# HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM (HFACS):

## As Applied to Asiana Airlines Flight 214


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### Mentor

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## Abstract

The Human Factors Analysis and Classification System (HFACS) is a safety tool that aids in the identification and analysis of organizational factors that contribute to aircraft accidents. By using the HