can be clearly learned without language barriers if domestic instructors are used, training material needs frequent updating, more practical drills are needed, and line training should be added to training syllabus, especially with regard to emergency evacuations. The authors apply a structural equation model on the data to assess the relationships among the training syllabus, skills learning, operational performance and flight safety performance. The results show that the training syllabus positively affects skills-learning, while skills-learning positively affects operational performance and flight safety performance. While the overarching conclusion is that operational performance directly affects flight safety performance.

Stéphanie Lopez, Anne Condamines, Amélie Josselin-Leray, Mike O'Donoghue, and Rupert Salmon describe the different uses of English phraseology and plain language within pilot-controller (or air-ground) communications. They conduct a comparative study between two collections of texts (corpora): one representing the prescribed norm and made up of examples of English from two phraseology manuals; the other consisting of the orthographic transcription of recordings of real air-ground communications. The results indicate that, in real air-ground communications, pilots and controllers tend to use more "subjectivity" markers (pronouns, courtesy expressions) than prescribed by the linguistic norm, reflects their need to use the language in its social role. The authors point out that their results can be used to improve English radiotelephony teaching.

Walter Nogueira Pizzo and Paulo Sérgio Cugnasca discuss how airspace control systems introduce automation into functions previously performed by human operators, in which degraded operation events can reduce the service level at any controlled airspace. Their paper analyses the relationship between the availability and the allocation of human resources in these cases. A simulation model for the Arena tool is presented, to access availability, and then the operational point of view is explored, focusing on the required availability scenarios. The results help dimensioning operational and maintenance teams, taking into account the reliability and maintainability parameters of airspace control systems.

Sze-Wei Chang and Ping-Wen Hwang discuss and compare the FAR Part 77 "Objects Affecting Navigable Airspace" commonly only used in the US, and the ICAO Annex14 "Obstacle Restriction and Removal" accepted by all other countries. They point out that the two systems were constructed with a different baseline, restrictive area and height. However, government regulations usually adopt one of them exclusively, causing concerns. The purpose of the paper is therefore to compare safety airspaces and identify differences. The results of their study indicate that the FAA imaginary surfaces system specifies a more extensive obstruction clearance than ICAO's and airports which apply the FAA regulations restrict urban development around airports more.

In the final paper of this Special Issue Ana Maria Vieira, Isabel Cristina dos Santos, and Paulo Renato de Morais cover training for skills needed to perform safety functions. Their objective of their papers is to show that when working in safety environments involving groups, individuals need specific training in interpersonal skills. They argue that professionals trained in communication skills are more likely to identify threats and risks caused by interpersonal situations, and more likely to take appropriate action. Their paper suggests a set of policies, procedures and practices for educating and training future professionals who will work in aviation safety.

We take this opportunity to extend our thanks to the authors and the reviewers for their contribution to air transport research and hope that the papers become a source for further inquiries into the respective topics.

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QANTAS FLIGHT QF32: LESSONS FROM AN INFLIGHT EMERGENCY

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ABSTRACT

This paper summarizes the address by Captain David Evans to the 2011 Air Transport Research Society annual conference in Sydney, Australia. The paper draws on the responses of the crew of Qantas flight QF32 to an inflight emergency to identify areas of weakness in simulator training. Two significant issues that emerge are the lack of simulated training for actions to be taken after the aircraft is successfully landed by the crew and the impact of a high workload on the crew's ability to hear audible signals.

Keywords: inflight emergency, crew's ability in emergency, weakness in simulator training, crew's decision-making process

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[b]Captain David Evans joined Qantas Airways in March 1984, and currently holds the position of Check and Training Captain on the airline's Airbus A380 fleet. Before joining Qantas, Captain Evans flew air ambulance operations with East West airlines in rural Australia.

1. INTRODUCTION

In November 2010, an uncontained engine failure on a Qantas Airways A380 aircraft as it climbed out of Singapore airport presented the crew with a highly degraded aircraft. The experience of the crew in dealing with that emergency offers insights into the design of simulator training, the increased reliance on automated systems for decision making on modern aircraft, the impacts of high work load situations on the awareness of audible warnings and the importance of airmanship as a primary skill when dealing with emergency conditions on an aircraft. This paper summarizes the keynote address delivered by Qantas Check Captain David Evans to the Air Transport Research Society Annual Conference in June 2011.

2. CHRONOLOGY OF EVENTS BY CAPTAIN DAVID EVANS

On the morning of 4th November 2010 Qantas 32, an Airbus A380 VH-OQA was to operate Singapore to Sydney. This was the continuation of the London to Sydney service that makes a transit stop through Singapore for fuel and a crew change.

I was tasked to conduct a 'route check' on the Captain of the flight, Richard de Crespigny who had positioned to Singapore the day before. I was also tasked to train and mentor a new Check Captain, Harry Wubben. Harry was to conduct the route check under my supervision.

A route check is simply a check of a pilot's normal procedures on a normal flight. The check pilot takes no part in the operation. In fact if a check pilot becomes involved in the operation the check is either a failure or incomplete. In the case of QF32 the check was incomplete as both Harry and I became involved!

To complete the picture the crew is also made up of First Officer, Matt Hicks and a Second Officer, Mark Johnson. This was an unusual crew complement as it was made up of 3 Captains, 1 First Officer and 1 Second officer, a total of 5 pilots on the flight deck.

The weather on the morning of 4th November was fine with a light South Westerly breeze with temperature of around 27C: a perfect day to go flying. After a normal take-off the aircraft was setting course passing through around 7000 feet when a pair of muffled explosions were heard on the flight deck. The aircraft was leveled at 7400 feet when the crew was faced with a multitude of ECAM procedures.

ECAM is an Airbus acronym for Electronic Centralized Aircraft Monitor. The system attempts to prioritize the various messages as best it can. On the 4th November it had its hands full with upwards of 50 ECAM messages to deal with.

The explosions were a result of a faulty oil stub pipe dating back to the original manufacture of the engine. The details of this failure have been well documented elsewhere and I won't go into too much detail here.

To summarize, the pipe failed allowing oil to ignite around the ITP shaft of the engine. The shaft failed causing the turbine to over-speed and subsequently burst. Aircraft manufacturers consider a burst turbine to have "infinite energy" and it is not containable.

Airbus, like all aircraft manufacturers, consider a turbine burst in its design and mitigate against this by routing critical services through a variety of paths so that the chances that all services are cut are extremely remote.

However, only one impact is considered in this design requirement. QF32 had all three major turbine pieces, weighing approximately 80kg each, impact the aircraft. Over 100 other impacts from smaller engine components struck along the left wing, fuselage and tail.

These impacts severed electrical wiring, fuel tanks and transfer pipes, hydraulic lines, pneumatic ducts, and flight control surfaces.

The result on the flight deck was an overwhelming display of almost 60 ECAM messages and procedures for the crew to follow. Airbus procedures demand that these procedures are auctioned in the order in which they are displayed to the crew. Richard and Matt without much delay began the process; however it eventually became evident that auctioning the messages was going to take some time.

One limitation of the ECAM is that it only displays one or perhaps two messages at a time and does not indicate how many are to follow. It was almost one hour into ECAM actions that Matt reached the end of this very lengthy list.

During the ECAM process it also became evident that some messages were spurious and more importantly not appropriate to proceed with. For example there were many FUEL messages indicating that the aircraft was going outside its lateral imbalance limits. This was already obvious as we were leaking fuel heavily from various points on the left wing. Some of the ECAM procedures were asking us to open cross-feed valves and to start transferring fuel from the undamaged heavier wing into the damaged lighter wing.

This didn't seem like a good idea and, as a crew, we elected not to implement some of these fuel procedures. This was a revelation to me as at no time during any of my Airbus training was I taught even to consider NOT doing a check-list!

On reflection it has occurred to me that as technologies advance, and some of the more mundane procedures are done by computers, we human beings start to rely more and more on them. This manifests itself into a belief that the system is right, however this reliance starts to kill off one's ability to think and even reason.

Common sense would suggest that it is not a good idea to pump JET A-1 fuel into a broken wing full of unknown ruptures and electrical faults, but ECAM was asking us to do just that. In aviation, "Common Sense" is equivalent to "Airmanship" and this "Airmanship" can be equally summarized as making "Sensible Decisions". The sensible decision on this occasion was to not follow these fuel balance procedures.

The fuel problem was just one of many issues that were affected by the turbine burst. In fact all aircraft systems were affected in one way or another.
They included:

- ✓ Engines: Engine 2 failed, while Engines 1 and 4 were left in a 'Degraded' mode and Engine 3 in 'Alternate' mode.

- ✓ Electrical: Engines 1 and 2 generators failed (suggesting that Engine 1 had taken some impact damage)

- ✓ Pneumatics: Left pneumatic duct ruptures.
- ✓ Brakes: The wing landing gear anti-skid system was inoperative.
- ✓ Flight Controls: The slats were inoperative, with only partial spoilers and ailerons available.
- ✓ Hydraulics: The ‘Green’ system was inoperative requiring gravity extension of the landing gear.

All of these procedures took time and during all this the crew and passengers in the cabin had to be kept informed. This was accomplished by several announcements from the flight deck. The cabin was well managed by the Customer Service Manager Michael Von Reith.

Interestingly, the A380 has a tail-mounted camera that is used on the flight deck for ground maneuvering. These images are also fed into the passenger entertainment system so that passengers can have a bird’s eye view of the aircraft. This feature is very popular during take-off and landing, and was also popular as well as the dramas unfolded on the QF32. The request came through from the cabin to switch off the tail camera as all the passengers were watching!

We reasoned that at least it gave the passengers something to do, and wondered what alarm would be sent through the cabin if all of a sudden the picture everyone was fixated on suddenly went blank. Using the “Airmanship” principle, making sensible decisions, the camera stayed on.

It was now time to consider landing the aircraft and to that end a number of calculations and preparations had to be completed. The landing performance of the A380 is calculated with the aid of a computer program. After all the various factors affecting our landing performance were entered (overweight, antiskid inoperative, no slats, partial spoilers, loss of hydraulics etc.) the computer couldn’t calculate an answer. After selectively eliminating minor (or what we considered minor) elements, an answer was arrived at but with the slimmest of margins. The computer suggested that we had a little over 100m surplus on a 4000m runway.

While +100m is certainly better than -100m, we had taken some items out of the calculation, so there is a very real possibility that we could overrun the runway. To that end Mark the second officer went back and briefed the cabin crew. He emphasized that we would be flying faster than normal due to our overweight condition and the lack of leading edge slats on the wing. The crew was to wait for our commands from the flight deck unless the situation in their zone became untenable.

As history will attest, the aircraft landed and didn't overrun the runway. However, when we came to a halt at the end of runway 20C in Singapore the next phase of the drama began. It is interesting to note that most airlines train their pilots to deal with various emergencies in the air, and that they end the training session after a successful landing. Only scant regard is given to the after effects of an emergency landing. Certainly our emergency procedures training considers this situation, but it not a big emphasis. On this day after the aircraft came to a halt we proceeded to shut down the engines as dictated by the procedure. The aircraft promptly lost all electrical power and air conditioning.

By this time the aircraft was surrounded by the Singapore Airport Fire services and they were trying to make radio contact with us. In this initial confusion of electrical power loss the First Officer's radio console had died, so it was some seconds before contact was established with the fire commander. Once contact was established, the Fire Chief asked us to shut down all engines, Matt told him we had. He replied that engine 1 was still running! Because the aircraft had reverted to 'essential' battery power, the normal flight instruments had gone blank. To be told an engine was still running came as quite a surprise.

Concurrently the 'body gear' brake temperatures were climbing through 1000C (the temperature gauge that only reads to 990C was already at this value) with fuel leaking from the aircraft under considerable pressure all around these hot brakes.

It doesn't take too much imagination to know that all that was missing in this volatile mix was an ignition source for things to get very bad very quickly. The Fire Chief was encouraged by Matt to start deploying fire retardant around the aircraft immediately.

Throughout all this, all five pilots were focused on Engine1, and the question of how to shut it down. Meanwhile in the cabin, the Customer Service Manager was frantically trying to make contact with us. Interestingly, no one on the flight deck heard the emergency cabin call chime, but after reviewing the Cockpit Voice Recorder in Canberra with the Australian Transport Safety Bureau, there it was blaring out!

It underlines that at times of heavy concentration the first sense you lose is hearing. Although the situation was still very serious the immediate threat of fire was rapidly fading, so now what to do?

Part of our standard operating procedure is to make a coded public address (PA) to the cabin which alerts the cabin crew to go to an 'alert phase' and 'stand by your door for a possible evacuation'. This was done almost immediately, leaving the crew faced with a choice: evacuate the aircraft or not.

An evacuation of a modern airliner is considered possible to be accomplished in less than 90 seconds using only half of the available exists. In fact, during the A380 certification the test aircraft was evacuated in about 75 seconds. But that evacuation was with able bodied people who were ready to react to the evacuation command. Even then there were reported injuries with the test evacuees.

Qantas flight QF 32 had 433 passengers on a double storied aircraft, some of whom were elderly and wheel chair bound. Certainly not what you would consider able bodied. An evacuation, although essential in a dire situation with fire, was going to injure people with some of those injuries potentially being fatal. It's a very serious decision to order an evacuation.

An alternative to an evacuation at Qantas is a "Precautionary Disembarkation". As the name suggests the urgency is removed. There are two versions of this, one using the aircraft slides and one using stairs.

We were located at the end of a 4000m runway, 4 km from the terminal, and there was no sign of any stairs. Opening some doors and inflating some slides was considered but this raised the question of what do you do with the passengers once they made it onto the ground. There was fuel and foam everywhere, and an engine was still running.

The decision was made to order stairs to the aircraft, but the next question was how to arrange that with one serviceable radio? That one radio is our lifeline to the fire commander who will be the first to tell us if there is a fire, so we don't want to lose that contact even for a second. Mobile phones were the only alternative, but who do you call?

I had a Qantas number on my phone so I dialed it. A switchboard operator answered the call. Trying to identify myself to this operator and explain my predicament wasn't making any progress, so I broke off the call and established contact with the Qantas Integrated Operations Centre in Sydney who connected me to the chief pilot. Peter Wilson was advised that we were on the ground safely but that the drama was still unfolding and that we needed stairs and buses to deplane the passengers. This was relayed back to Singapore and the process was begun.

It was after midday in Singapore by now and the outside temperature was over 30C. As we had lost electrical power and air-conditioning, the inside air temperature of the A380 which had 469 passengers and crew onboard was well in excess of that.

It was almost one hour after we landed before the first set of stairs arrived at the aircraft. As busses started to turn up the crew carefully counted passengers as they disembarked to ensure that we didn't lose anyone. If it was a 30-seat bus, then the cabin crew very carefully counted 30 passengers to disembark. All cabin baggage was left on board and only passports and essential medicines were taken. It took a further hour to get all the passengers and cabin crew back to the terminal.

Throughout, it wasn't one individual who made all the decisions but rather a "collective brain" or think tank to overcome the series of obstacles presented to the crew; in any case, the final decision rested with the "pilot in command".

This was by no means a normal flight and because both Harry and myself became involved in the operation, the flight ceased to be a check flight. The successful injury free outcome was a result of sound crew resource management, (CRM). The crew was more than just the pilots and cabin crew. It also consisted of Singapore Air Traffic Control and Fire Services. Even the passengers played their part in the successful recovery of Qantas QF3[1].

3. CONCLUSION

This highly practical address identifies important areas to be addressed in both aviation practice and aviation research. Several of the key issues emerged after the aircraft had come to a stop on the runway. For researchers of human factors, the crew resource management issues include cockpit work (over)load, even after the aircraft had landed, that lead this five man experienced crew to miss an audible emergency call from the cabin, and the need for airmanship to override system generated messages that, if followed, may have had a negative impact on the survival of the aircraft. For airframe builders the capacity of the monitoring systems to process a high volume of messages and to present the crew with essential data around which to base airmanship decisions should be addressed.

Gaps in the simulator training of pilots were identified. Current simulations are regularly designed to end as the aircraft achieves a safe landing. The experience of the QF32 crew highlights several post landing issues, including communication with fire and emergency crews when aircraft systems are degraded, managing the orderly (non-emergency) evacuation of the aircraft to minimize the risk of injury to passengers and crew, and dealing with the consequences of failed engine control systems.

An unusually large and experienced crew brought the aircraft back safely and without injury. This success can be built on by learning from the crew's decision-making process and focus on airmanship as a primary skill.

[1] VH-OQA remained in Singapore for almost 18months while a complex repair took place. The aircraft then returned to service in the Qantas fleet and is currently flying the line with the only legacy of the incident being a slight increase in fuel burn.

THE HIDDEN DANGERS OF RUNWAY EXCURSIONS

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ABSTRACT

Overrun accidents continue to occur despite the good intentions of those involved in identifying and managing risk. Our ability to predict and prevent accidents that "can't happen" must depend on our willingness to look for the possibilities in what our conventional ways of seeing assure us are failure-proof systems. In 1968 astronaut Frank Borman said it was a "failure of imagination" that led to the Apollo I fire. Today, as economic pressures work to squeeze more capability from our airplanes, pilots, and runways, the question remains not "could a runway excursion occur" but "will it be our inability to imagine risk that contributes to the next runway accident"? This paper will focus on the different ways risk can be measured as well as how the nature of randomness can influence our perceptions of safety. By examining the interrelated effects of probability modeling, safety assurance practices and current policies and regulations a new definition of safety hazards and mitigations will be defined.

Keywords: Uncertainty, Black Swan, safety management systems, safety assurance, naval aviation.

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1. INTRODUCTION

The professional aviation community stands on the firm conviction that we live in a world where knowledge has the absolute power to vanquish uncertainty. According to Gittens (2011) "ICAO statistics indicate (that) runway excursions are both the most frequent and most deadly type of runway incidents that can occur." To this end, various organizations have endeavored to identify and classify the components that lead up to such an event. Our world is knowable to most people, and therefore our exposure to risk is also knowable. What we don't know today we can almost certainly know it tomorrow. We think this way because it is the way an engineer thinks, and if there's one thing our aviation world is built upon, it's the certainty and predictability that the engineering approach to building and operating machines provides us. But what if our world wasn't as predictable and certain as we thought it was? What if uncertainty itself was the product of our design process? Could that change the way we identify hazards and manage risk?

2. UNCERTAINTY

What you don't know can be more important than what you do. Risk is the relationship between the probability that something will happen and the resulting consequences if it does. In order to understand the risk inherent in an action, we must take a closer look at the properties of probability itself and understand the difference between randomness and predictability. To frame the discussion of runway safety in this context we will look at how randomness was first introduced in classical scientific reasoning, how it was used to influence decision-making models, and how randomness can affect probability in very different ways. We will then look at how risk is managed in carrier landings at sea and compare that to the safety management/safety assurance methods available to the civilian community. We will conclude by looking at how the limits of our knowledge affect our view of runway overrun risk and the possible remedies available to us.

"God does not play dice with the universe" was the famous quote from Einstein. For him the universe operated according to a grand design, with nothing left to chance. His Theory of Relativity was the ultimate triumph of reason over chaos. And so it annoyed him to no end when a young physicist named Werner Heisenberg, and the respected Niels Bohr, developed a theory of quantum physics that spelled out precisely the opposite. The problem started innocently enough when a Scottish botanist was examining pollen suspended in water under a microscope back in 1827. Unlike Einstein's universe, Brownian motion was chaotic and patently unpredictable. As Werner Heisenberg searched to understand why the atoms in water behaved in such a way he stumbled upon a branch of mathematics called matrix algebra that seemed to solve this problem quite elegantly. Forget trying to understand why atoms behaved the way they did, what was critical was the probability of their behavior. In the strange and bizarre world of the quantum particle, something could exist and not exist at the same moment, for no rational reason whatsoever! The uncertainty about its existence would forever remain a scientific constant (Lindley, 2008). Uncertainty lingered in the cloud chambers, spectrographs, and Geiger counters for everyone to see; sometimes things simply did "just happen," and for reasons that would forever remain a mystery.

The most dramatic illustration of this concept in the aviation world came from the work of a junior Air Force pilot named John Boyd who looked at the performance of the F-86 Sabre during the Korean War and came up with a groundbreaking discovery. Boyd was familiar with Heisenberg's work, but it was the random movements of an enemy fighter that concerned him. When compared to the MiG 17, the enemy's aircraft, the F-86 was inferior on paper in more than a few aerodynamic aspects. What made the F-86 such a formidable fighter, however, was how it was built on Heisenberg's observations regarding uncertainty. The cockpit layout, the size and position of the canopy, and especially the hydraulically boosted controls— all features of the MiG in which it was deficient—enabled the Sabre pilot to use uncertainty as a weapon by allowing him to modify his actions much quicker than his opponent. The theater of aerial combat was in many ways like the inner workings of the atom. Empirical causation for enemy fighter movements did not exist; what remained instead was a range of possibilities for action given the random changes in direction presented. Boyd introduced the concept of getting inside your opponent's decision loop—a concept that has entrenched itself in everything from business to military tactics. The deliberate use of uncertainty had entered the real world.

3. BLACK SWANS

The study of uncertainty then challenged everyday reasonableness when a professor from Lebanon named Nicholas Taleb made some observations about the nature of randomness itself. A financial trader, Taleb noticed that randomness affected people in two distinct and different ways. In one environment, variations in data were cumulative, with one data point slightly influencing the total outcome, such as in a bell curve. In another environment, variations in data produced significant changes that drastically changed the total picture. In the first case, history crawled, in the second, history jumped. For example, a dentist would have to spend years drilling teeth to make his fortune, while a speculator could lose or win a fortune in a matter of minutes (Taleb, 2007). Randomness to a dentist could mean an unhappy patient, an event with negligible impact on his total earnings. To the speculator even one unpredictable event could spell fortune or disaster in a matter of minutes.

Why can't we predict some events? Taking insight from the observations of the mathematician Poincare, who saw that as the dynamics of a process increased, the error rate in modeling grew very rapidly (Taleb, 2007). As an example, he used the movement of billiard balls. While the process for predicting what would happen on the first hit was easy enough, to properly predict the ninth impact would require an account of the gravitational pull of the person standing next to the table!

Taleb called outcomes that carried significant consequences but appeared randomly, "Black Swans". In his book he discusses how a person's attempt to retrospectively explain why such an event took place creates a fundamental error. "We are," he states, "an explanation seeking animal who tends to think that everything has an identifiable cause ..." When, in fact, what we are seeing may well be the noise of randomness, turned into information by our own self doing, and not a depiction of reality. According to Taleb (2007) Black Swans are a matter of luck "We tend to underestimate the role luck plays in our daily life but overestimate it in games of chance". The key to success is to maximize our ability to profit from good luck and minimize the outcomes of bad luck. 9/11, the Challenger accident, and the recent financial meltdown were all examples of Black Swans where our inability to acknowledge the existence of unpredictability created conditions that generated severe consequences.

As we look at the dynamics of landing aircraft, we see that the performance of the aircraft and the possibility of an overrun are affected by a few significant variables: point of touchdown, excessive airspeed, relative flight path, and contamination on the runway. These variables have a significant effect on the outcome of the landing. For example a long landing can increase the risk of an overrun by as much as 55% (van Es, 2005). Some form of variation is experienced in almost every landing. A runway with standing water, a slightly longer touchdown, and higher approach speed can add up to requirements for rollout distances well in excess of what is available, even on runways not considered challenging with reference to their field length.

The question is: how unpredictable is the average landing? The vast majority of the flying is anything but unpredictable. With backup instruments, backup systems, and technology ensuring the integrity of everything from my navigation to system status, there is little left to chance in the modern cockpit. Many of the overruns examined in accident reports occur following an approach coupled to the autopilot. So why do things seem to go so wrong from that point? To answer that we will first look at how randomness and risk are managed through the employment of a safety management system.

4. SAFETY MANAGEMENT

Safety Management Systems (SMS) have two core principles: safety management and safety assurance. The first step involves identifying relevant hazards and developing methods to reduce exposure to risk in a formalized manner; the second step assures quality in that process and provides an avenue for feedback. The SMS concept, while somewhat involved in its administration is basically a method for obtaining what is knowable to make decisions about risk and actively looking for the results of those decisions. To understand how this procedure relates to overrun risk, we will take a look at how this process is applied to runways that are 300 feet long.

In 2005 there was an overrun involving a B-737 at the Chicago Midway airport. The results of that investigation spurred major changes to the way the FAA looked at safety margins and aircraft performance methods concerning contaminated runways. To completely understand the challenges the average passenger jet landing present, we must look at the battle the airport was named for, the battle of Midway Island in WW II. Considered a major turning point in the war, it was an event completely defined by aircraft that landed on ships at sea. For these aircraft carriers, a landing airplane is not just a matter of safety but of national security as well. A detailed process was developed in the Naval Aviation community for defining, observing, designing, training, and assuring every single aspect of risk associated with a modern jet as it lands. Let us examine the process first from the view of safety management.

Safety management starts literally at the drawing board for a naval aircraft. The airframe has to be designed to land repeatedly at a 1200 fpm descent rate without damage while simultaneously transferring the forces of a tailhook throughout the airframe. The plane is designed to fly not airspeed but under a predetermined angle of attack that positions the airframe, landing gear, and tailhook at a precise angle to the runway. As most of you are probably aware, there is no flare in a carrier landing. The jet lands in the same manner as it flies the glide slope three miles out. The whole design produces an engineering constant called a “hook to eye”, distance that literally defines the vertical length between the end of the tailhook and the pilot’s eyeball.

Unlike the civilian ILS system, the radar tracking used to guide carrier-based jets provides a precision glide slope tailored to each specific type of aircraft. The ship then compensates for different “hook to eye” values of different aircrafts electronically. At three quarters of a mile from touchdown, when the aircraft is between 600 and 800 feet above the water, the pilot transitions to an optical glide slope. A Fresnel lens takes a light source and modifies it to produce a fine line of light that moves up and down a stack of lenses as the pilot’s eye moves above or below the glide slope. Since the light source produces a horizontal plane of light, that plane is then slightly rotated so that when that plane intersects the centerline of the ships landing area it produces a higher or lower glide slope to accommodate differences in “hook to eye” values.

The light source is situated so that it provides precision guidance until the aircraft’s glide slope literally intersects the runway. This places the tailhook before a selected steel cable that brings the jet to a quick but metered stop. For the pilot in the cockpit, visual cues to angle of attack above the glare shield facilitate a quick scan between the visual landing aid—called the “meatball”—his lineup on centerline (remember that the ship is constantly moving to his right due to the angled deck), and his all important angle of attack.

Runway contamination plays a negligible role in this case, once the aircraft touches down, there is an immediate engagement between the tailhook and a large steel cable engineered to bring the aircraft to a stop in 2 ½ seconds, while the engines are at full power. Crosswinds are kept in check merely by turning the entire landing field into the prevailing wind. These are luxuries that no civilian airfield would ever dream of.

So much for safety management, now the safety assurance part of SMS comes into play. On the side of the flight deck, there is a platform with special instruments and communication equipment where another carrier pilot, known as the Landing Signals Officer (LSO), stands. He controls the optical landing system, the arresting gear, and the status of the flight deck. Just as there are three attitude indicators on most jets (captain, first officer, standby) there are three LSO's for each landing event. In order to increase experience and training there is a controlling LSO, a backup LSO, and a senior or "Wing" LSO. Each one has the same radio and controls and can make the call to inform, direct, or wave off an approaching aircraft. The variables mentioned earlier are all carefully monitored and corrective instructions are given by the LSO throughout the approach. Airspeed (angle of attack) is identified by a three-colored light source in the approaching aircraft's nose gear; glideslope is monitored on a heads up display for the LSO; and point of touchdown is visually confirmed as the aircraft nears the flight deck. Tolerances measured in inches are observed and any pilot whose deviations stray too far is ordered to go around. The goal is to bring each aircraft to a point where normal variations in performance will not produce any adverse consequences that cannot be recovered from.

What's important here is that every aspect of the carrier landing is subject to a robust safety management/safety assurance process, from the extension of the landing gear to the final stop on the deck. As we compare this process to a civilian jet landing, we begin to see vast differences. A report by the National Aerospace Laboratory titled, "Running out of Runway," (van Es, 2005) analyzed thirty-five years of landing overrun accidents. The report described a "good landing" as the following:

1. A stabilized approach on speed, in trim, and on glide path.
2. An aircraft positioned to land in the touchdown zone.
3. A (runway) threshold crossing at correct speed and height.
4. A flare without rapid control movements followed by positive touchdown without floating.

Of critical interest to our discussion are deviations in approach path where variances in glide path add from 700 to 1000 feet to the desired touchdown point.

While the observations of the report are accurate, there are some practical issues with the employment of their definition of a "good landing." One of the main issues was the focus on one of the debates with the FAA among the members of the Takeoff and Landing Performance Advisory Rulemaking Committee in 2006: how to make a transition from an ILS glide slope to a 1500 foot touchdown point? The end consensus in the Committee was that, aside from Category III landings, all landings are essentially visual approaches. Any electronic glide path merely serves to get an aircraft to a point where a visual approach can be made. With careful avoidance of any association with phrases like "duck under," the consensus among the industry and FAA was that pilot training and techniques would take over to ensure the flare to touchdown occurred by the desired distance. For carrier operations, the mere thought of placing the entire ship's safety in the hands of pilot technique and training would be perceived as reckless. Lessons written in blood from years past have taught carrier aviators that only the most robust quality assurance process yields acceptable risk tolerances.

For the civilian airline pilot, this aircraft capability, airport capability, and level of oversight for each landing are simply not present. The visual glideslopes make no discrimination between a 757 and a regional jet. There is no wire to catch, only the friction available from the runway to stop the plane, often during changing conditions. Crosswinds can make pinpoint touchdowns difficult, and there is no one standing by the side of the runway to radio the pilot to go around should his touchdown point unexpectedly stray from planned parameters. In practicality, it is nearly impossible to achieve one hundred percent compliance with all the parameters required.

The point is that while the factors leading to a successful landing are essentially the same for the carrier approach as they are to the civilian field, the latter occurs in a virtual desert of safety management and safety assurance procedures when compared to carrier operations. While a touchdown from a specific glide path to a specific point at a specific energy state on a specific surface can be accomplished, it can never be assured.

It can never be assured unless there is a process in place to make sure that little is left to chance. In the US Navy, the operational support used to ensure the flight path of aircraft is enormously expensive and far from cost effective when compared to their civilian counterparts. Civilian aviation certification standards and established operating procedures prohibit the kinds of risk avoidance processes needed to ensure the level of quality control a carrier approach enjoys. The result is that all civilian landings must by definition carry a far greater degree of the unknown, the random, and even the improbable, than their sea based counterparts. Furthermore, such randomness has the capacity to cause drastic variations in performance. Therefore, any true approach to safety must address not only what we wish others to know, but also the limits on our knowledge and capabilities as well. Even our efforts on Cockpit Resource Management seem fairly shallow when compared to three specially trained and experienced pilots (LSO's) whose job is to specifically capture errors in plan continuation bias, perception based errors, and unforeseen events.

All the above discussions take for granted the fact that an airplane remains the same in every landing. For those of us who are professional pilots however, it is well known that this is not always the case. The modern cockpit is in the process of evolving and changing, and so are the procedures that surround it. Analog instruments have given way to flat panel displays, ground based navigation is now giving way to space based technologies, and the relationship between automation and flight is has steadily grown to place itself between the pilot and his/her aircraft. The result is a process of continuous change that itself can produce an environment for unexpected errors both while on approach and during landing.

A runway overrun must therefore be considered another example of a "Black Swan" event. While every incident may be explainable through hindsight, the existence of runway overrun incidents will forever remain unpredictable and carry great consequence. The conditions under which civil aviation operates dictate that uncertainty will forever play a role in the visual approach and the possibility of severe consequences will never be eliminated.

5. CONCLUSION

I do not wish to propose that we should ever stop trying to improve the odds in preventing landing overruns. There are still improvements in training, cockpit design, and pavement management that can be made. What is important is that the risks involved in aviation should be taken with our eyes open to the unpredictability inherent in the activity itself. To this end, there are some areas where our efforts should continue to be focused on. Here are my recommendations for improving safety in this area:

1. Runway Safety Areas will always remain vital to public safety. All runways need some form of arrestment condition beyond the paved surface. Such an arrestment could be a grassy overrun or other unprepared surface. However, if a hazard exists in this area, or if the area's length is less than 1000 feet, the risk (or hazard) should be mitigated through some effort such as an EMAS bed.
2. A standardized touchdown point (1500 feet) should be established as a clearly marked and lighted reference position on all runways servicing turbine-powered traffic.
3. Standardized training for touchdown point control should be explicitly delineated in training manuals, taught on the line by check airmen, and practiced in the simulator during normal training cycles.

4. Approval criteria for ground based friction measurement devices should articulate accuracy and repeatability standards for common surfaces so that all devices read the same value for the same surface. In addition all operators should meet standardized training requirements for the use of such devices if their readings are to be reported to aircrews.
5. All aircraft should be equipped with a cockpit readout indicating actual braking performance during landings.

While these efforts will not totally eliminate the chance of landing accidents, I strongly believe that targeting the problem of reducing chance deviations while recognizing the existence of unpredictability as a fundamental constant in safety management, is essential. Only by changing current views to embrace the thought that uncertainty can never truly be eliminated, can we achieve the necessary levels of risk reduction.

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EFFECTS OF AIRLINES' CABIN CREW TRAINING ON THEIR FLIGHT SAFETY PERFORMANCE

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ABSTRACT

This study examines the impact of airlines' cabin crew training on their flight safety performance, and evaluates the effectiveness of the cabin crew's emergency evacuation training, in order to better understand whether their training performance affects airlines flight safety in practice. Kirkpatrick's four-level training performance assessment method is used as the basis of this study, while factor analysis, *t*-test, ANOVA and SEM (Structural Equation Modelling) are used for data analysis. Most respondents agree that the training content can be clearly learned without language barriers if the airlines use domestic instructors. In addition, most respondents felt that airlines should improve the frequency with which they update the training material and that more practical drills and line training should be added to training syllabus, especially with regard to emergency evacuations. SEM method is used to assess the relationships among the training syllabus, skills learning, operational performance and flight safety performance. The results show that the training syllabus positively affects skills-learning, skills-learning positively affects operational performance and flight safety performance, and operational performance directly affects flight safety performance.

Keywords: Airline, cabin crew, training, flight safety performance, emergency evacuation

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1. INTRODUCTION

On August 2, 2005, an Air France Airbus flight 358 veered off the runway in landing and ended up in a ditch next to the runway, leading to an engine fire and the whole airplane eventually caught on fire. Fortunately, all 309 people on board were evacuated safely within four minutes, although investigators later found that only four out of the eight emergency exits were open, and only two emergency slides were deployed. The emergency evacuation procedures that were followed for Air France Flight 358 have been widely used as important training materials with regard to in cabin flight safety (Airway, 2005).

This example indicates that good emergency evacuation and safety training of the cabin crew play a critical role in the survival of passengers, even though this particular evacuation process did not comply with the FAR Part 25, Section 803 regulation, which states that for an airplane with over 44 passengers, all passengers must be evacuated within 90 seconds (FAA, 1990).

Tracy Jen (2006) stated that the purpose of cabin crew training is to achieve the most effective implementation of the given procedures, to assist crewmembers in avoiding errors, to improve efficiency, and to motivate other crewmembers to improve their overall performance. Only appropriate training will enable the crew members to have effective emergency response ability and to undertake improved communication, so that if an emergency situation occurs, they can work to ensure the survival of passengers. Thus, the definition of successful cabin safety training is the degree of improvement in cabin crewmembers situational awareness, emergency responses, and communication.

2.1. Education and Training of Cabin Crew

According to Article 171 of Taiwan’s Civil Aviation Flight Operation Regulations (CAA, 2008), “The airline operator shall have a cabin crew training plan. The cabin crew can officially perform their duty only after the completion of their training; and in order to maintain the familiarity of the emergency equipment and their duties during emergency evacuation, the cabin crew shall have recurrent training ever year after.”

In order to improve service quality and to ensure flight safety, operators should subject newly hired cabin crew to a program of rigorous training. In addition to a brief introduction of the company’s operations and objectives, cabin crew training in Taiwan can also include the following two areas:

1. Ground school training syllabus. A ground school syllabus contains the basic training of the cabin crewmembers. The duration of training varies from operator to operator, but generally lasts for three months, and covers the following subjects:
    - Emergency Escape Training: The curriculum should include the introduction of the exit door and emergency equipment operating procedures, life jacket demonstration, CPR and swimming. Some operators have simulators to provide more realistic situation training in sea and land emergency escapes, cases of fire and so on.
    - Safety Training and Medical Emergency Training: Safety training includes the cabin crewmember’s Crew Resources Management (CRM), as well as dealing with hi-jacking, explosives, dangerous goods, and unruly passengers, and medical emergency training courses such as CPR and first aid.
    - Service, Language, and Deportment Trainings: Service training covers service procedures and techniques, wine and cocktail mixing, and preparing special meals. Language training includes Mandarin and English announcement (some companies even including Japanese and Taiwanese), conversational

English, Taiwanese, and Japanese. Deportment training includes personal dress, hairstyle, make-up techniques, and dealing with passengers.

2. Flight Training. After passing the ground school training, in order to fully understand the service procedure, and improve situational responses and handling in an actual flight, the students must undergo real flight training. Flight training typically requires one to three months and tests are conducted after its completion. If the trainee does not meet the required standard of training items, then they are not accepted for employment. The cabin crew who pass the test must undergo recurrent training at least once every year, with a focus on emergency escape drills and safety training.

This paper will emphasize the crew training related to flight safety, such as emergency escapes, while other training items, such as service, language, medical, and deportment, will not be discussed in this paper.

2.2. Principles in Training Performance Assessment

Performance assessment is the final step in a training process, and it provides feedback that can be used to improve training method. This paper utilizes Kirkpatrick's (1959a, 1959b, 1960a, 1960b, 1979, 1985) four-level training assessment model as explained below, which is perhaps the most widely accepted approach for training program evaluation (Alliger and Janak,1989).

- Reaction: This is defined as trainee's feeling towards the training method and procedure. Responses from trainees at the end of the training will be measured, including their assessments of the instructor, content, training material, and training methods.
- Learning: This is defined as the trainee's understanding and absorption of the training

principles, factual materials, and techniques.

- Behaviour: This is defined as the application of the training principles and techniques, and it measures the effectiveness of trainee's conduct when working in the real working environment.
- Result: This is defined as the results achieve in relation to the required goals. Its main purpose is to present the results from the training development, and to assess the effectiveness of training with regard to improving the performance of an organization.

3. METHODOLOGY

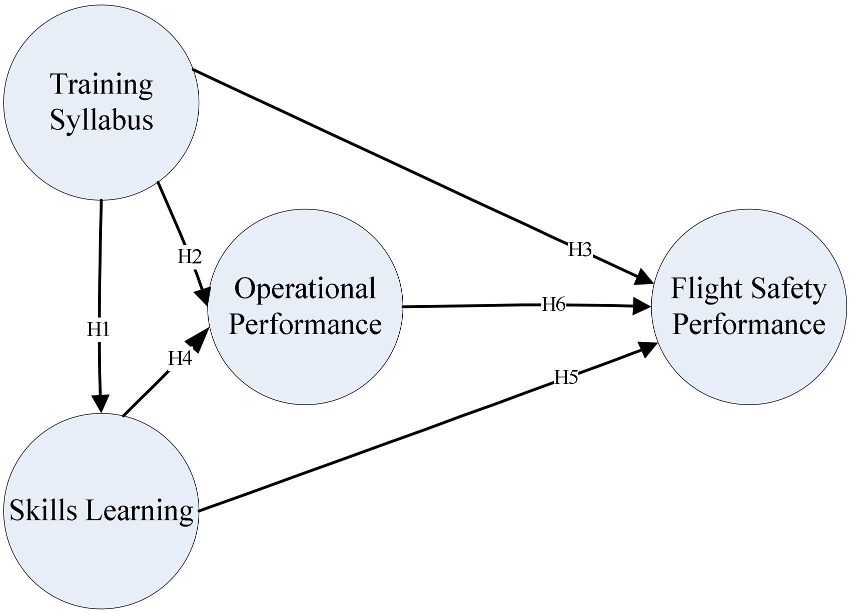
3.1 Structure of the Research

Based on the references mentioned in the previous sections, as well as the goal of this paper, the structure of this work is shown in Figure. 1. By following Kirkpatrick's (1959) four-level training performance assessment model, the reaction level is re-named as the training syllabus, the learning level as skills learning, the behaviour level as operational performance, and the result level as flight safety performance. The resulting structural model is used to assess the effects of cabin crew training on flight safety performance. In addition, the demographic backgrounds of the crewmembers are also considered to see if they have any significant effects. It is expected that the results of the analysis presented in this paper can be used as reference to improve airlines' training programs. The hypotheses are as follows:

- Hypothesis 1: A training syllabus has a positive effect on skills learning (Kirkpatrick, 1959; Dean, 1999).
- Hypothesis 2: A training syllabus has a positive effect on operational performance (Kirkpatrick, 1959; Dean, 1999).
- Hypothesis 3: A training syllabus has a positive effect on flight safety (Kirkpatrick, 1959; Dean, 1999).

- Hypothesis 4: Skills-learning has a positive effect on operational performance (Kirkpatrick, 1959; Dean, 1999).
- Hypothesis 5: Skills-learning has a positive effect on flight safety performance (Kirkpatrick, 1959; Dean, 1999).
- Hypothesis 6: Operational performance has a positive effect on flight safety performance (Kirkpatrick, 1959; Dean, 1999).

Figure 1: The Research Model



3.2 Design of the Questionnaires

Based on literature review and expert opinions, a drafted questionnaire was completed, and feedback was then obtained from operators and experts. After several rounds of corrections, the final questionnaire was completed, containing 45 items. A five-point Likert scale was used to assess the importance of each item, with 1 as the least important and 5 as the most important. The questionnaires were then sent to the flight service departments of Taiwan's domestic airlines for distribution to cabin crewmembers.

3.3 Data Analysis

This research utilized the basic descriptive statistics to gather the respondents' opinion about their training performance and self-evaluation of their flight safety performance. We used factor Analyses methods to identify a smaller set of dimensions, or factors related to training performance and flight safety performance. The Cronbach's alpha-value reliability analysis was used to evaluate the content of the questionnaires, and the ANOVA method was used to assess differences in respondents' demographic backgrounds. Finally, SEM was used to summarize the overall effects of training performance on flight safety.

4. RESULTS

4.1 Sample and Population

The received questionnaires were analysed using STATISTICA 6.0, SPSS 10.0 and AMOS 5.0. The questionnaires were sent to a domestic airline on Jan. 15, 2007, and returned on Feb. 26 of the same year. A total of 1,000 questionnaires were sent with 225 returned. After eliminating 17 responses due to incompleteness, there was a valid return rate of 20.8%.

The questionnaires include items on the respondents' gender, age, and years of employment, educational level, and job classification. Out of the 208 valid responses, 168 were females (80.8%), 38% aged 31-35 and 33.7% over 35. Years of employment ranged from 35.6% for 7-9 years and 44.7% for over 9 years, 13% between 4-6 years, and 6.7% under 3 years. Overall, 80.3% of the respondents had over 7 years of employment, which indicates most of them went through multiple training classes. With regard to the educational level, 61.1% of the respondents had college degrees, 36.1% had been to vocational schools, and 2.9 % with degrees higher than college level. One interesting note is that over 50% of the responses were from more senior crewmembers, which added to the credibility of this research.

4.2 Descriptive Analysis of Cabin Crew Training Performance and Flight Safety

4.2.1. Training Syllabus

In general, the feedback agrees with the importance of the training syllabus (agreement index ranges from 4.27 to 3.58). The total mean of the training syllabus items is 3.79, of which "the practical training is one of the best training methods" and "line training can improve my understanding of my job" received the highest marks of agreement (both over 4). Thus, it is important for airline operators to consider both practical and line trainings when designing the training syllabus.

The training syllabus items with the lower scores are as follows: "my understanding of the English instructions used by the foreign instructors", "my understanding that the training material is often updated", "I am satisfied with the company's training method", and "my satisfaction with the content of company's training material". The scores for all these items are below 3.7, which indicates that the respondents' satisfaction with the content and arrangement of the training was low. It is thus suggested that the airlines should revise the design and arrangement of their training courses. In particular, the respondents stated that it was especially difficult to understand content that was not delivered in their native language. Because English ability is the recognized international aviation language, its proficiency is very important in commercial aviation related works. Although Taiwan airlines have set up minimum requirement of English ability (TOEIC 550) to recruit new cabin crew, this result implies that the cabin crew's foreign language ability is not sufficient. The suggested solution is to increase the English requirements, including speaking, listening and reading ability.

4.2.2. Skills Training

The survey's results indicate that the respondents were generally satisfied with the items in this category, and the scores range from 4.24 to 3.55. The total mean of skills training is 3.88, and the items with higher scores are: “I can correctly operate the emergency exit door and equipment after training”, “the training improves my understanding of emergency evacuation procedures”, “the training improves my ability to accurately follow the emergency evacuation SOP”, “the training improves my understanding of the basic knowledge of the airplane”, and “the training improves my overall professional skill”.

The items with the lower score questionnaires are: “I can effectively handle medical emergencies after training”, and “I am better at controlling my emotions after training”. Both of which had scores lower than 3.7. It is thus suggested that airlines should improve their training in handling medical emergencies and emotion control techniques. Another solution to solve this problem is to give priority to recruit cabin crew with medical background.

4.2.3. Operational Performance

Generally speaking, the results indicate the respondents' positive attitude towards operational performance, with the scores ranging from 4.4 to 3.58. The total mean of operational performance is 3.94, and the higher rated items are: “trust among crewmembers is important”, “the SOP makes it easy for me to effectively do my job”, and “the debriefing during shift changes is important to the management of a team”.

The items with the lower scores are: “I will proactively question my doubts about some of the items in the SOP”, and “I will voice my opinion when other crewmembers do not follow the SOP”, with both scores are less than 3.7. This result indicates the crewmembers will not voluntarily voice their opinion on the SOP, nor they will openly correct their colleagues when the SOP procedures were violated. These results are most likely related to safety culture. The airlines should thus establish an anonymous voluntary reporting system and encourage their employee to speak up in order to mitigate this problem. However, it is difficult to be effective without trust between upper management level and employees.

4.2.4. Flight Safety Performance

Positive responses were obtained in the category of flight safety performance as indicated by the range scores of 4.14 to 3.47. The total mean of flight safety is 3.80. Among the related items are: "I will ask my colleagues when I have questions during a flight", "better communication is achieved among domestic crewmembers", and "my emergency response capability has improved because of the training", all have scores higher than 4.0.

The items with the lower scores are: "my decision making ability will not be affected because of emergencies", "communication with expatriate crewmembers has improved after training", and "my understanding of the expatriate crewmembers seldom results in mistakes", and all of these had scores of less than 3.7. This result indicates that the current training does not improve the crewmembers' decision-making and communication abilities. It is thus suggested that airlines should improve the communication and decision-making skills training in the design of their future training courses.

4.3 Factor Analysis

The Kaiser-Meyer-Olkin (KMO) overall Measure of Sampling Adequacy (MSA) was used to determine the appropriateness of using factor analysis. KMO values above 0.50 for the factor matrix indicate that using factor analysis is appropriate (Hair et al., 1995); the KMO value for the present study was 0.783~0.887 (Table 1). The factor analysis employs the principal component analysis method. The eigenvalues suggested that three-factor solution explained

65.273% of the total variance for training syllabus construct, four-factor solution explained 73.152% of the total variance for skills learning construct, two-factor solution explained respectively 62.477%, 55.539% of the total variance for operational performance and flight safety performance construct.

All factors with eigenvalues greater than 1.0 and a factor loading of 0.5 or greater (Norusis, 1985) were retained for analysis. Cronbach's alpha was calculated to test the reliability of each factor. The alpha coefficients for all factors ranged from 0.606~0.915, above the minimum reliability value of 0.6 (Fornell and Lacker, 1981). The three factors were labelled factor 1: Training content, factor 2: Capability of instructors and factor 3: Training method for training syllabus construct. The four factors were labelled factor 1: Work attitude, factor 2: Professional capability, factor 3: Emergency handling and factor 4: Knowledge for skills learning construct. The two factors were labelled factor 1: Following procedure and factor 2: Team work for operational performance construct, and the two factors were labelled factor 1: Communication and factor 2: Decision making in emergency for flight safety performance construct.

Table 1: Factor Analysis of the Training Syllabus, Skills Learning, Operational Performance and Flight Safety Performance

Construct	Factor	Eigenvalue	Cronbach's Alpha	% of variance	KMO
Training syllabus				65.273	0.887
	Factor 1 Training content	4.909	0.866		
	Factor 2 Capability of instructors	1.231	0.878		
	Factor 3 Training method	1.040	0.625		
Skills learning				73.152	0.898
	Factor1 Work attitude	7.811	0.915		
	Factor2 Professional capability	1.596	0.854		
	Factor3 Emergency handling	1.256	0.845		
	Factor4 Knowledge	1.041	0.764		
Operational performance				62.477	0.822
	Factor1 Following procedure	2.747	0.753		
	Factor2 Team work	1.001	0.606		
Flight safety performance				55.539	0.783
	Factor1 Communication	3.385	0.729		
	Factor2 Decision making in emergency	1.058	0.630		

4.4 The T-Test and ANOVA Analysis between Sample Characteristics and Factors

This paper utilizes a *t*-test and ANOVA to analyse any significant differences between different sample characteristics and the training, performance and flight safety. The results are given in Table 2. Using *t*-test analysis, significant differences between gender groups were found in the case of Factor2, Decision making in emergency of flight safety performance. We found that male respondents rated their decision making in emergencies as better than the females respondents.

The significant differences between age groups were found in work attitude, emergency handling and knowledge of skills learning construct. The following procedure factor of operational performance construct, communication factor and decision making in emergency factor of flight safety performance construct are also found to have significant differences related to age. The agreement about those factors is higher for those with age 35 and older. A probable explanation of this finding is that the elder cabin crew are more experienced in their job, so generally, they are more recognize the effectiveness of training which may improve their skills learning, operational performance and flight safety performance.

The significant differences between work experience groups were factor capability of instructors, work attitude, following procedure and decision making in emergency. There is a distinct difference in the opinion of the respondents about the instructor's capability for those cabin crew with less than 3 years of experience as compared to those with more than 3 years. The junior cabin crew's English ability and professionalism are usually not as good as senior ones. Therefore, they are more agreeable and dependent on the importance of capability of instructors during training courses.

In work attitude of the skills leaning factor, there is a distinct difference between those respondents with 7 to 9 years of work experience and those with over 9 years. In following procedure category of the operational performance factor, those respondents with over 9 years of experience gave very different responses to those with less than 3 year and 4 to 6 years work experience. In the emergency decision making category of the flight safety performance factor, those with over 9 years work experience gave very different responses to those with 4 to 6 years of experience. These results imply that the more senior crew members have better work attitude, following procedure, and better decision making ability in emergency since they are more experiences in this field.

Table 2: *t*-test and ANOVA results between Sample Characteristics and Factors

	Gender	Age	Work experience	Education	Job level
	Male (a)	20-25 yrs old (a)	<=3 yrs (a)	College (a)	Purser (a)
	Female (b)	26-30 yrs old (b)	4 -6 yrs (b)	University (b)	Subordinate Purser (b)
		31-35 yrs old (c)	7 -9 yrs (c)	Graduate school (c)	Senior cabin crew (c)
		> 35 yrs old (d)	> = 9 yrs (d)		Cabin crew (d)
Training syllable					
Factor 1 Training content	0.055	0.237	0.374	8.887**a>c,b>c†	0.756
Factor 2 Capability of instructors	0.053	1.804	2.779* a>b,a>c,a>d†	2.597	2.927*a>b†
Factor 3 Training method	0.004	1.261	0.969	0.525	2.118
Skills learning					
Factor1 Work attitude	0.082	4.704** d>c†	2.933* d>c†	3.736*a>c,b>c†	0.603
Factor2 Professional capability	1.073	1.768	1.764	1.049	0.722
Factor3 Emergency handling	0.774	4.182** d>a†	1.706	0.040	1.785
Factor4 Knowledge	0.768	3.302* d>a†	2.256	1.033	0.931
Operational performance					
Factor1 Following procedure	1.208	10.532** d>a, d>b, d>c†	6.389* d>a,d>b†	1.835	7.149**a>d,a>c,b>d†
Factor2 Team work	1.495	1.427	2.526	1.289	1.406
Flight safety performance					
Factor1 Communication	2.728	3.979** d>c†	0.582	2.148	1.938
Factor2 Decision making in emergency	6.023* a>b†	5.448** d>a,d>b,d>c†	2.659* d>b †	1.164	3.701*a>d,a>c†

* p<0.05; ** p<0.01; † Scheffe P post-hoc analysis results

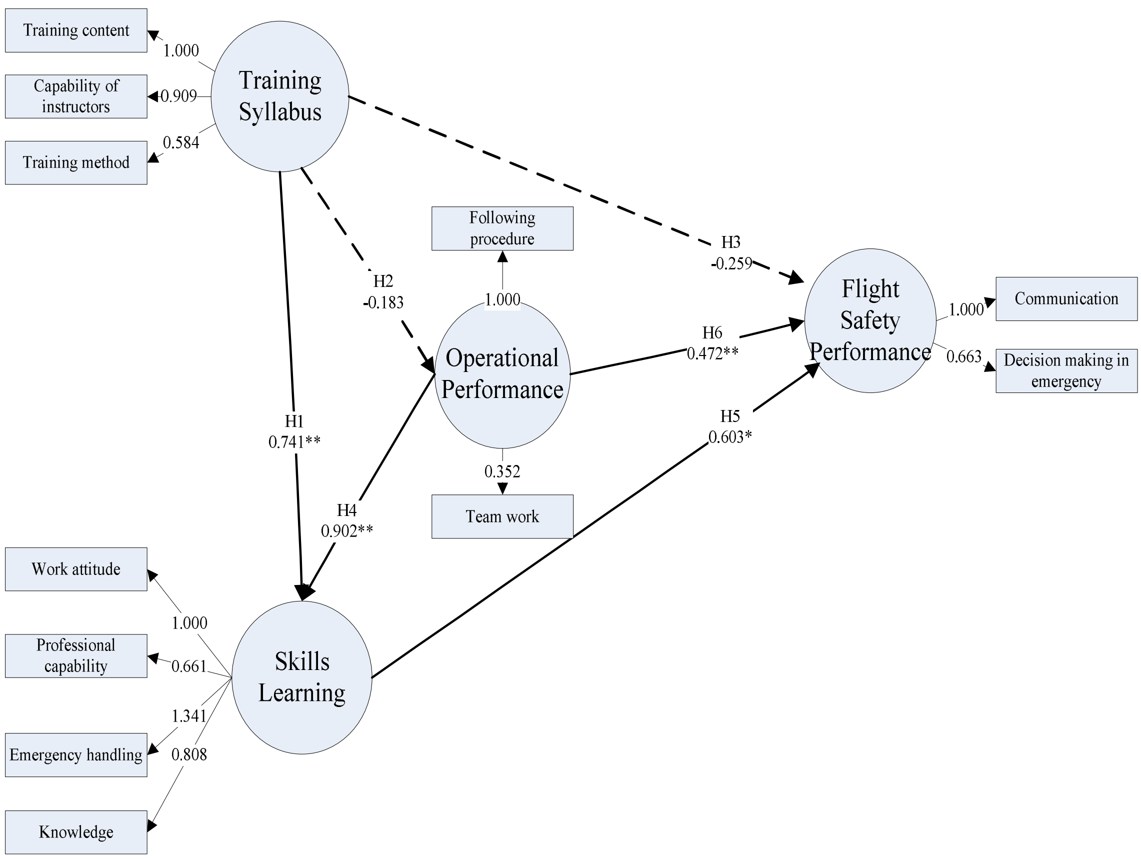
In the category of training content and work attitude category of skills learning, there is a distinct difference between those respondents who have graduate school degree and those who did not. In training content, the score is higher for college graduates and in work attitude the score is highest for those with less than a college education.

There are significant differences between job level groups in the factors of capability of instructors, and following procedure and decision making in emergency. There is a distinct difference between the pursers and their subordinates in the factor of capability of instructors, as the pursers show higher agreement. Similar results for the items related to following procedure in the conduct behaviour factor, there is a distinct difference between pursers and their subordinates, with the former have the highest scores. In emergency decision making factor of the flight safety performance construct, there is a distinct difference between pursers, subordinates purser and senior cabin crew. These findings imply that senior pursers are more recognize the effectiveness of cabin crew training, especially on the factor of following procedure and decision making in emergency.

4.5 SEM Analysis

The proposed model was tested by using the following four construct: training syllabus, skills learning, operational performance and flight safety performance. The three factors “Training content”, “Capability of instructors” and “Training method” were used as the measurement variables of training syllable. The four factors “Work attitude”, “Professional capability”, “Emergency handling” and “Knowledge” were used as the measurement variables of skills learning. The two factors “Following procedure” and “Team work” were used as the measurement variables of operational performance. In addition, the two factors “Communication” and “Decision making in emergencies” were the measurement variables for flight safety performance. After the completion of the model (Figure 1), AMOS software was used for the SEM analysis to examine the relationships between each pair of hypothesized constructs. The results of the hypotheses testing indicated a good fit between the model and observed data in Table 3. The overall fit indices of the measurement model were as follows: the χ^2/df ratio of model was 1.3333, p = 0.0898, Goodness of Fit Index (GFI) = 0.96, Adjusted Goodness of Fit Index (AGFI) = 0.93, Comparative Fit Index (CFI) = 0.98, Normed Fit Index (NFI) = 0.95, Root Mean Square Error of Residual (RMR) = 0.016, and Root Mean Square Error of Approximation (RMSEA) = 0.04. One can see the model fit all eight-conformance indices, indicating the overall conformance of the research is consistent.

Figure 2: The Structural Model



The results of the analysis show that the training syllabus has a significantly positive effect on skills learning (estimate=0.741, $p < 0.001$). Skills learning has a significantly positive effect on operational performance and flight safety (estimate=0.902, $p < 0.001$; estimate=0.603, $p < 0.01$). Finally, operational performance also has a significantly positive effect on flight safety (estimate=0.472, $p < 0.001$) (see Table 3) Therefore, the hypothesized model fits the empirical data, and H1, H4, H5, and H6 are supported. However, H2 and H3, that the training syllabus has a positive effect on operational performance and flight safety performance, were not supported due to the insignificance of estimated coefficients of –0,184 and -0.259 ($p > 0.05$), respectively.

Table 3: Structural Model Results

Relationship	Estimates		Hypotheses testing
H1 Training syllabus → Skills learning	0.741	**	Supported
H2 Training syllabus → Operational performance	-0.184		Not Supported
H3 Training syllabus → Flight safety performance	-0.259		Not Supported
H4 Skills learning → Operational performance	0.902	**	Supported
H5 Skills learning → Flight safety performance	0.603	*	Supported
H6 Operational performance → Flight safety performance	0.472	**	Supported
Goodness of fit indices of model	**Criteria**		**Indicators**
χ^2/d.f	< 2		1.3333
p- value	> 0.05		0.0898
Fit indices			
GFI	> 0.9		0.96
AGFI	> 0.9		0.93
CFI	> 0.9		0.98
NFI	> 0.9		0.95
RMR	< 0.05		0.016
RMSEA	< 0.05		0.04

*p<0.01,**p<0.001

5. DISCUSSION

5.1 The Results of Descriptive Analysis

It is generally agreed by the surveyed cabin crewmembers that practical drills and line training will make the training performance better with respect to the emergency evacuation and safety trainings. With regard to the training contents, the result indicates that the frequency of updating the training material is inadequate when compared to the other items in the questionnaire. The results from the factor analysis also indicate that the training content, instructors' capability, and training methods are the three most important factors in the design of an the airline training course.

The cabin crewmembers considered that their work related knowledge, attitude, and skills have improved after training. It was generally agreed by the respondents that training improves the crew's basic knowledge of the airplane, and enables them to have a better understanding and execution of the SOP during emergencies, and better handling of on-board emergency equipment. However, the crewmembers considered the training were less effective in the improvement of work attitude. In general, the formation of attitude is something cultivated in a complex, long-term process (Fabrigar et al., 2006), more related to how people value life (Debono, 1987; Homer and Kahle, 1988) and a reflection of personality (Ulleberg and Rundmo, 2003). Therefore, the cabin crew's respondent in the present study is understandable. Also, the crewmembers considered that both teamwork and following the SOP are important and the results show that they tend to trust each other and follow the SOP. However, when they have doubts about the SOP, or if the other crewmembers do not adhere to the SOP, they would not proactively ask questions or raise their concerns. This situation is typical related to Chinese culture and worth to further research to this area.

5.2 Effect of Personnel Characteristics

The results indicated that male cabin crew had more confidence in their emergency decision making in the category of flight safety performance. In addition, the male cabin crew considered that the training definitely improved their decision-making abilities.

Those crewmembers aged 35 and older had better responses with regard to work attitude, emergency handling, and knowledge in skills learning, following procedure of the operational performance factor, and communication and emergency decision making in the flight safety factor. This indicates that the older cabin crewmembers considered that the training can definitely improve their work attitude. After receiving several recurrent trainings, it can be expected that such employees would possess more professional knowledge and emergency handling capabilities. Besides, their understanding and practical application of the SOP, can also be expected to be better than those of their younger colleagues. For the cabin crew with less than 3 years of work experience, their responses for the instructors' capabilities were higher in the training syllabus factor. This result indicates that the company is likely to provide better instructors for newcomers.

Positive responses were obtained from those employees with more than 9 years of work experience, with regard to skills learning in the work attitude factor, following procedures in the operational performance factor, and emergency decision making in the flight safety factor. This indicates that the longer an employee has been working for an airline, the more positive their work attitude are as well as the better their understanding and execution of the SOP.

The cabin crewmembers with graduate school education were less positive with regard to the training contents of the training content factor, and work attitude in the skills learning factor.

This result indicates that those crewmembers with higher education levels demanded more with regard to the substance of the training materials and courses. They considered that the training was not very effective in improving their work attitude.

Pursers had more positive views of the instructors' capabilities with regard to the training content, following procedure of the operational performance factor, and emergency decision making in the flight safety factor. This result indicates that when a crewmember reaches higher level in the company, in order to be a role model to their colleagues, they tend to view the qualifications of the instructors more positively, and follow the SOP more faithfully. Further, they also agree more strongly that the training would improve their emergency decision making.

5.3 SEM Results

The SEM results show that the training syllabus does not positively affect operational and flight safety performance. Previous analysis indicated that frequently updating the training material is essential for cabin safety training. Therefore, outdated training content could cause the training syllabus to become less effective with regard to operational performance and flight safety performance. The results also show that the instructors who speak the same language as the crewmembers are more capable of providing training that improves the operational performance and emergency decision making in cabin safety related factors. These findings may explain why the results showed no support for the training syllabus's positive effect on performance and flight safety.

6. CONCLUSION AND RECOMMENDATIONS

This paper examined the effects of airline cabin crew training on their flight safety performance. The results indicate that airlines should improve the frequency of updating the training material so that the crewmembers can obtain the most up-to-date flight safety information. More practical drills and line training should be added to the training syllabus as it can make the crew become more familiar with the exit door operations and emergency equipment. The airlines may also consider use domestic instructors so that the crewmembers can clearly learn and understand safety information and professional skills without language barriers. On the other hand, how to improve their cabin crew's English ability, especially junior one, is also essential in the improvement of their knowledge.

This research only examined the emergency evacuation and flight safety trainings of the cabin crew, and it is recommended that follow up research should be done in medical and language trainings to uncover those influential factors, and that a review of the literature be conducted to find other influence factors.

Lastly, the culture aspect in flight safety is suggested for future research since safety is related to more than just technical area, but also strongly affected by the culture of different regions.

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LINGUISTIC ANALYSIS OF ENGLISH PHRASEOLOGY AND PLAIN LANGUAGE IN AIR-GROUND COMMUNICATIONS

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ABSTRACT

The aim of this paper is to describe the different uses of English phraseology and plain language within pilot-controller (or air-ground) communications via a comparative study between two collections of texts (*corpora*): one representing the prescribed norm and made up of examples of English from two phraseology manuals; the other consisting of the orthographic transcription of recordings of real air-ground communications. The comparative study is conducted at a lexical level. It focuses on the discrepancies observed in the distribution of the corpora lexicon. Our preliminary results indicate that, in real air-ground communications, pilots and controllers tend to use more "subjectivity" markers (pronouns, courtesy expressions) than prescribed by the linguistic norm. This observation reflects their needs to use the language in its social role. A description of the different markers introducing subjectivity in air-ground communication can help understand the use of a more natural language in radiotelephony. In the long run, the results from the comparative study can be used to improve English radiotelephony teaching.

Keywords: Air Traffic Control, Language for Specific Purposes (LSP), Corpora, Linguistic Comparative Analysis

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1. INTRODUCTION

In some professional contexts, accomplishing a very specific task can entirely depend on verbal communication between experts of a given field: being able to communicate is for these experts a necessity for sharing and transferring the specialised knowledge required to fulfil their job. When these communication-dependent situations are recurrent enough, linguistic norms can be created by institutions and authorities, who then enforce them. The aim of these linguistic norms is usually to create less ambiguous communication thanks to simplified rules (at a syntactic, lexical and semantic level for instance). The linguistic normalisation also enables the various interlocutors to minimise their linguistic and cognitive efforts in carrying out the task at hand thanks to their shared knowledge (Falzon, 1986). The use of natural language, on the other hand, would not be efficient enough to express this common knowledge and could easily lead to rough estimation, misunderstanding and incomprehension (Vergely, 2008).

The domain of air traffic control offers an instructive example of such an established linguistic norm: that of *phraseology*, the specialised language used by pilots and controllers to conduct what is intended to be unambiguous and effective radiotelephony communications. One should actually talk about *phraseologies* since civil aviation uses six official languages[6] in which phraseologies are employed. It is generally in English – used as a *lingua franca* (Crystal, 2003; Seidlhofer, 2005) – that international flights are dealt with: it allows dialogue between a controller and a pilot who do not necessarily share the same first language. For instance, an aircraft flying in French controlled airspace can receive control services in French or in English, depending on the pilot's first language. The ICAO's Annex 10 volume 2 (2001) explicitly confirms the function of English as the common language of aeronautical aviation:

> *Air-ground radiotelephony communications shall be conducted in the language normally used by the station on the ground or in the English language (5.2.1.2.1).*
>
> *The English language shall be available, on request from any aircraft station, at all stations on the ground serving designated airports and routes used by international air services (5.2.1.2.2).*

[6] The six official languages of civil aviation are English, French, Spanish, Russian, Chinese and Arabic.

English phraseology and the different uses made of it are at the core of our study, conducted within Lopez's doctoral research project. This project has been initiated by the French Civil Aviation University (ENAC), in collaboration with the linguistics research institute CLLE-ERSS (*Cognition, Langues, Langage, Ergonomie - Équipe de Recherche en Syntaxe et Sémantique*), in order to try and meet some of the ENAC's specific needs in terms of English radiotelephony teaching[7]. The aim of this research project is to draw up a panorama of the different types of usages made of the English language by French controllers and pilots from all over the world in radiotelephony communications and bring their differences and similarities to light. The method of analysis consists of a comparative study between two *corpora* (see section 4): one representing the prescribed norm and the other representing the real usages made of it. A *corpus* can be defined, in linguistics, as a large collection of texts or utterances gathered in electronic form according to a specific organisation and set of criteria in order to serve as a data-base for linguistic descriptions and analyses (Bowker & Pearson, 2002; Sinclair, 1991).

In this paper, we aim at presenting to what extent some usages of English by pilots and controllers in real air-ground communications can differ from the prescribed norm by the presence of markers of a subjective individual speaker. To do so, we first introduce the specialised languages used in radiotelephony (sections 2 & 3). We then present the two corpora under study (section 4). Finally, we introduce various comparisons between these two corpora as well as some preliminary results (section 5).

2. ENGLISH PHRASEOLOGY

In air traffic control, air-ground communication is mainly performed using a specialised or operative[8] language known as *phraseology*. It was created and has been continually up-dated by the International Civil Aviation Organisation to cover the most common and ordinary situations encountered in air navigation in order to optimise and ensure safety in radiotelephony: "the purpose of phraseologies is to provide clear, concise, unambiguous language to communicate messages of a routine nature" (ICAO, 2010: 1.1.3). Phraseology and the messages that employ it are therefore subject to simplified but strict syntactic,

[7] The ENAC (*École Nationale de l'Aviation Civile*) is in charge of the English training for France's air traffic controllers and pilots and has therefore to comply with ICAO language proficiency requirements.
[8] We use the same term as Falzon (1986), who prefers it to "specialised language" to refer to languages shaped by the type of knowledge peculiar to a specific activity, i.e. by "operative knowledge".

lexical, semantic and phonetic rules. The following examples, extracted from our reference corpus (see section 4), give an idea of what phraseology looks like:

(a) *P: golf charlie delta, request Right turn when airborne.*[9]
C: golf charlie delta, Right turn approved, runway 0 6 cleared for take-off.
P: runway 0 6 cleared for take-off, Right turn, golf charlie delta.

(b) *C: Citron Air 3 2 4 5, multidirectional departure runway 2 8, at 800 feet turn Right heading 3 1 0, climb 3000 feet QNH.*
P: multidirectional departure runway 2 8, at 800 feet turning Right heading 3 1 0, climb 3000 feet QNH, Citron Air 3 2 4 5.

(c) *P: Blagnac Tower, good morning, foxtrot bravo x-ray.*
C: foxtrot bravo x-ray, good morning, pass your message.
P: foxtrot bravo golf bravo x-ray, PA28, VFR from Albi to Blagnac for touch-and-go, Agen next, 1500 feet, echo time 1 0 0 5, with information India. Requesting joining instructions.
C: foxtrot bravo x-ray, roger, report echo.
P: will report echo, foxtrot bravo x-ray.

Phraseology's specific and very particular characteristics – which make it obscure for everyone but experts – have been previously described as (DGAC, 2007; Mell, 1992; Philps, 1989, 1991; Rubenbauer, 2009):

- The omnipresence of the imperative form in the controller's messages (due to his role as an administrator who provides pilots with manoeuvre instructions and authorisations):
  e.g. "*turn Right*" and "*climb 3000 feet*" in example (b) above, "*report echo*" in (c), etc. – rather than "*we would like to turn*", "*you should climb*" or "*could you report*", etc.
- The rarity of the interrogative and negative forms.
- The almost complete absence of modals.
- The deletion of determiners:
  e.g. "*request Ø Right turn*" in (a), "*Ø heading 3 1 0*" in (b), etc. – rather than "*I request a Right turn*" or "*the/your heading is 310*".
- The deletion of subject pronouns:

[9] Messages beginning with "*P:*" correspond to pilots' messages while those introduced by "*C:*" correspond to controllers' messages.

e.g. "*Ø request Right turn*" in (a), "*Ø turning Right*" in (b), "*Ø will report*" in (c), etc. – rather than "I request", "we are turning" or "*we/I will report*", etc.

- The deletion of prepositions:

  e.g. "*departure Ø runway 2 8*" and "*climb Ø 3000 feet*" in (b), etc. – rather than, "*departure from runway 28*" or "*climb to 3000 feet*", etc.

- The deletion of auxiliaries *be* and *have* in [*be + past participle*] forms, [*be + -ing*] forms and [*have + past participle*] forms:

  e.g. "*Right turn Ø approved*" and "*Ø cleared for take-off*" in (a), "*Ø turning Right*" in (b), etc. – rather than "*Right turn is approved*", "*you are cleared for take-off*" or "*we are turning Right*", etc.

- The nominalisation of concepts:

  e.g. "*Right turn*" in (a), "*multidirectional departure*" in (b), etc. – rather than "*you should turn Right*" or "*you will follow the multidirectional route*", etc.

- A highly specialised, univocal and finite lexicon (less than 1000 different words):

  e.g. "*QNH*" in (b), "*VFR*" and "*touch-and-go*" in (c), etc.

- An alphabet proper to the aeronautical domain:

  e.g. "*golf charlie delta*" in (a), "*foxtrot bravo x-ray*" and "*information India*" in (c), etc. – rather than "*GCD*", "*FBX*" or "*information I*".

- The specific spelling and pronunciation of numbers:

  e.g. "*runway 0 6*" in (a), "*Citron Air 3 2 4 5*" (with "3" pronounced as "*tree*") in (b), etc. – rather than "*runway 6*" (without "0") or "*Citron Air 3245*" (with "3" pronounced as "3").

Phraseology's syntactic, lexical and semantic characteristics make it the essential communication tool for the transmission of the fundamental information required for providing optimal and safe guidance of air traffic. However, since it has been created to cover only a limited number of air navigation situations, phraseology is a limited tool:

> *While ICAO standardized phraseology has been developed to cover many circumstances, it cannot address all pilot and controller communication needs. It is widely acknowledged by operational and linguistic experts that no set of standardized phraseologies can fully describe all possible circumstances and responses (ICAO, 2010: 1.2.3).*

Thus, when facing situations for which phraseology does not exist, pilots and controllers must resort to a more natural language known as "plain language".

3. PLAIN LANGUAGE

Pilots and controllers' communication needs in situations for which phraseology is not enough requires the usage of natural language – though constrained by phraseology's rules of clarity, preciseness and concision (Mell, 1992: 73). This form of natural language is referred to by the ICAO as "plain language" and is prescribed as a last resort when phraseology has reached its limits:

> *ICAO standardized phraseology shall be used in all situations for which it has been specified. Only when standardized phraseology cannot serve an intended transmission, plain language shall be used (2001: 5.1.1.1).*
>
> *ICAO standardized phraseology should always be used in the first instance (2010: 4.3.3).*

The transition from an operative language, such as phraseology, to natural language in unusual situations is accounted for by Falzon (1986: 37) by the absence of procedure patterns in such situations which leads operators to use a more powerful but not specialised representation tool, i.e. natural language. Unlike natural language, prescribed linguistic norms leave indeed no room for creativity. According to the ICAO, natural language – and the creativity that it implies, particularly when dealing with an unexpected turn of events – is the best instrument for human interaction:

> *Linguistic research now makes it clear that there is no form of speech more suitable for human communication than natural language. [...] Human language is characterized, in part, by its ability to create new meanings and to use words in novel contexts. This creative function of language is especially useful in accommodating the complex and unpredictable nature of human interaction, including in the context of aviation communications. There is simply no more suitable form of speech for human interactions than natural languages (2010: 1.3.2).*

Nonetheless, the terminology chosen by the ICAO to refer to the language used when phraseology does not exist is "plain language", not "natural language". One could then assume that plain language and natural language are not alike: plain language should not be considered as natural language since it is supposed to comply with phraseology's standards. It has indeed been recently officially defined as such by the ICAO:

> *Plain language in aeronautical radiotelephony communications means the spontaneous, creative and non-coded use of a given natural language, although constrained by the functions and topics (aviation and non-aviation) that are required by aeronautical radiotelephony communications, as well as by specific*

safety-critical requirements for intelligibility, directness, appropriacy, non-ambiguity and concision (2010: 3.3.14).

Plain Language can thus be considered as the spontaneous, creative and non-coded use of a given natural language within the context of the very specific domain of air traffic control. Yet, professional context is not enough to avoid the presence of linguistic difficulties, such as polysemy or impreciseness, which, while harmless in every day communications, could lead to serious consequences in professional contexts due to a lack of correctly transferred information (Condamines, 2008). In this context, can plain language really be considered as sharing phraseology's characteristics of clarity, preciseness and concision? Furthermore, the linguistic difficulties related to the use of plain language are acknowledged by the ICAO:

The features of plain language, [...], can be far from plain and present a challenge to listening skills. They include the use of a wider vocabulary referring (often with less precision) to domains and topics outside the aviation area (medicine, military organizations, etc.), references to complex notions such as hypothesis (we may divert), indirectness (we would like a request) and, under stressful conditions, much longer and less organized sentences (2010: 3.3.16).

The notion of plain language, as defined and presented by the ICAO, is far from clear for civil aviation professionals in charge of English radiotelephony teaching. Consequently, in order to determine with greater clarity what constitutes plain language in air-ground communications, an observation of the different usages of English by French controllers and pilots from around the world by means of a comparative study between two corpora was initiated.

4. PRESENTATION OF THE TWO CORPORA UNDER STUDY

A comparative study between a reference corpus (henceforth referred to as *RefC*), representing the prescribed norm, and a corpus representing the real usages made of it (henceforth referred to as *UseC*) is essential to the identification, description and categorisation of the different real usages made of radiotelephony English. Two such corpora had thus to be compiled.

The first step in the compilation of RefC was to select official texts from which representative samples of standard phraseology could be extracted. This type of texts being quite rare, the examples in English from two phraseology manuals – one edited by the ICAO (2007) and the other by the French government (DGAC, 2007) – have been selected to constitute this corpus. By choosing those two phraseology manuals, we aim at representing the norm from an international as well as national point of view.

The second corpus consists of the orthographic transcription[10] of about twenty-two hours of recording of real air-ground communications from two French En-route control centres and one French major airport[11]. These three centres have been chosen to ensure that the corpus is representative of the language used in every day radiotelephony[12].

The first corpus, RefC, is constituted of a total of 11,844 word tokens and 805 word types[13] while the second corpus, UseC, contains 49,020 tokens and 1238 types, as illustrated in Table 1.

Table 1: Number of Word Types and Tokens in Each Sub-Corpus

	Reference Corpus (RefC)			Real Usages Corpus (UseC)			
	ICAO Manual	DGAC Manual	Total	Centre 1	Centre 2	Airport	Total
Tokens	5712	4723	10,434	13,768	9754	20,051	43,572
Types	629	524	801	715	550	806	1252

We should specify here that the total number of word types in each corpus – 801 for RefC and 1252 for UseC – does not correspond to the sum of the word types contained in each of their respective sub-corpora as the latter share some common word types. For instance, the word "will" is found in both manuals constituting RefC. One interesting thing to notice is that, in spite of the total occurrences in each corpus, the number of different word types they contain remains rather low. This observation results from the fact that the phraseology lexicon is finite, as mentioned earlier: the number of different word types used is limited.

[10] A specific transcription protocol has been created and applied and the different transcriptions have been reviewed by air traffic control experts.
[11] To collect these communications, an official authorisation was needed beforehand as in France this type of data is not accessible to the general public. For reasons of anonymity, the names and locations of these three centres will not be revealed in this paper. They have been chosen for the concentration of English used on their frequencies as well as their interest for our research project.
[12] Different types of air traffic control (aerodrome, approach and en route), different control stations, time slots and interlocutors have been taken into account to constitute *UseC*.
[13] In a corpus, each different word is known as a "type" (or "word type"). For instance, "will" and "would" are two different word *types*. The number of time a given word type occurs in a corpus is known as "token" (or "word token"). For instance, 56 *tokens* of the type "will" are found in RefC. In other words, "will" occurs 56 times.

The observation of the different uses of English by controllers and pilots initiated by the ENAC is conducted through a comparative analysis of these two corpora.

5. COMPARING THE TWO CORPORA

Phraseology's specific features concern several linguistic levels: the lexical level, with a highly specialised lexicon; the semantic level, with univocal meanings; the syntactical level, with very specific sentence structures; and the phonetic level, with the standardised pronunciation of certain words. A detailed comparative analysis between our two corpora at each of these linguistic levels should be dealt with in Lopez's thesis in order to point out the differences and similarities found between the prescribed norm and the real uses made of it. However, for lack of space, this paper only focuses on some of the lexical features of the two corpora. The various observations and comparisons of the data are made possible by the use of a processing tool known as *Concordancer*, which, among other things, allows one to know exactly how many times a word type is used and to have access to the contexts in which every occurrence of a word is used.

5.1. Preliminary Methodology

The first preliminary step in comparing the vocabulary of the two corpora was to draw up a list of the different word forms they contain. Yet, from a lexical point of view, comparing a corpus made up of written data – and thus including no feature of verbal communication – with one made up of spoken data would not guarantee satisfactory results. Consequently, in order to obtain a well-balanced comparison of the lexicon found in the corpora, not all the different word types have been taken into account in our lexical analysis. The different categories of word types that have been excluded and the reasons for their removal are presented in the following table.

By choosing not to take into account the word forms mentioned here, we aim at focusing on specific and recurrent air traffic control vocabulary as well as proceeding to a well-balanced comparison of the two corpora lexicon. The two corpora henceforth contain fewer word types and tokens: RefC is now constituted of 7154 tokens and 671 types while UseC contains 24,278 tokens and 495 types.

The second preliminary step in comparing the corpora lexicon was to classify the different word types left for the analysis according to their grammatical categories. Such a classification was made manually since the particular syntactic structures of phraseology do not allow a correct automatic tagging[14] of the corpora. The results of this classification show that nouns are the part of speech most commonly found in both corpora (47.2% for RefC and 34.8% for UseC), followed by verbs (21.3% for RefC and 23.8% for UseC) and prepositions (11.7% for RefC and 10.9% for UseC). The other grammatical categories, i.e. adjectives, adverbs, conjunctions, determiners, interjections and pronouns, are present to a lesser extent (less than 8%). Some discrepancies have been observed in the distribution of several categories between one corpus and the other.

Table 2: Types of Word Forms Excluded from our Lexical Comparison

Excluded word types	Related Corpus	Examples	Reasons for Exclusion
Speech disfluencies[15]	UseC	-*huh*-; *we tr/ try*; etc.	RefC does not contain any speech disfluency.
Politeness and greeting markers in languages other than English[16]	UseC	*arrivederci*; *merci beaucoup*; *konichiwa*; *hasta luego*; etc.	RefC is only constituted of examples in English.
Alphabet letters	Both corpora	*alpha*; *bravo*; *charlie*, etc.	The comparison of alphabet letters is not relevant for our study.
Proper Nouns[17]	Both corpora	*Air Citron*; *Albi*; *Airbus*; *Castelnaudary*; *Georgetown*; *Fastair;* etc.	Proper nouns cannot really be compared with one another as different proper nouns are found in the two corpora.
Hapaxes[18]	UseC	*actually*; *big*; *careful*; *east*; *reason*; *whatever*; etc.	Since they occur only once, these word forms cannot be considered as representative of the language used.

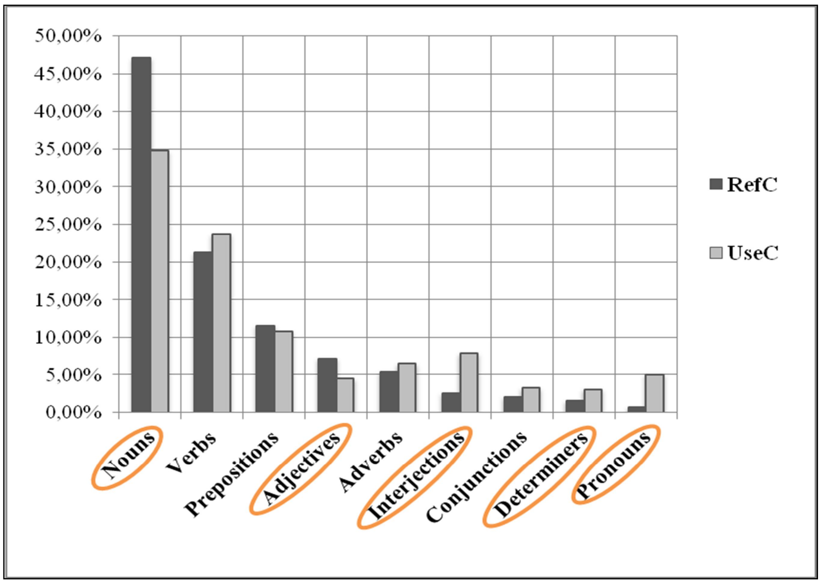
5.2. Discrepancies Between The Two Corpora

The classification performed on the corpora lexicon reveals striking differences in the distribution of some grammatical categories between the two corpora: the nouns, adjectives,

[14] A tagged corpus contains word forms to which a grammatical tag has been applied.
[15] Speech disfluencies are typical features of spoken language. They include, among other things, cut-off words, repeated words or syllables and fillers such as *huh*.
[16] They depend on the interlocutors' creativity.
[17] They correspond to authentic or imaginary names of towns, airports, aircraft, beacons, etc. Only the proper nouns corresponding to different control stations on the ground have not been excluded from our analysis.
[18] Hapaxes are words which occur only once in a corpus.

interjections, determiners and pronouns are unevenly distributed in RefC and UseC, as illustrated in Figure 1. This discrepancy in distribution can be seen as a reflection of the difference existing between the specific features of the prescribed norm (represented by RefC) and the uses made of it (represented by UseC). For some of the grammatical categories, we could go even further and consider them as preliminary clues to the potential differences in the characteristics of phraseology and plain language.

Figure 1: Distribution of the Grammatical Categories in the Corpora



A detailed observation of the word forms contained in these unevenly distributed grammatical categories will help us to give a complete description of the lexical differences and similarities existing between the two corpora in the future. In this paper, we only discuss some of the word forms contained in the noun, interjection and pronoun categories.

5.3. Possible Comparisons between the Distribution of some Word Forms

5.3.1. The Noun Category

The noun category is the most frequent category in both corpora: it accounts for 47.2% of all the tokens in RefC and for 34.8% of all the tokens in UseC. RefC and UseC contain respectively 301 and 147 noun word forms and have 95 noun forms in common, that is to say 26.84% of all noun forms. In other words, RefC contains 207 noun forms that are not present in UseC and UseC contains 52 noun forms are not present in RefC.

The three nouns used most often in RefC are “runway” (8.84% of all its noun tokens), “level” (7.6%) and “flight” (4.15%) while in UseC, the three most used are “level” (18.74% of all its noun tokens), “flight” (11.76%) and “heading” (6.04%). All the other nouns account respectively in RefC and UseC for less than 4% and less than 6% of all noun tokens. One interesting thing to mention is that the term “flight level” occurs only in one of the two manuals constituting RefC: no occurrence of “flight level” has been found in the French manual. Yet, if this manual took into account the extensive use of “flight level” by pilots and controllers in air-ground communications (61.54% of all “level” tokens in UseC), it would then reflect much better how phraseology and its standards are employed in real everyday radiotelephony.

Now, if we take a closer look at the noun forms that are specific to the real usage corpus (UseC), we can notice that all of them account for less than 1.4% of all its noun tokens, with only the three most frequent ones accounting for more than 1%. These three top noun forms are “sir”, “course”, and “Radar”[19]. Out of the 52 noun forms specific to UseC, up to 29 can be considered as not exclusively belonging to the air traffic domain. The word forms “sir”, “problem”, “madam”, “moment”, “afternoon”, “mountain(s)”, “question”, “best”, “help”, etc. indeed belong to a more general area. These noun word forms reflect a part of the lexicon needed by pilots and controllers to answer their communication needs that are not fulfilled by phraseology: they are everyday words used within radiotelephony communications.

The 207 noun forms specific to RefC account for less than 1.3% of all its noun tokens. 49 of them (16.50%) can be considered as specific to the domain of air traffic, such as, “helicopter”, “touch-and-go”, “transponder”, “airfield”, “aerodrome”, “airway”, “pilot”, “mid-runway”, including 22 acronyms among which “ATIS” (Automatic Terminal Information Service), “CTOT” (Calculated Take-Off Time”), “IFR” (Instrument Flight Rules), “NDB” (Non-Directional Beacons), “FIR” (Flight Information Region), “GNSS” (Global Navigation Satellite System), “RVSM” (Reduced Vertical Separation Minima), “VASIs” (Visual Approach Slope Indicators), “VMC” (Visual Meteorological Conditions) and “VFR” (Visual Flight Rules). These 207 noun word forms could undoubtedly be encountered in real air-ground communications: it is only by chance that they are not found in UseC (the specific air traffic situations in which these noun forms are generally used were not encountered while recording the communications constituting UseC).

[19] “Radar” refers here to a control station on the ground.

5.3.2. The Interjection Category

According to the *Oxford Dictionary of English Grammar* (Chalker & Weiner, 1994) an interjection is a "minor word-class whose members are outside normal clause structure, having no syntactical connection with other words [...]". We have thus decided to tag as "interjections" all the word forms which corresponded to this definition as well as those labelled as such in various English dictionaries.

RefC and UseC are thus respectively constituted of 2.7% and 7.9% of interjections. RefC contains 189 interjection tokens distributed in 10 different word types while UseC comprises 1918 interjection tokens for 26 different word types. The two corpora share 8 identical interjection forms. The main interjection forms in RefC are "Roger" (35.98% of all its interjection tokens), "wilco[20]" (14.29%) and "negative" (11.11%). These word forms are less frequent in UseC: "roger" accounts for 4.48% of all UseC interjection tokens while "wilco" accounts for 0.78% and "negative" for 1.15%. The three interjection word types used the most in UseC are the farewell and politeness markers "bye" (35.87%), "goodbye" (11.42%) and "thank you" (8.76%).

If we take a closer look at this type of marker, we can notice that they are not completely absent in RefC: "good morning", "good day" and "thank you" are indeed part of this corpus. However, they are only to be found in the French manual and no greeting or politeness marker is used in the ICAO manual. Yet, the ICAO recommends, as part of the communicative functions of aeronautical radiotelephony communications, that users be able to understand and use markers referring to different attitudes such as politeness (2010: 3.4.9). According to Rubenbauer (2009: 72) expressions of courtesy can indeed "often be heard to facilitate the flow of information between participants in ATC or intra-cockpit communication".

Greeting, farewell and politeness markers represent more than 61% of all UseC interjection tokens and involve up to 16 different word forms such as "hello", "good morning", "good afternoon", "good evening", "good day", "bye", "good bye", "welcome", "thank you", "thanks" and "please". The use of such markers is explained by Nübold and Turner (1983: 51; quoted in Rubenbauer, 2009: 27) by the fact that "the requirement to use English with the prescribed procedures is interfered with a constant, unremitting need which pulls the

[20] The term "wilco" is used in radiotelephony as an abbreviation of "we will comply with". We have chosen to consider it as an interjection since it is generally used outside normal clause structure and has no syntactical connection with other words.

language into the opposite direction; by the human being's desire to use language in its social and affective roles". The quite extensive use of interjections and courtesy expressions in UseC could indeed be explained by the speakers' prevailing need to customise and "humanise" air-ground communications and their perpetual repetitive tasks.

5.3.3. The Pronoun Category

While pronouns are nearly absent from RefC (0.7% of all its tokens), they account for 5.1% of UseC. The 5 different pronoun forms found in RefC are "you" (65.52% of all its pronoun tokens), "I" (20.69%), "one" (8.62%), "me" (3.45%) and "what" (1.72%). On the contrary, UseC comprises 19 different pronoun forms of which the most used ones are "you" (44.28%), "we" (23.02%), "I" (9.19%), "it" (7.37%) and "that" (6.81%). All the other pronouns found in UseC account for less than 2.5% of all its pronoun tokens. The pronoun "we", which is not at all present in RefC, is mainly used by pilots in UseC: 94.51% of all the 328 occurrences of "we" are in pilots' messages. Controllers generally use the pronoun "I" rather than "we". However, 16 occurrences of "we" in controllers' messages can be found in UseC. It seems that some controllers tend to use the plural pronoun in situations for which they cannot provide pilots with what they want or need, as if trying to remind their interlocutors that the situation in which they are is not really up to the controller on frequency, and that a much more complex system is behind the provided control services. The pronoun "we" is also used by controllers to refer to themselves as a team as in France, *two* controllers deal with all the aircraft of a specific sector, even though only one of them is in contact with the pilots: they share the different air traffic control tasks the way two pilots share the tasks relating to the flight of an airplane. Some of the occurrences of the pronoun "we" in controllers' messages are presented below:

(d) *P: […], any chance for higher level?*
C: […], we call you back -huh- soon for climb if possible.
P: thank you.

(e) *P: (right) so, we are flight level 3 4 0 on course to BOKNO, -huh- with the CBs*[21] *in sight, -huh- // we request a final 3 6 0 if possible.*
C: okay, we try to get higher for you, I call you back.

(f) *P: yes, […] 5 0 5 8, requesting flight level 3 8 0, light turbulence.*
C: okay, 5 0 5 8, we tr/ we try // but -huh- it was impossible in the previous minutes, we try again.

[21] A cumulonimbus (or CB) is a mass of thick cloud that usually involves rain and thunder and that cannot be crossed by any aircraft.

P: okay, that was 3 6, we're trying 3 8.

C: yes sir, I know that but we try.

C: [...] 5 0 5 8, I'm sorry but we tried again and it was impossible.

P: okay merci, [...] 5 0 5 8.

(g) *P: -huh- [...] 8 1, would flight level 3 5 0 be available?*

C: -huh- okay, we check that and call you back sir.

P: copied, [...] 8 1, thanks.

The general use of pronouns in UseC can again be explained by the "human" character of the communications it comprises. We can indeed consider phraseology as an "objective" type of discourse which strives to reduce the presence of individual speakers to a minimum (Kerbrat-Orecchioni, 1999: 80): the main syntactic characteristics of phraseology (the deletion of subject pronouns, determiners and modals, for instance) illustrate the objectivity of this type of discourse. Therefore, air-ground communications containing subject pronouns, but also determiners, modals, or interrogative forms, can be considered a far more personal or subjective type of discourse. Pronouns can be seen as "subjectivity" markers which insist on the presence of individual speakers despite the norm that is imposed on them: a reminder that pilots and controllers are humans and not machines.

6. CONCLUSION

The first results obtained by comparing the distribution of the corpora lexicon corroborate our idea of the relevance of a linguistic approach and, more specifically, of a comparative study between our two corpora of English radiotelephony. The preliminary results of our lexical analysis indicate a general pattern of similarities between the two corpora: both are constituted of a finite lexicon comprising less than 700 word types and being mainly composed of nouns, then verbs and prepositions. Yet, differences have also been observed and a description of the different markers introducing subjectivity in air-ground communication can help understand the use of a more natural language in radiotelephony. In addition, a more detailed comparison of the word forms distributed in the corpora in the various grammatical categories, as well as a comparison of the corpora at a syntactic, semantic and phonetic level will enable us to draw a panorama of the different types of usages made of the English language by pilots and controllers. Conducting the study at other linguistic levels will allow observing, for instance, the word collocations, i.e., which words are generally used together, the syntactic structures employed by pilots and controllers, or the use of certain verbs with specific complements.

The various results obtained will be used by the ENAC for the English training it provides future controllers and pilots with. This training, based on real usages from different air traffic control centres in the world, tries to heighten future controllers and pilots' awareness about the various difficulties related to language uses. Original teaching materials could be founded on UseC and the results acquired could serve as the basis for various exercises. Such appropriate and up-to-date pedagogical materials could reflect both standard phraseology and the usages made of it in real air traffic control situations and thus, prepare controllers-and-pilots-to-be to face different types of language uses, as required by ICAO's language proficiency requirements.

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AVAILABILITY ASSESSMENT SIMULATIONS FOR ALLOCATING HUMAN RESOURCES IN AIRSPACE CONTROL CENTERS

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ABSTRACT

Airspace control systems introduced automation into functions previously performed by human operators. This situation increased the dependence on the availability of computer systems, in which degraded operation events can reduce the service level at any controlled airspace. This paper presents a relationship between availability and allocation of human resources in these centers, where maintenance and operations personnel are occasionally asked to repair losses caused by automated functions. A simulation model for the Arena tool is presented, to access availability, and then the operational point of view is explored, focusing on the required availability scenarios. The results presented herein can help determine the size of operations and maintenance teams, considering the reliability and maintainability parameters of airspace control systems.

Keywords: Availability Assessment, Human Factors, Maintainability, Simulation.

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1. INTRODUCTION

1.1 Critical Systems in Airspace Control Centers

Due to the worldwide growth in airspace utilization, airspace control systems have been increasing their technical complexity (Müller and Santana, 2008), introducing new features into the existing automation or creating additional automation of functions previously performed by human operators. Therefore, the dependence (FAA, 2006) on the availability of the computer systems used by these control centers has increased. Operational procedures and design features are established to maintain the safety integrity level of the services during degraded operation, but availability remains a critical parameter to the efficiency of these centers.

In this context, this paper presents results from a simulation model, previously developed with the Arena tool (Kelton et al, 2007), in order to show its practical application for determining the size of operations and maintenance teams needed in an airspace control center, as a function of the service level – or the availability requirements - established for that specific installation of interest, considering its reliability and maintainability parameters.

First, a summary of an availability analysis is presented. More details about this model were described in a previous paper (Pizzo and Cugnasca, 2009) in which the initial focus was devoted to the availability assessment based on comparisons among distinct architectural approaches (reliability design and redundancy policies) to achieve certain levels of required availability. The new simulations presented herein consider large size scenarios for airspace control centers (with about 30 operational positions) and focus on the results of the capability of performing adequate human resources allocation compatible with the required availability.

1.2 Concepts of Airspace Control Services

Airspace control services are performed within operational centers with structures defined by international organizations such as the International Civil Aviation Organization (ICAO, 1996). These centers are hierarchically organized with four levels of control described as follows:

a) Tower Control level (TWR), where local management of landings and take-offs are performed regarding operations of an aerodrome;

b) Terminal Area level (APP), where the air traffic control manages approach procedures for landing, as well as for take-offs for en-route flights;
c) Area Control Center level (ACC), responsible for the control functions of the aircrafts flying through the en-route airways;
d) Air Traffic Flow Management level (ATFM), responsible for statistical analysis and optimization of flow, involving long-term planning of flights.

For each level described, there is a corresponding operational time scale, in which the control of processes ranges from the decisions made in seconds or minutes, at the Tower and at the APP levels, to the control of en route operations, also involving operations of some hours, at the ACC level; while at the ATFM level tactical decision-making (Weigang et al, 2008), statistical analysis and strategy planning are performed in the scale of days to months.

1.3 Operational States of an Airspace Control Center

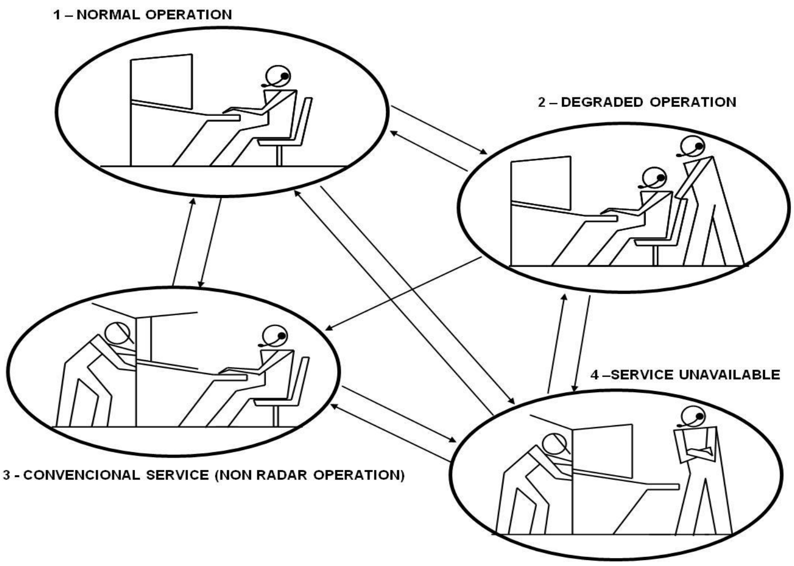
Since airspace control services are not fully automated, they intrinsically dependent from the human intervention (Pizzo and Cugnasca, 2006), a key condition to the continuity of the services is the availability of operations teams (air traffic controllers) and technicians responsible for the maintenance tasks.

In this context, the services provided within an airspace control center could be summarized in the following states, as illustrated in Figure 1:

1. Normal Service: characterized by the regular execution of services at nominal capacity, when the computer systems operate with all automation tools;
2. Degraded Mode Service: characterized by some loss in automated functions, resulting in control services being provided below their nominal capacity, therefore limiting the number of controlled aircrafts or imposing constraints on response times;
3. Conventional Service (non-radar mode): characterized by the loss of computer functions, when an operational position becomes limited just to its voice communication capabilities between controller and pilot, resulting in an all-human based control;
4. Unavailable Service: characterized by the interruption of the control services, due to either an unavailability of any critical infrastructure (i.e. controller-pilot communications, power, etc.) or critical unavailability of human resources for operation.

Transitions are previewed from the Normal state (1) to the Degraded state (2), when the system requires additional operational work from the spare operators or supervisors. A transition to the Failure state (3) occurs when a critical failure demands any service from the maintenance team. Another possible transition would take to the Unavailable Service state (4), but for the purposes of this study, restricted to the availability of the computer systems, only states (1), (2) and (3) were considered. The fourth state (4) should be considered in order to evaluate more specific issues related to other failures in the control centers infrastructure, apart from those originated by the computer systems, such as controller-pilot communication or other human factor impacts.

Figure 1: Operational States of the Services Provided in an Airspace Control Center (Pizzo and Cugnasca, 2009)



Source: Pizzo and Cugnasca, (2009)

2. AVAILABILITY MODELLING APPROACH

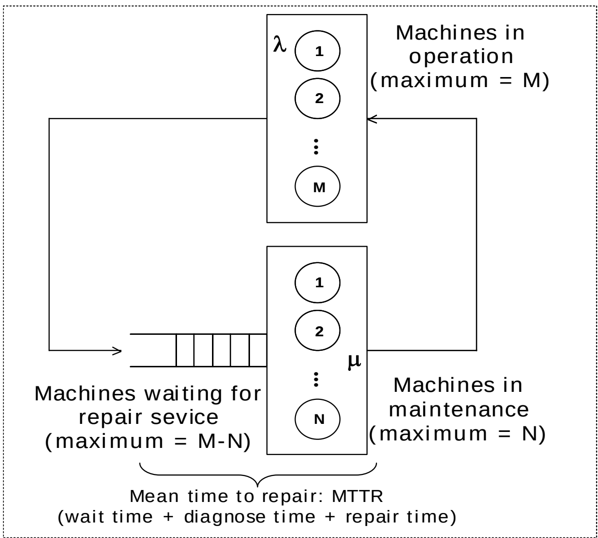
2.1 Availability Analysis Of Computer Systems With Queuing Theory Models

Summarized from more detailed descriptions available in a previous paper by the authors (Pizzo and Cugnasca, 2009), this section outlines an availability analysis model applicable to computer systems in airspace control. Using some techniques from the queuing theory, as illustrated by a data center case study (Menascé et al., 2004), the authors built a simulation model in order to study problems of staff sizing as a function of availability assessment of a data center.

One of the fundamental management problems of a computational data center is sizing the necessary maintenance staff to service the operation, in order to establish the number of machines needed to guarantee a certain confidence in the operation. That means keeping a nominal service level as expected or required by formal agreements.

In a typical computational center, the management is interested in keeping high levels of availability, by means of high reliability (reduced failure rates), as well as optimizing maintenance services, with diagnostic systems, specialized technical staff, efficient execution of repairs and quick return to operation, after any equipment that has been serviced. These parameters are related to the number of people allocated to maintenance activities, as well as to technical skills of the staff, both resulting in the meantime to repair the failed machines (MTTR). As shown in Figure 2, a closed network model can represent this operation. Some considerations are assumed for this data center: a) all machines are identical and operate independently; therefore, all of them are assumed to have the same failure rate , where λ = 1/MTTF (mean time to failure); b) each one of the M machines represents only two possible states ("operational" or "failure"); c) a diagnostic mechanism checks the operation and, when a failure occurs, the machine that failed goes to a queue to be serviced; d) in the queue, this machine waits for one of the N people of the repair staff; and e) once repaired, it immediately returns to the pool of operational machines.

Figure 2: Queuing Model for the Operational-maintenance States of a Computer Center



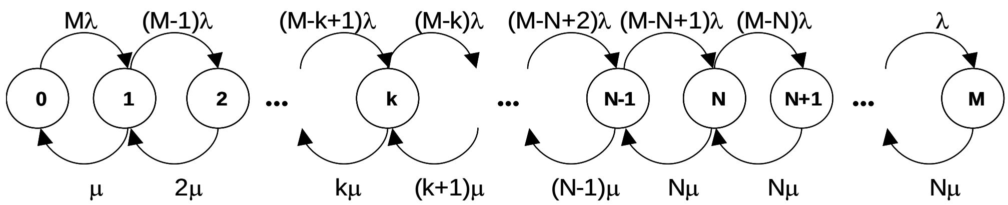
Source: Menascé et al. (2004)

The repair rate μ, equivalent to the inverse of the mean time to repair 1/MTTR, is considered to be identical for any kind of repair performed and is also independent of the technician executing the service. In case of different failure rates observed, a more complex model could be used, considering multiple class queuing models. If it were necessary to distinguish repair rates for each technician, a heterogeneous multi-server model could be defined to represent those individual rates.

As described in the cited case study, a solution for the closed queuing network can be modeled by a Markov chain (Shooman, 2002), in which each state corresponds to the situation in which there are k failed machines out of the total of M machines, with a maximum of N machines under maintenance, as illustrated in Figure 3.

The transition from state k to state k+1 occurs when a machine fails, an event that occurs with a fail rate λ multiplied by the number M-k of machines in operation. Similarly, a transition from state k to state k-1 takes place whenever a machine is repaired, a process that occurs at a repair rate μ times the number of machines being repaired k, limited to a maximum of N.μ, as the maximum number of machines under maintenance is limited to N (maximum size of the maintenance technical staff).

Figure 3: Markov Chain Model for a Data Center with M Machines

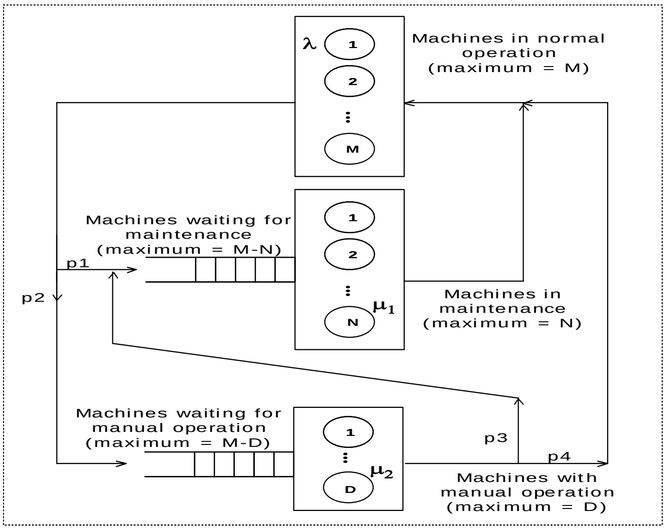


Source: Menascé et al. (2004)

2.2 Availability Model for Airspace Control Systems

Focusing on the scope application of the model previously described, a third state was considered to represent the degraded operation events existing in a real world airspace control system. Therefore, this queuing net model can be extended to the configuration illustrated in Figure 4. This new model considers not only the effect of size N of the maintenance staff, but also the effect of size D, regarding the team of extra operators available, who must be prepared to perform any manual operations necessary, being responsible for dealing with any degradation situation, when some of the automatic processes happen to be temporarily unavailable.

Figure 4: Availability Model of an Air Traffic Control Center Considering Degraded Operation



Source: Pizzo and Cugnasca, 2006

In this model, rate λ is the flow of machines that leave normal operation, corresponding to the addition of flows $\lambda.p_1$ and $\lambda.p_2$, referring transitions from normal state to failure situation (with probability p_1), or from normal state to degraded situation (with probability p_2). The return from the maintenance state to normal operation occurs with repair rate μ_1, while μ_2 represents the rate of machines that leave degraded operation, going from manual state to the maintenance condition or to the normal condition, respectively, with probabilities p_3 and p_4, thus composing flows $\mu_2.p_3$ and $\mu_2.p_4$.

3. IMPLEMENTATION OF THE SIMULATION MODEL WITH ARENA

3.1 Simulation Environment

From the queuing model previously described, this section illustrates how to apply a simulation tool in order to define an adequate number of human resources compatible with the availability of the system.

It is worth stressing that the studies presented herein aim to demonstrate practical uses and benefits obtained with the simulation model, and do not evaluate any specific real center. The main purpose of the following examples is to show possibilities and advantages of the simulation tool to determine the size of an effective team, both for spare controllers and for maintenance teams.

3.2 Inputs Considered in the Simulation Model

This item describes the input variables used in the simulation model, as follows:

- Dimension of the control system, in terms of the number (P) of operational positions;
- Reliability of the system, represented by the failure rate λ of each operational position;
- Maximum capacity of simultaneous operational service, represented by the size (D) of the available operational personnel, composed of the extra controllers or operational supervisors responsible for dealing with any event of degraded service;
- Maximum capacity of simultaneous technical service, represented by size (T) of the maintenance team, composed of engineers or technicians responsible for the repair services in case of any critical failures in the computer system;
- Repair rates corresponding to the average times spent by technical and operational teams during their service activities: rates μ_1 and μ_2, respectively;
- p_1 is the percentage of critical failures, in the total number of occurrences λ, which need services from the technical maintenance team. Derived from p_1, percentage p_2 is the share of non-critical failure events solved by operational service: $p_2 = 1 - p_1$;
- p_3 is the percentage of critical failures occurred during the operational team services, when the sys-tem migrates from a degraded condition to a technical failure condition. Derived from p_3, percentage p_4 represents the success rate of the operational team: $p_4 = 1 - p_3$, which indicates the proportion of non-critical events solved by the operational team.

3.3 Outputs Considered in the Simulation Model

This item describes the output variables used in the simulation model, as follows:

- Global availability of the system, represented by the average percentage of positions available during the simulation, compared with the total installed positions (P). When the global availability is less than 1, it means that there are some unavailable positions (outside the normal state). This does not mean, however, that the services provided have been affected, once the loss might be restricted to the margin of redundant positions installed in this system;
- Nominal Availability of the system, represented by the average percentage of available operating positions compared with the minimum number (P_n) of positions required for the provision of service in its nominal capacity. This number (P_n) was admitted to be 80% the size of the system (P): $P_n = 0.8$ P, which is equivalent to a 25% redundancy level (e.g. P_n=24 and P=30 means a system with 6 spare positions). When the nominal availability is less than 1, it means that the operation is below the required capacity, and

degradation in the services provided is thus expected, if the demand reaches its nominal load;

- Average size of the operational queue, which is the average of positions that are waiting for available controllers (operational service) during a degraded operation interval;
- Average size of the maintenance queue, which is the average of positions that are waiting for available technicians (technical maintenance service) during a period of time when any failure event demands maintenance service;
- Maximum length of the operational queue, which is the average of maximum values of the number of positions waiting for available controllers, during any events of degraded operation;
- Maximum length of the maintenance queue, which represents the average of the maximum values of the number of failure positions waiting for available technicians, during any critical failure events that demand maintenance.

3.4 Typical Scenarios Considered

For establishing typical reliability, a theoretical calculation was taken for a hypothetical air traffic control operational position, considered to be configured with commercial off-the-shelf equipment, including workstations, monitors and other peripherals, as referenced by Pizzo and Cugnasca (2009). Thus, the reliability obtained (mean time to fail) for each position was MTTF= 11187 hours, considering a typical value for critical failures at each operational position. The non-critical failures, related to common operational occurrences that could demand attention from the operational staff (such as additional workload of assistant controllers or any interaction with operational supervisors), could be measured directly, but for the purposes of this study (devoted to demonstrating the application of the simulation model), it was assumed to be a fraction of the critical failures, and was therefore defined with p_1= 1% and p_2= 99%, leading to a typical value for the reliability of each position (MTTF = 112h). If any different value was measured from an existing air traffic control center, it could also be defined as the proper relationship between p_1 and p_2, as observed.

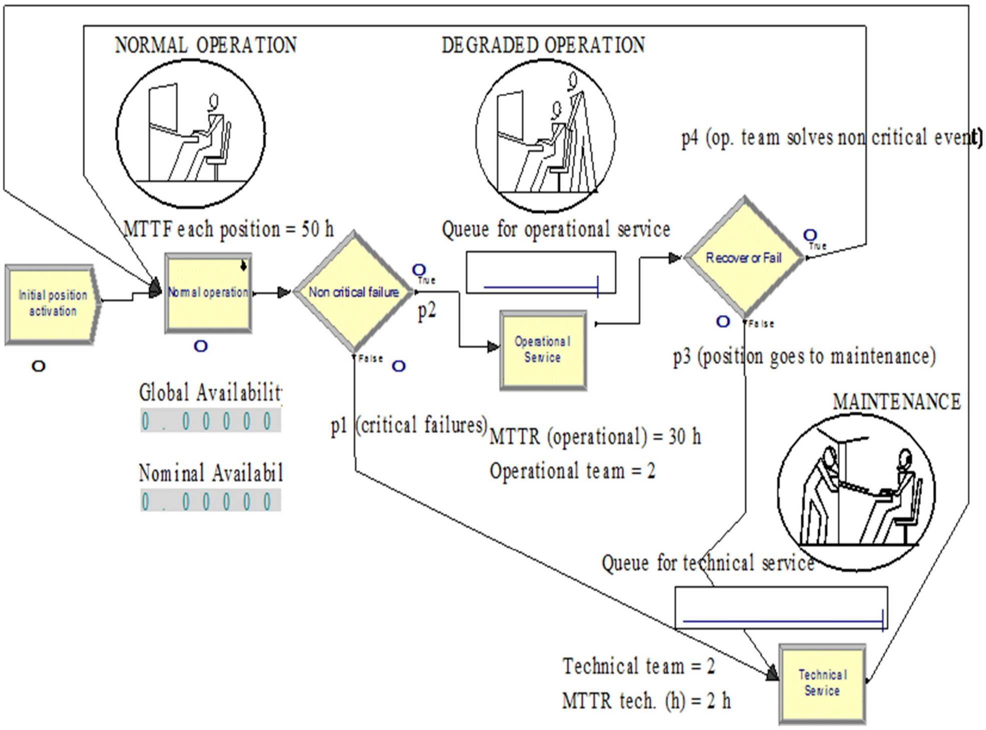
Various scenarios were simulated, representing different classes of reliability and reparability of the systems. Both high (A) and low (B) reliability classes were considered, respectively, with 200h and 50h MTTF. The same variations in reparability were also studied, considering different classes for high and low mean times needed to finish an operational repair: $MTTR_{op}$ from 0.1h(A) to 2.0h(B); as well as mean times needed to finish a technical repair: $MTTR_{tech}$ from 0.5h(A) to 24h(B).

Extending the previous study (Pizzo and Cugnasca, 2009), new simulations were conducted for large (L) size scenarios of airspace control centers, with 30 operational positions. These scenarios also considered a 25% level of redundancy, meaning that 6 spare positions were already included. The simulation model used an exponential distribution to represent the random nature of failure rate λ for electronic equipment, while repair rates μ were modeled with a triangular distribution.

In the Arena environment (ROCKWELL, 2005), the model of queues described in section 2.2 can be implemented as shown in Figure 5, with the following components:

- “Initialization” object: a closed network model requires a startup object, which periodically activates new operational positions at the beginning of the simulation, until the number of positions in the network reaches the total size of each scenario (P);
- "Normal Operation" module: simulates failure events for the positions in state 1: normal operation. Such events could lead the system to a degraded operation state or to the maintenance state. This module is simulated with an exponential distribution of failures with rate λ = 1/MTTF;

Figure 5: Simulation Model Developed on Arena



Source: Pizzo and Cugnasca (2009)

- Decision module "critical failure": responsible for routing a failed position to states 2 or 3, depending on p_1 and p_2, as described in item 2.2;
- "Operation Service" module (state 2): characterized by a queue of operational care, with repair rate $\mu_2 = 1 / MTTR_{op}$;
- Decision module "Recover or fail": responsible for routing each position in the operational service, with rates p_3 and p_4, respectively representing the migration to the maintenance service, or a possible return to the normal state;
- Maintenance service (state 3): characterized by the queue of the technical maintenance service, with repair rate $\mu_1 = 1/ MTTR_{tech}$.

4. SIMULATION RESULTS

4.1 Results from Simulations of Controller Staff

As the recommended use of the Arena tool (Kelton et al, 2007), when the purpose is to obtain significant values, with 95% confidence for the average results, the values presented were obtained from the execution of several repetitions for each scenario simulation (parameter “REPS” presented in Tables 1 and 2). This practice avoids erroneous comparisons between scenarios, which may occur when there is no proper confidence that results variations came from inputs variations, and are not caused by statistical deviation from different runs.

Each scenario is initialized and simulated many different times, with independent random root conditions. These repetitions are also called “runs” or “replications". The statistical definition of the necessary number of replications followed the same criteria adopted by Ribeiro (2003), establishing the minimum repetition number that generates convergence in the averages of results, with standard deviations smaller than 0.0001. Thus, the results presented here were obtained from the execution of at least 50 replications for large size scenario simulations.

Table 1 presents results from large size scenario simulations in order to verify ideal allocation of extra operators needed for this control center, considering LBB availability parameters. This table shows a row for each simulated scenario, with average results obtained with the total number of runs ("REPS") each one for the simulation of a five-year operation.

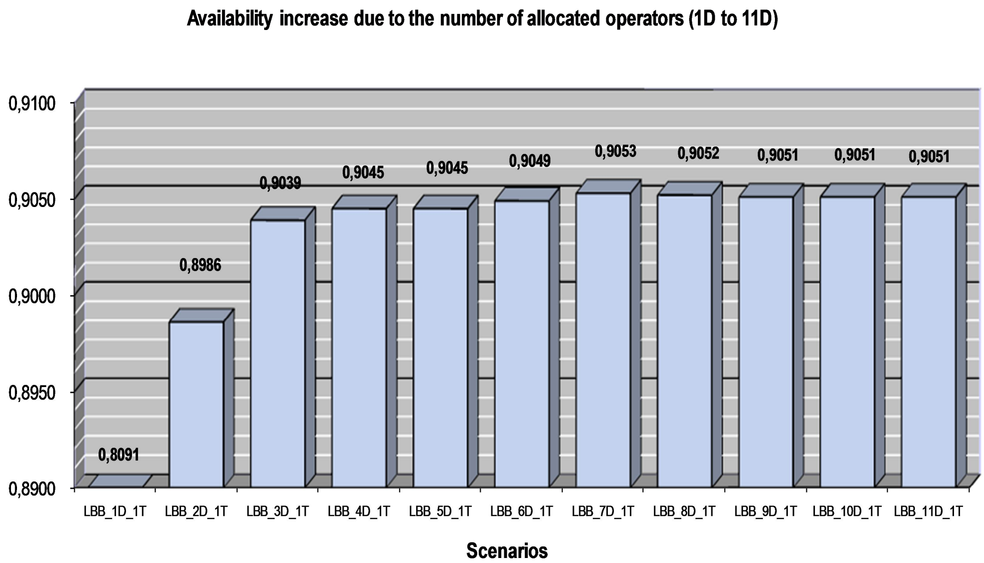
Table 1 - Results obtained from Large Scenario Simulations

Scenario Properties		Controls					Responses		
Scenario	Reps	MTTF pos (hours)	MTTR operator (minutes)	MTTR technician (minutes)	Operators (Available controllers)	Technicians	Max Op Queue (avg)	Max Tech Queue (avg)	Global availability
LBB_1D_1T	50	50	120	1440	1	1	3,752	0,742	0,8091
LBB_2D_1T	50	50	120	1440	2	1	0,218	1,158	0,8986
LBB_3D_1T	50	50	120	1440	3	1	0,033	1,155	0,9039
LBB_4D_1T	50	50	120	1440	4	1	0,005	1,165	0,9045
LBB_5D_1T	50	50	120	1440	5	1	0,001	1,169	0,9045
LBB_6D_1T	50	50	120	1440	6	1	0,000	1,159	0,9049
LBB_7D_1T	50	50	120	1440	7	1	0,000	1,149	0,9053
LBB_8D_1T	50	50	120	1440	8	1	0,000	1,155	0,9052
LBB_9D_1T	50	50	120	1440	9	1	0,000	1,156	0,9051
LBB_10D_1T	50	50	120	1440	10	1	0,000	1,158	0,9051
LBB_11D_1T	50	50	120	1440	11	1	0,000	1,158	0,9051

The inputs for the simulation are presented in a group of columns named "Controls", corresponding to the input parameters, such as: the number of extra operational personnel (spare controllers), the number of maintenance technicians and the mean times of failure and repair considered. The outputs of the model are represented in the right group of columns named "Responses", which highlights the nominal availability averages obtained, illustrating the ability of the system to operate in its rated capacity.

The results listed in Table 1 illustrate the effects of increasing the number of operational personnel over the availability of the system. Figure 6 shows that there is no improvement in the global availability with more than 6 operators, thus indicating the ideal number of spare operators allocation needed for this control center.

Figure 6: Availability Growth with the Increment in the Number of Extra Operators (Spare Airspace Controllers)



4.2 Results from Simulations of Technicians Staff

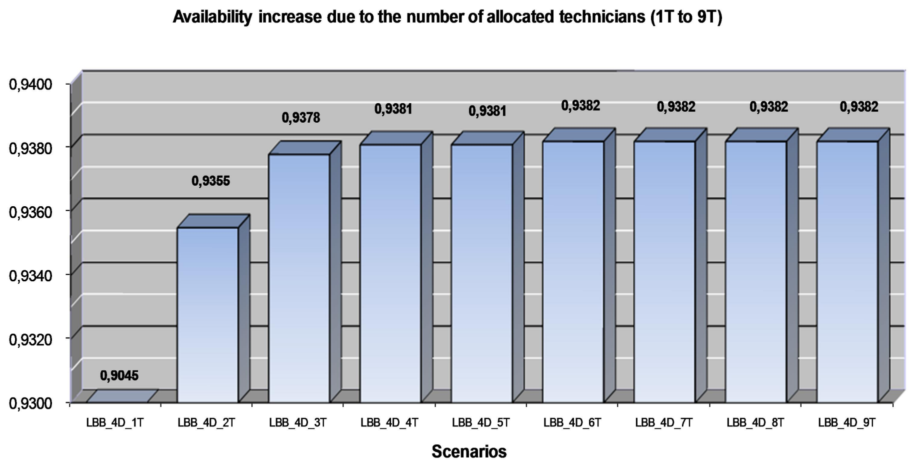
The following table presents the results of the simulation of large size scenarios, with up to 30 operational positions.

Table 2: Results Obtained from Large Scenarios Simulation

Scenario Properties	Controls						Responses		
Scenario	Reps	MTTF pos (hours)	MTTR operator (minutes)	MTTR technician (minutes)	Operators (Available controllers)	Technicians	Max Op Queue (avg)	Max Tech Queue (avg)	Global availability
LBB_4D_1T	50	50	120	1440	4	1	0.005	1.165	0.9045
LBB_4D_2T	50	50	120	1440	4	2	0.006	0.088	0.9355
LBB_4D_3T	50	50	120	1440	4	3	0.006	0.011	0.9378
LBB_4D_4T	50	50	120	1440	4	4	0.006	0.001	0.9381
LBB_4D_5T	50	50	120	1440	4	5	0.006	0.000	0.9381
LBB_4D_6T	50	50	120	1440	4	6	0.006	0.000	0.9382
LBB_4D_7T	50	50	120	1440	4	7	0.006	0.000	0.9382
LBB_4D_8T	50	50	120	1440	4	8	0.006	0.000	0.9382
LBB_4D_9T	50	50	120	1440	4	9	0.006	0.000	0.9382

The scenarios of rows 2 to 10 in Table 2 indicate improvement in the system availability by the allocation of more technicians in the maintenance staff. In these cases, Figure 7 shows that there is no significant improvement in the global availability of the system from the allocation of more than 3 technicians. This happens due to the same reason found in the previous scenarios, when the queues stop forming due to the permanent existence of at least one technician available whenever a machine needs maintenance service.

Figure 7: Availability Increase Due to the Increment in Number of Allocated Maintenance Technicians in Large Size Scenarios



5. CONCLUDING REMARKS

An extension of a previous study was presented demonstrating the application of a simulation model for assessing the availability of computer systems used in airspace control centers. The previous paper focused on the results of the simulation tool to generate contributions to the design of the computer systems in these centers, by means of comparing different technical approaches to achieving a desired level of availability, both by means of design (reliability increase) and by means of redundancy policies. This paper focused on the application of the simulation model for determining the size of proper human resources compatible with the availability of an airspace control system. The model presented can be used both as a tool for assessing the availability of critical systems as a function of its reliability and maintainability parameters, as well as being applicable to achieve an appropriate allocation of human resources, both in terms of spare operators and in terms of maintenance technicians compatible to the availability requirements, or service level agreement established for an airspace control center.

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DIFFERENCES AND COMPARISON BETWEEN FAA AND ICAO OBSTACLE RESTRICTION REGULATIONS

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ABSTRACT

FAR Part 77 "Objects Affecting Navigable Airspace" is commonly only used in the US, whereas ICAO Annex14 "Obstacle Restriction and Removal" is accepted by all other countries. These two systems were constructed with a different baseline, restrictive area and height. Since government regulations or research publications usually adopt one of them exclusively, users and researchers may perceive ambiguous figures. The purpose of this paper is to compare safety airspaces and identify differences. The results indicate that the FAA imaginary surfaces system specifies a more extensive obstruction clearance than ICAO's. We also show that airports which apply the FAA regulations restrict urban development around airports more.

Keywords: Obstacle restriction, Obstruction identification surfaces, Safety airspace, Airport design, Geo-spatial information science.

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1. INTRODUCTION

Airspace protection and obstacle clearance are vital to airport and aircraft operation. Restrictions should be established on the heights of buildings, antennas, trees, and other objects as necessary to protect the airspace needed for safe operation of the airport and aircraft. The most commonly used methods to determine the complicated airport imaginary surfaces are FAR Part 77 "Objects Affecting Navigable Airspace" (FAA, 1993) and ICAO Annex14 "Obstacle Restriction and Removal" (ICAO, 2004). Both of them are used to identify potential aeronautical hazards thus preventing or minimizing adverse impacts to the safe and efficient use of navigable airspace.

The imaginary surfaces, which depict the ICAO Annex14 or FAR Part 77 regulations, are used to identify objects that penetrate these imaginary surfaces, to evaluate hazardous effects and to ensure the safe separation between aircraft and obstructions. While FAR Part 77 is commonly used only in the US, ICAO Annex14 is accepted by all countries except the US. These two imaginary surface systems were constructed using different criteria, dimensions, slopes, and even calculation units. Since government regulators or academics usually adopt one of them exclusively, airport planners or researchers may perceive ambiguous figures without clear comparisons. Especially for airports inside highly populated urban areas, the airspace size of the restrictive area and restrictive height may be critical to the degree of adverse impact on urban development. The purpose of this paper is to compare the differences between the ICAO and FAA systems and analyze their safety airspaces for facilitating future airport planning and management.

2. LITERATURE REVIEW AND METHODOLOGY

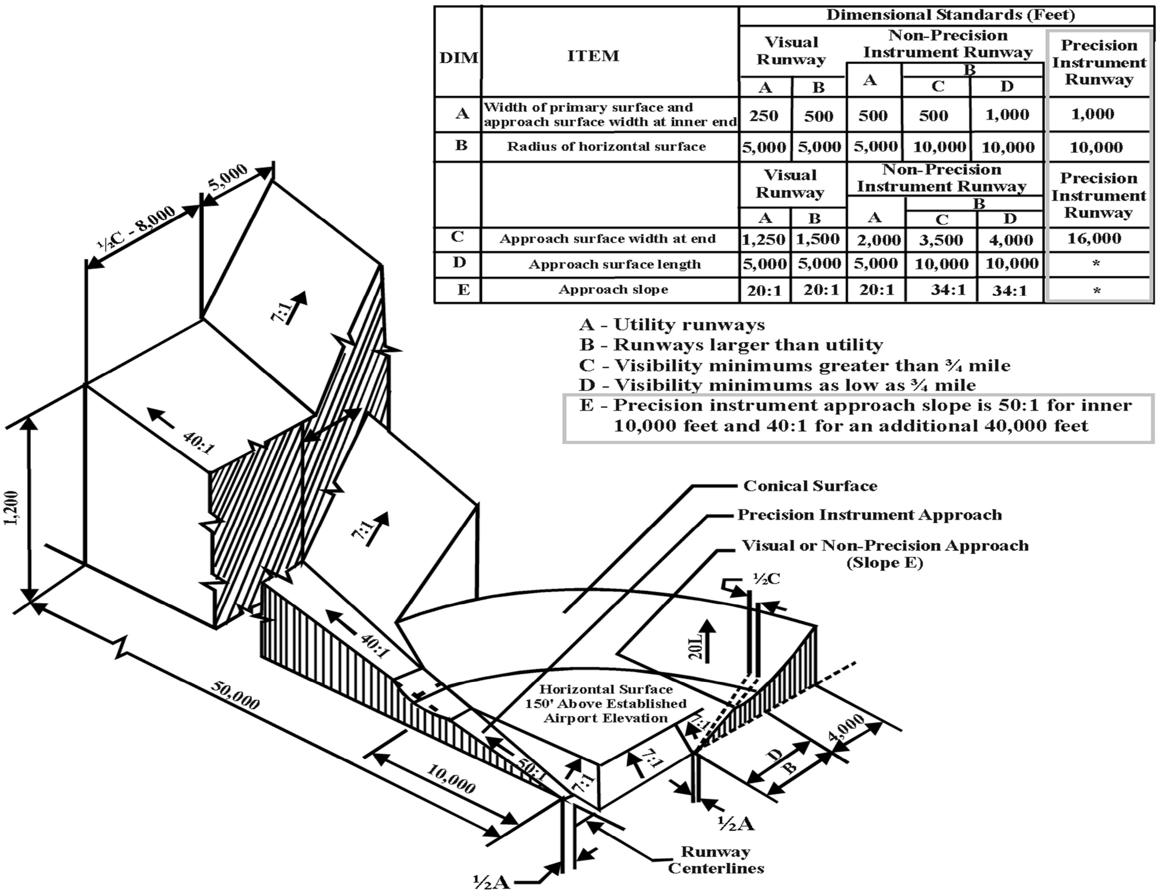
Horonjeff (1994) argues that the ICAO requirements are similar to FAR Part 77 with the exception of the approach surfaces, circular horizontal surface, and conical surface distance (Horonjeff et. al, 2010). In contrast, Kazda and Caves (2007) adopt the ICAO regulations without further discussion of the differences between the ICAO and FAR. Panayotov and Georgiev (2008) point out that the ICAO Annex 14 determines and establishes the standards to prescribe the physical characteristics of Obstacle Limitation Surfaces (OLS). Based on this document each country establishes detailed standards and regulations that are more restrictive than ICAO standards and are more appropriate for the specific country. FAA specifies the standards and regulations for the airports in the United States of America. Ulubay and Altan (2002) present an overview of spatial data integration from different aspects and explore the role of visualization. In the paper, they mainly use the ICAO Annex 14 regulations "Obstacle Restriction and Removal" and OLS, which is slightly different from FAR Part 77 "Objects Affecting Navigable Airspace" and OIS. Finally, Litsheim and Xiao (2009) comment that the most commonly used criteria to determine complicated airport obstacle surfaces are FAR Part 77 imaginary surfaces, TERPS, and the one engine inoperative obstacle identification surface for air carriers. That paper addresses the differences and relationships among these three criteria but only within the scope of FAA Regulations.

After examining the extant literature, we found that no journal or book draws up a clear picture of the differences between these two sets of regulations. By applying the analytical method in this paper, the design criteria of imaginary surfaces will be addressed, the imaginary surfaces along 3D coordinates will be re-constructed, the critical points will be identified, the volume of decomposed surfaces along critical points will be calculated, and the safety airspace of each imaginary surface will be analyzed and compared.

The characteristics of imaginary surfaces are specified on the basis of types of airports (transport, general aviation, heliports, etc.) and are related to the intended use of the runway in terms of take-off, landing and the type of approach (non-instrument approach, non-precision or precision approach). Within the scope of this paper, the comparison between FAR and ICAO Obstacle Restriction Regulations only focuses on major airports with large transport runways and precision instrument facilities which provide minimum visibility approaches as low as 3/4 mile.

3. OBSTACLE RESTRICTION REGULATIONS

Figure 1: FAR Part-77 imaginary surfaces (FAA, 1993)



DIM	ITEM	Dimensional Standards (Feet)					
		Visual Runway		Non-Precision Instrument Runway			Precision Instrument Runway
					B		
		A	B	A	C	D	
A	Width of primary surface and approach surface width at inner end	250	500	500	500	1,000	1,000
B	Radius of horizontal surface	5,000	5,000	5,000	10,000	10,000	10,000
		Visual Runway		Non-Precision Instrument Runway			Precision Instrument Runway
					B		
		A	B	A	C	D	
C	Approach surface width at end	1,250	1,500	2,000	3,500	4,000	16,000
D	Approach surface length	5,000	5,000	5,000	10,000	10,000	*
E	Approach slope	20:1	20:1	20:1	34:1	34:1	*

A - Utility runways
B - Runways larger than utility
C - Visibility minimums greater than ¾ mile
D - Visibility minimums as low as ¾ mile
E - Precision instrument approach slope is 50:1 for inner 10,000 feet and 40:1 for an additional 40,000 feet

3.1 Far Part 77 Objects Affecting Navigable Airspace

Subpart C of FAR part 77 establishes standards for determining obstructions to air navigation. The standards apply to existing and constructed objects, trees, and terrain. The Obstruction Identification Surfaces (OIS), depicting the standards, are used to ensure the safe separation between aircraft and obstructions. The dimensions of imaginary surfaces for the major airport with a large transport runway and precision instrument approach navigation aids are shown in Figure 1 and described below.

- Primary surface: Extends 500 feet on each side of the runway centerline and extends 200 feet beyond each end of the runway.
- Horizontal surface: Constructed by swinging arcs of 10,000 feet radii from each end of the primary surface and connecting each arc by tangent lines, with 150 feet above the established airport elevation.
- Conical surface: Extends outward and upward from the horizontal surface at a slope of 20 horizontal to 1 vertical for a distance of 4,000 feet.
- Approach surface: Extends outward and upward, diverging from the inner width of 1,000 feet to outer end width of 16,000 feet, at slopes of 50:1 for the first 10,000 feet of horizontal distance (nearest the runway) and then 40:1 for the next 40,000 feet of horizontal distance.
- Transitional surface: Extends outward and upward at a slope of 7:1 from the primary surface up to the 150 feet horizontal surface, and from the approach surface over a horizontal distance of 5,000ft.
- Obstruction to air navigation: These reach a height of 200 feet above the airport elevation up to 3 nautical miles from the Airport Reference Point (ARP) and increase by 100 feet for every nautical mile up to 500 feet at 6 nautical miles from the ARP. These standards for determining obstructions to air navigation are also contained in FAR Part 77, in addition to

the imaginary surfaces.

3.2 ICAO Annex 14 Obstacle Restriction And Removal

The objectives of the ICAO Annex 14 Obstacle Restriction and Removal are to define that the airspace around aerodromes is maintained free from obstacles so as to permit the intended airplane operations at the aerodromes to be conducted safely and to prevent the aerodromes from becoming unusable by the growth of obstacles around the aerodromes. This is achieved by establishing a series of Obstacle Limitation Surfaces (OLS) that define the limits to which objects may project into the airspace (ICAO, 2004). ICAO recommends that the following obstacle limitation surfaces shall be established for a precision approach runway category II or III. Even though ICAO uses different terminology, we try to categorize those OLS into groups with FAA's OIS by interpreting their design features.

- Runway strips: Similar to FAR's primary surface but with different calculation units.
- Conical surface: Similar to the FAR design feature but with a vertical dimension of 100 m, which is different from the horizontal distance of 4,000 feet in FAR.
- Inner horizontal surface: ICAO specifies that its shape is not necessarily circular, whereas in FAR it is constructed directly by swing arcs and tangent lines.
- Approach surfaces and inner approach surface: ICAO separates arrivals and departures and specifies dimensions for the approach surfaces and takeoff climb surfaces for departures. The takeoff climb surface has a smaller width, slope and divergence angle than the approach surface. If runway direction is intended to be used for approach and takeoff, whichever dimensions are more restrictive, such as the 2% slope, 15% divergence angle and 300 m length of inner edge must be adopted to meet both requirements. The inner approach surface is a rectangular portion of the approach surface for category II or III runways.

- Transitional surface: Similar design feature to that in FAR.
- Inner transitional surface: Similar to the transitional surface but closer to the runway, and intended to be the controlling OLS for navigation aids, aircraft and other vehicles near the runway.
- Balked landing surface: An inclined plane located at a specified distance after the threshold, extending between the inner transitional surfaces.
- Outer horizontal surface: An outer horizontal surface is a specified portion of a horizontal plane around an aerodrome beyond the limits of the conical surface. Its design concept is similar to the obstruction to air navigation of FAR but with only one criteria height of 150m.

4. COMPARISON BETWEEN ICAO AND FAR

After exploring the design criteria of two imaginary surface systems by applying the analytical method, the imaginary surfaces with similar design criteria can be categorized into groups for calculation. Table 1 shows the process as well as the results of categorization, conversion and calculation. Column 2 shows the imaginary surface dimensions of the ICAO regulations in the metric system. Since the definitions of some imaginary surface are noticeably different, conversion and calculation are necessary. Column 3 displays the dimensions after conversion to the imperial/USA system of measurement. Those values without an asterisk are specified dimensions, while others with an asterisk are the calculation results. It was found that the dimensions of some imagery surfaces, such as the conical and approach surfaces, are significantly different. Column 4 shows the FAR imaginary surfaces dimensions: most are specified while others are calculated. From columns 3 and 4 in Table 1, it is easy to compare the similarities and differences between ICAO and FAR imaginary surfaces. This table can be a useful reference tool to promote future studies and trade-off analysis to facilitate airport planning.

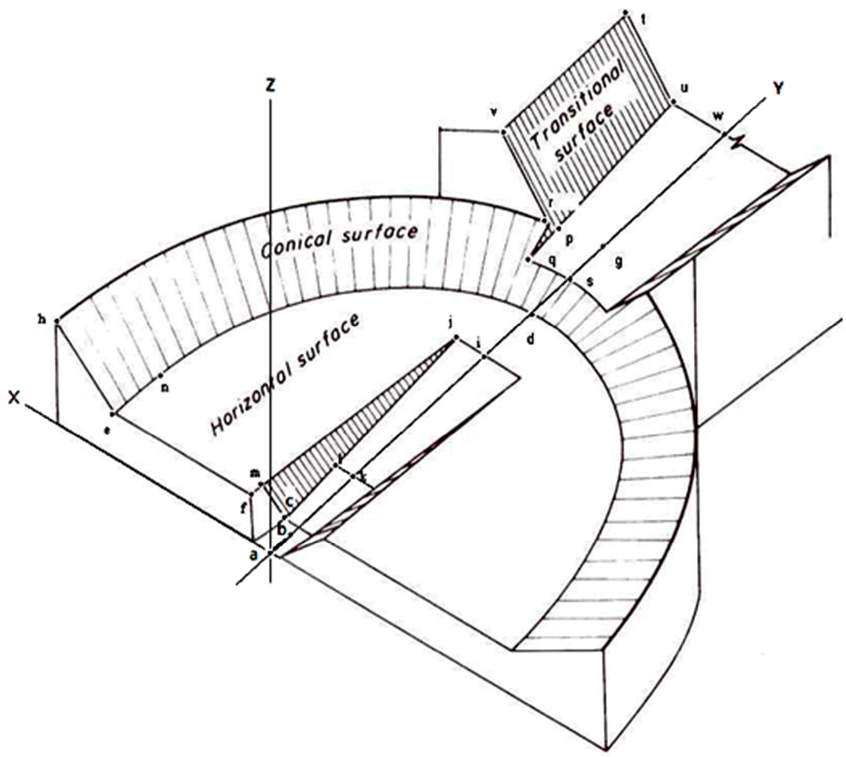
Table1: Comparison between ICAO and FAR

Surfaces	ICAO(m)	ICAO(feet)	FAR(feet)
Inner horizontal			Horizontal surface
Height	45	147.6	150
Radius	4,000	13,123.2	10,000
Conical			
Slope	5%	20:1	20:1
Horizontal distance		6,562*	4,000
Height (Total height)	100	328.1(475.7)	200*(350)
Inner approach			
Width	120	393.7	400
Distance from threshold	60	196.8	200
Length	900	2,952.7	3,000
Slope	2%	50:1	50:1
Approach			
Width of inner edge	300	984.2	1,000
Distance from threshold	60	196.8	200
Divergence (each side)	15%	15%	15%*
Width in final end	4,800*	15,747.8*	16,000
First section			
Length	3,000	9,842.4	10,000
Slope	2%	50:1	50:1
Second section			
Length	3,600	11,810.9	40,000
Slope	2.5%	40:1	40:1
Height		492.1	1,200
Horizontal section	(Limited by outer surface)		(Obs to air navigation)
Height	150	492.1	500
Length (Total Length)	8,400	27,558.7(49,212)*	(50,000)
Transitional			
Slope	14.3%	7:1	7:1
* - Calculated dimensions			

The safety airspace in this study is defined as the airspace provided by the imaginary surfaces system surrounding an airport in which the aircraft can takeoff, approach, land and operate safely. That is a measurement of volume which is calculated by multiplying the restrictive area with the restrictive height.

In order to compare the safety airspace, imaginary surfaces must be re-constructed into 3D coordinates. The critical points, which are necessarily for calculating each surface's area and volume, will be identified and located along 3D coordinates. The values of critical points along the X, Y and Z axes will be determined. Based on the critical points, the restrictive area and height of each surface will be decomposed and calculated. Figure 2 illustrates the process of re-constructing 3D coordinates, identifying critical points and decomposing imaginary surfaces.

Figure 2: Imaginary Surfaces along 3D Coordinates and Critical Points



Source: Adapted from Horonjeff and Mckelvey, 1994

Table 2: Safety Airspace Analysis for ICAO and FAR Imaginary Surfaces

	ICAO			FAR		
Surfaces	Dimensions (feet)	Area ($Mile^2$)	Volume ($Mile^3$)	Dimensions (feet)	Area ($Mile^2$)	Volume ($Mile^3$)
Outer horizontal		167.75	15.63		172.62	13.14
Height	492.1			200-500		
Radius	49,212.0			50,000		
Inner horizontal		9.70	0.27		18.97	0.54
Height	147.6			150		
Radius	13,123.2			10,000		
Conical		12.13	0.72		13.90	0.66
Slope	20:1			20:1		
Height	475.7			350		
Horizontal distance	6,562.0			4,000		
Approach		15.06	0.89		15.35	1.19
Width of inner edge	984.2			1,000		
Distance from threshold	196.8			200		
Divergence (each side)	15%			15%		
First section		0.55	0.01		0.57	0.01
Length	9,842.4			10,000		
Slope	50:1			50:1		
Second section		2.70	0.11		14.78	1.89
Length	11,810.9			40,000		
Slope	40:1			40:1		
Width of inner edge	4,593			4,600		
Width in final end	8,136			16,000		
Horizontal section		11.81	0.77			-0.71
Length	27,558.7			25,926.6	(Obstructions to Air Nav)	
Height	492.12			500		
Width in final end	15,748			16,000		
Total length	49,212			50,000		
RCKH runway length:10330ft; Width: 200 ft; Precision instrument approach Cat II						

By applying the logic analysis and basic mathematics, the measurements of area and volume for each imaginary surface are calculated. Table 2 shows the results after calculations. The imaginary surface, which specifies a larger area and lower height, yields a more extended obstacle separation, safer airspace, larger land-use requirement and therefore has more adverse effect on neighboring urban development. Intuitively, the measurement of volume may not vary proportionally with the degree of safety airspace, because volume is the product of two opposing factors, area and height. In any respect, if height is constant, a larger area is more restrictive. On the other hand, if the area is constant, a lower height is more restrictive. Generally, if one of the factors is constant, the volume comparison is meaningful.

For the comparison of outer horizontal surfaces, the FAR requires less volume and safer airspace than ICAO, since it has nearly the same area but lower height. For inner horizontal surfaces, the ICAO has a longer radius but much smaller area than FAR, if the circular shape is intended to be used. With equal height and two times larger area, FAR has a much safer airspace than ICAO. If taking the horizontal section into account, the FAR approach surface also has a slightly safer airspace than ICAO. With all other surfaces which are not significantly different in size, FAR generally has a safer airspace than ICAO.

5. CONCLUSION

For the purposes of both airport engineering and airport planning, a better understanding of these different obstacle surfaces and their application is important. This paper compares the safety airspace of the FAR Part 77 “Objects Affecting Navigable Airspace” and ICAO Annex14 “Obstacle Restriction and Removal”. By applying the analytical method, the comparison of imaginary surfaces between ICAO and FAR was thoroughly investigated. The results can be a useful reference tool for promoting future studies and for use in tradeoff analysis to facilitate airport planning. By using basic mathematical calculations, the restrictive area and height for each imaginary surface were computed. It was found that FAA regulations of Objects Affecting

Navigable Airspace specify a more extensive obstruction clearance and presumably safer airspace and consequently has a more restrictive influence on urban development.

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SOCIAL SKILLS TRAINING IN FLIGHT SCHOOLS: A PROACTIVE TOOL FOR MANAGEMENT THREATS AND RISKS

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ABSTRACT

Safety Management Systems in aviation generate training programs that develop skills needed to perform safety functions. The objective of this study is to show that, in groups, individuals need to have interpersonal skills and, in particular, ability to communicate with others, to listen, and to influence. It is for this reason that Social Skills Training is important in Aviation. Professionals trained in social skills are more likely to identify threats and risks caused by interpersonal situations, be assertive, and take appropriate action. As a contribution, this paper suggests a set of policies, procedures and practices for educating and training future professionals who will work in aviation safety.

Keywords: Aviation safety, communication, interpersonal skills, social skills training

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1. INTRODUCTION

A previous research conducted by Sexton and Helmreich (2000), which covers two decades of the Aviation Safety Reporting System (ASRS), indicates that over 70% of the accidents or incidents that occurred in Aviation were, directly or indirectly, associated with interpersonal communications matters. "Factors related to interpersonal communication have been implicated in up to 80% of accidents in aviation over the past 20 years", concluded Krifka, Martens, and Schwarz (2003, p. 1).

The Federal Aviation Administration – FAA - (2004) confirmed that communication matters have been responsible for approximately 80% of accident and incidents in aviation over the past 20 years. A faulty communication tends to generate fatal errors of understanding. Language misunderstandings, incorrect use of expressions, accents, slang, the tone of voice are pointed as some human communication factors which can interfere positively or negatively on flight operation.

Bühle (2008) presented the results of a research called "Cockpit Human Factor Research Project" on the Trilateral Safety & Mission Assurance Conference, in 2008. According to him, 2100 pilots responded anonymously a questionnaire about their last critical incident. So, over 3.200.000 factors were pointed out and have been analyzed. These amounts could be categorized in nine different categories of factors as such: Design, Construction, Software, Hardware, Maintenance, Dispatch, Air Traffic Control, Flight Planning and Flight Operations. The last two categories regarding flight planning and flight operations were written in red and bold letters by Bühle.

Digging deep into the causes of the reported incidents, it was observed that in 48% of all cases matters that emerged were related to: calls out that have not been made; considerations that have not been made, messages that have not been transferred, were overheard or misunderstood (Bühle, 2008).

Bühle research (2008) stressed that social interaction difficulties within a team may increase the number of critical incidents. Driven by Bühle´s research outcomes, Lufthansa Airline has underlined a requisite program addressing human relationships and interactions development. By establishing social intelligence and interpersonal competences, Lufthansa concluded that 80% of accidents could be avoided if there was an appropriate interaction among the flight team members (Anderson, 2011). However, the responsibility for decisions made during the flight is restricted to the command of the aircraft, with the support of the on the ground staff. In this way, to reach positive results it is important that the officers involved are able to overcome the most common communication barriers. In this case, it is essential that the information from the cockpit to the aircraft control, and vice versa, is transferred with clarity and completeness.

People whose work activities require continuous interaction with human beings often lack the social skills necessary to perform their job safely, leading to unnecessary escalation of risks. Social Skills Training (SST) can help aviation professionals who are involved in operational duties, such as private pilots, helicopter pilots, flight controllers, flight dispatchers, airport staff, flight attendants, aircraft maintenance professionals, managers, employees and airport security agents; in short, all these professionals should be submitted to a social skill training to foster safe aviation, to deal with difficult interpersonal situations through effective self-control and better understanding of others.

Crew Resource Management (CRM) training was a great success for normal and routine operations bringing change to the aviation industry and increasing the overall level of safety. However, recent accidents and incidents demonstrate that CRM problems remain a source of air accidents. Therefore, continuous improvement of training techniques must take place so that they address the shortcomings of existing approaches: "Although the CRM exert positive and traceable effects on the crew behavior, these effects are of short duration" (Helmreich, Merritt, Wilhelm 1999, p. 10). Furthermore, failure in CRM training remains the main reason found in nearly 30% of aviation accidents" (Wiegmann and Shapell, 2001, p. 28).

For instance, CRM failures were identified in nearly one out of every five air carrier accidents examined. Even more interesting, the nature of the CRM failure differed between the two commercial operations. That is, while over 60% of the CRM failures associated with air carrier accidents involved "inflight" CRM failures (e.g., inflight crew coordination, communication, monitoring of activities, etc.), over 80% of the CRM failures observed during commuter operations involved "pre-flight" activities such as planning and briefing (Shappell et al., 2006).

The causes for these failures are believed to be mostly related to language, interpersonal communication and social skills. One could ask if CRM should include emphasis on SST to improve safety performance even further (FAA, 2004). In fact, researchers have shown that

SST in teams is tightly linked to the development of individual skills (Mohrman, Cohen and Mohrman, 1995; Dickson and Hargie , 2004; Sexton and Helmreich, 2000; Segrin and Flora, 2000; Krifka, Martens and Schwarz, 2003; Caballo, 2006). This is because, if the individual does not develop or assimilate SST, the result will be difficulties in the ability to think and interact in a team. In other words, individuals need to recognize their own strengths and limitations and strive to overcome weaknesses through the use of SST.

> *"Before working in groups, individuals need to develop interpersonal skills and, in particular, the individual capacity to relate to others, listen to them, influence them, and so on" (Mohrman, Cohen and Mohrman, 1995, p. 21).*

According to the Flight Safety Foundation (FSF, 2009) the technical and non-technical aspects of flight operations are like two sides of the same coin that cannot be evaluated separately. So the first rule is to consider technical and non-technical skills as elements of a set of integrated skills. And for that to happen, it is important to change the traditional teaching method to a more holistic approach. Thus, there is a clear need to review the curricula of aviation schools with this in mind.

Based on our literature review the study proposes a reflection on current practices to encourage new holistic training environments pushing aviation safety one step forward. The article seeks to demonstrate the relevance of the SST to mitigate safety threatening communication errors.

2. SOCIAL SKILLS

The terms "social skills", "interpersonal skills" and "communication skills" are often used interchangeably. The latter, however, may cover writing skills. In academic and professional areas, the most common concept used is "interpersonal competence" or "social skills" (Dickson, 2004). Social skills include interpersonal relationships, assertiveness (expression of negative feelings and defending own rights), and communication, interpersonal problem-solving, and cooperation.

Social skills involve the ability to establish and maintain productive and satisfactory interactions (Del Prette and Del Prette, 2004) in both routine and non-routine situations. According to Pestana (2006), interpersonal communication is the process by which information is exchanged and understood by two or more persons, usually with the intent to motivate or influence behavior. The communication process occurs when two people interact involving a merger of mutual roles and mutual empathy.

In safety situations, assertive behavior is generally appropriate and generates better reinforcement of appropriate procedures than other types of behavior: an individual has more opportunities to express himself freely and to achieve his goals without harming himself and others. An aggressive stance will stir up feelings of opposition in others, leading to criticism and rejection. Non-assertiveness prevents the achievement of goals, submission to the will of others, and loss of respect for own rights.

The Social Skills Training (SST) consists of providing technical instruction, behavioral rehearsal, simulation, verbal and video feedback, housekeeping, cognitive restructuring, problem solving, relaxation (Caballo, 2006) and the use of experiences according to Del Prette and Del Prette (2004). Segrin and Flora (2000) concluded that social skills can generate significant benefits in people's lives, especially those subjected to work in unsafe and stressful conditions.

Professionals with higher levels of social skills deal with stress more easily and cope better in risky situations, while individuals with less social skills aggregate problems when confronted with stressful events: So in the field of aviation, there are significant advantages in acquiring social skills. When socially skilled these professionals can contribute significantly to improve the organizational environment, as well as the quality of intra- and intersectoral relationships, and the relationship with suppliers, customers and the public.

We use the definition of Caballo (2006) in which social skills are a set of behaviors of an individual in an specific interpersonal context, expressing feelings, attitudes, desires, opinions or rights adequately to that situation, respecting others and solving the immediate problems of the situation while minimizing the likelihood of future problems. And, we will include in this definition, verbal behavior, nonverbal behavior (body expression, gaze and gestures) and written communication.

The “theory”, if one can call it, behind SST is to teach the trainee those ways of interacting that will be pleasing and attractive to others (to enhance affiliations with them) and to interact in ways that are effective (to enhance the attainment of instrumental goals through interaction with others). It is generally assumed that enhancement of these skills will ultimately lead to greater personal happiness and success, as well as to more positive and less negative effect in those who interact with the trainee.

The offering of a SST course in flight (and related to flight operations) schools is primarily intended to make communication a skill that must be developed and exercised by future professionals. We argue that technical skills are not enough to make a fully effective professional. Candidates need to have strong interpersonal skills in order to work effectively in teams. Personality factors may be a limitation on the effectiveness of CRM training (Helmreich et al., 1996). Clearly, we need to devote much energy to create new strategies to improve social skills for future aviation professionals, on air or on the ground.

2.1. Social Skills and Aviation Safety

What ordinary individuals say and do in a routine situation can rarely affect, in a decisive way, the lives of hundreds of people. However, in an emergency, a late message, misinterpreted or not carried out could lead to disastrous results. It is therefore important that workers exposed to situations of extreme risk are well trained in technical and non-technical skills.

Getting a mutual understanding among all those who are involved with flight operations, seeking to articulate interests and monitoring communication conflicts, one can avoid situations as shown in the excerpts below taken from the confidential forms Aviation Safety Reporting System (ASRS) in which problems are voluntarily reported with no punitive consequences to make sure that situations that could have caused an accident or incident are reported.

Ultimately better interpersonal communication between the CA and FO is needed. A strong factor in this loss of radio communication with ATC was a high level of animosity between the CA and FO. Throughout this rotation the FO was consistently hesitant/slow to perform her duties and when she did so she was often "inaccurate" and defensive. On this final leg of a multi-day day trip, this less than professional performance by the FO began to wear on the Captain. There was minimum communication between the two by this point and when the FO was not willing to update the FMS as the CA requested the CA became very frustrated (ASRS, 2009).

Poor CRM and communication between the First Officer and Captain was a significant factor. I was timid based on past history with this Captain and I never clearly and confidently told the Captain to stop the plane when I saw him taxiing without a clearance. Certain hazardous attitudes, including get-home-it is and aspects of anti-authority, invulnerability, and macho definitely affected the Captain's decision making [...]. The result is a breakdown of proper teamwork and open communication between pilots in the cockpit, and an operation that decays toward a single-pilot operation by the Captain (ASRS, 2009).

Call the dispatcher 15 minutes prior to departure to amend the release. He asked me why the fuel-load changes and I told him I had added the fuel. He said that was unacceptable and not going to agree to it and hung the phone up. So I called back and talked to the duty mgr and explain why I added the fuel and expressed my dissatisfaction with the dispatcher's interpersonal skills. Synopsis: A B737 captain increased the flights fuel load by 1000 lbs for enroot WX. His dispatcher strongly disagreed and threatened action against the pilot (ASRS, 2008).

This is not the first NASA report I have submitted, but it is the first one that I have submitted where the problem I believe was entirely due to a lack of communication on the flight deck. I am a female captain and have had some problems in the past with attitudes towards me. But it has never been this pronounced and never resulted in any real problem event. I arrived at the aircraft and met my first officer, whom I had never met before. He seemed reserved and did not say much. I was not sure why but hoped that he was just nervous or uncomfortable for some reason and that he would loosen up. Sometimes I have found that men are at first uncomfortable with women pilots. But usually I can overcome that by being relaxed and friendly. I attempted to strike up conversation, asking about his family, where he lived - the usual. He answered with one word responses and never pursued conversation further. [...] in normal circumstances I will communicate to my first officer a reminder that we will need an amendment to our release before departure as a way of reminding him and myself. I thought of this, but did not say it. I felt as though words would be wasted and that he would not probably even acknowledge my remarks so I did not verbalize my thoughts. Synopsis: interpersonal relationships and CRM issues result in enough distress to cause operational and performance problems on a crew (ASRS, 2000).

The Captain, it's not a democracy, it's a dictatorship, and that really is just the way it is. [...] This Captain is on a hair trigger regarding Captain's authority. My "insubordinate act" caused *him to lose control in the cockpit, act verbally and physically aggressively with me, and endanger the operation. Had I been on a similar hair trigger, the situation might have easily evolved even further. 2) In spite of his statement during the initial brief that he flies the aircraft as the company wants us to fly it, I think the numerous events of this sequence do not bear that out: the non-standard take-off briefing, non-inclusion of the First Officer during FMC edits, requesting non-FMC or flight plan altitudes, exclusion of the First Officer during planning, and entirely disregarding First Officer's input or concerns. In fact, I cannot think of a single time that any of my suggestions, offers to help, or input, were accepted. They were usually completely ignored. 3) I generally disregard other pilot input regarding eccentric Captains, as my experience is that I am able to fly with most anyone. That said, during this sequence, no fewer than four pilots said "sorry" or something to that effect, when they found out that I was flying with this Captain. Clearly this Captain has established a reputation, and it isn't good (ASRS, 2010).*

Typically, emotional reactions generate irrational behaviours that can place people in a bad mood to the point of refusing support. A poorly handled communication often results in taking contradictory positions, and, in aviation, where teamwork is an important tool, it represents a serious flaw. Assertive communication is essential for good teamwork, it is a means of attracting attention and respect of others without being submissive or aggressive. Pilots and airline staff should be helped to identify their weaknesses and strengths and should be trained to exercise discernment ability, flexibility, style and ability to handle different types of conflicts.

According to Caballo (2006), social skills training enables to develop cognitive abilities that enable the development of more accurate expectations about one's behavior, more positive expectations of consequences, more tolerance for conflict, more positive personal communication, view situations from multiple perspectives, and greater knowledge of assertive content.

Kellermann (1992) argues that in shaping the future professional the fusion of communication with social skills is intentional and necessary so that the communicators are able to recognize their needs and motivations and realize they can choose to conduct special communication to meet such needs and motivations. To adapt communication means that communicators must adapt what they say and what they do on an on-going basis in response to the goals they pursue and within operational limitations.

The crew when trained with the ability to properly communicate a problem, besides having the facility to apply objectively the information that could help them, are able to communicate clearly their intention to act, ensuring that other members of the crew and flight controllers are successful in determining corrective actions.

Hawley, administrator of the Transportation Security Agency, USA, in an article published in the New York Times, stated that the evolution of security in airports these days focuses on social skills training of agents (New York Times, 2008). The training is geared towards the maintenance of mental serenity, to ensure an environment of organization, reducing occurrences of aggressive talk and behaviors, thereby neutralizing disruptions that could result in incorrect or sarcastic answers, which hamper the resolution of problems and facilitate the creation of a hazard.

The Federal Aviation Administration (FAA) and the Airport Consultants Council (ACC) published a list of Best Practices to encourage improvement of interpersonal communication:

Common to all activities, and perhaps most important of all, are the personal relationships that exist among the individuals of the organizations involved. Recognizing the importance of this, the list of best practice opportunities begins with Relationships/Communication and Conflict Resolution (FAA /ACC, 2008).

However, a list of a short duration workshop, despite being a positive step, cannot be considered a sufficient initiative to promote good interpersonal relationships. According to SMS, professionals in aviation training should develop and maintain a training program that offers the professional the necessary abilities to perform their functions of safety.

It is imperative to monitor and anticipate undesirable situations that may occur during flight and properly communicate the hazards and risks in an adequate time, and take appropriate measures to solve the problems encountered. This is the reason why we need to train people on interpersonal communication skills to act in these organizations in order to avoid situations that pose a risk to flight safety as shown in the example below.

SAO PAULO - The Air Force and Fligh Protection Service in Sao Paulo, Brazil, investigate a dispute between a pilot and a controller in midair. The two disagreed on a manoeuvre. The discussion took place at 6am.

Controller: You can fly the way you want, make it around wherever you want. No need to call me to fly over this area like the way you are flying. OK?
Pilot: I think it is an absurd you send me one back flying for standing by at Six o clock in the morning, waking everybody up there, is absurd!
Controller: You do not even know how to fly and now wants to be a flight controller, commander? Who is in control is me, I know what I'm doing, the way you wanted to would lead you to a final resolution.
Pilot: You do not even know what is a final resolution, I'm almost five miles away and you talk about the final resolution, this is absurd, waking up everyone there.
Controller: Learn how to fly, commander!
Pilot: I know how to fly, I have over 27 years of flying. And you do not know how to control. You should control something else, not a plane or a helicopter. This is absurd!
Controller: I'll let this registered here and we'll see what is absurd!
Pilot: Let it be recorded, then.
Controller: Learn how to fly, sir.
Pilot: I have been a licensed pilot for the last 27 years, you must be very young. Six o'clock in the morning and here I am stressing myself with a controller! You want to kill us all!
(Globo News, 2008)

Flight controllers and pilots must be skilled communicators, people who develop an ability to capture the widest range of signals available. They should be flexible enough to quickly change their own attitude, in order to avoid deterioration of communication that can cause an accident. In fact, unskilled communicators tend to remain within a narrow band of behaviours.

The social skills training uses techniques designed to encourage individuals to become more aware of their egos and analyse the communication between people. This will allow them to consider alternative responses when interactions are not successful.

3. SST IN AVIATION COURSES

The main recommendation of this study is that SST should provide a secure platform for the development of social skills, taken as a key resource for future professionals to act properly in managing the risks incurred during communication, rather than react to them. SST needs to become the essential link that will integrate social skills with technical skills. The combination of "technical and social skills" appears here as a fundamental tool for the qualification of instructors of aviation schools and all who participate in the training and evaluation of future professionals performance.

The program of the Social Skills Training (SST) should provide techniques and activities that capitalize on three types of mechanisms: acquisition, refinement and strengthening of these skills. It's important to point out that the process of learning social skills is not the same used in learning other skills, it is a phenomenon closely linked to the issue of self-esteem. Students may perceive, for example, some suggestions of change as a threat. To support and ensure a safe environment, there is the need, therefore, of additional reinforcements, for example, positive comments and compliments.

In the early stages of interaction with others, participants may be affected by insecurity. It is therefore important that SST takes place right from the beginning. Thus, at the end of SST, they will have learned to control anxiety and be able to experiment with this ability on other aspects of the training course.

Individuals cannot watch their own behaviour, however, observing the behaviour of others provides a mental image of how behaviour can and should be performed, arousing feelings as "this task can be accomplished" or "something can be done to solve this problem or achieve this goal." When people have no sense of effective response, they may perceive a situation as hopeless and without a solution.

The basic format recommended for Social Skills Training (SST) is summarized below. This format is based on the "Handbook of assessment and training of social skills" developed by Caballo (2006), in "Psychology of Interpersonal Relations" developed by Del Prette and Del Prette (2004), with additions provided by the authors of this paper.

3.1. Basic Format of Social Skills Training (SST)

3.1.1 Objective

To develop skills for interpersonal communication, verbal, nonverbal, written, as well as effective listening, adopting discursive styles that best benefit the productive relationships necessary to Aviation Security, given the stressful nature of this relationships, the rapid pace and the large amount of information that characterize the Aviation environment.

The main purpose of this training is to help students develop social skills for effective communication in order to mitigate interpersonal problems that may affect Aviation Safety.

3.1.2 Methods

Use real situations observed in aviation to determine the inadequacies in communication, in order to:

- Distinguish the difference between assertive responses from non-assertive and from aggressive responses.
- Correct the non-assertive modes of communication.
- Help students to recognize that everything they say or write can influence feelings and behaviours.

3.1.3 Training Techniques

i. Role playing: students represent short scenes that simulate real life situations. Through this procedure, they can develop appropriate and effective ways to address problematic situations in the aviation environment. In summary, the role playing technique will enable the student to:

   a) practice social skills in simulations;
   b) be informed about their performance, through audio or recorded video; and
   c) discuss their performance with instructors and other students.

   The purpose of Role Playing Training is to learn to modify non-adaptive response modes, replacing them with new responses.

ii. Modelling: Student exposure to a model that demonstrates a correct way to address a particular situation, enabling observational learning. Modeling can occur live or via recorded video. This technique has the advantage of showing verbal, non- verbal and paralinguistic components.

iii. Feedback: procedure which "returns" to the student all the information about playing the role assigned to it. It is a regulatory mechanism of performances. Feedback allows the correction, maintenance and improvement of the relationship between performance and results, allowing students to observe how they behave and how their behaviour can affect other people.

iv. Experience: Use of experience allows the instructor and the students not only to see more clearly communication difficulties but also to redefine general objectives clearly (Del Prette and Del Prette, 2004).

3.1.4 Evaluation of SST

Caballo (2006) calls "generalization and transfer" the assessment phase of training with regard to retention, application, and behaviour change. The main aim of any training program is not classroom performance; rather, it must demonstrate its power, stability and usefulness in real life.

SST in Aviation, generalization and transfer are observable features through the practice of technical exercises, such as simulator training, training of board service, first aid, sea and land rescue, plus other technical training programs developed for each function in Aviation.

The instructor observes all forms of social interaction that the student uses during technical exercises and how communication affects performance. At the end of the first year of practice, he examines technical results in order to identify failures or successes. Depending on the results achieved a certificate will be issued. Pointing out deficiencies or interpersonal communication skills used by the student and how that communication contributed to his performance, always emphasizing that the good result of technical manoeuvres depends on good communication skills.

4. CONCLUSIONS

In this paper we emphasized the relevance of the role of social skills in aviation. Moreover, we aimed to develop awareness of communication processes and their implications to aviation safety. We offer the following conclusions:

1. Aviation schools need to offer content related to the development of social skills in order to match the needs of airlines operations.
2. Training Social Skills because 80% of all "Human Errors" in complex situations can be avoided with proper social interaction.
3. The program of the Social Skills Training (SST) should provide techniques and activities that capitalize on three types of mechanisms: acquisition, refinement and strengthening of these skills.
4. A complete training process in aviation and flight operations must focus both on technical and interpersonal issues.
5. Theoretical knowledge of communication skills is not enough to directly influence performance: formal training in communication skills requires active learning. It must be intentional, systematic, specific and also experimental.
6. The development of personal skills is a relevant tool, significant to the effectiveness of CRM training, and offers the opportunity for each individual to analyse her/his

own attitudes and to promote appropriate changes in order to improve teamwork ability.

7. The SST is complementary and aims to improve students' performance, helping them not only to understand the appropriate communication skills, but also to learn and incorporate appropriate behaviours in their daily practices.
8. Supporting aviation professionals to develop their social skills can be seen as a proactive strategy to develop an appropriate communication process and improve the decision making process, especially in situations of danger or imminent risk. And finally, the developmental process will gradually increase the aviation safety.

We have argued the importance of training social skills in the aviation community to improve aviation Safety. We based our theses on the recurrent incidents of communication breakdown between the various actors in aviation leading to accidents and incidents. We hope to raise awareness in the aviation community and hopefully stimulate further research on the role of SST, in the belief that such measures may move aviation safety one imperative step forward.

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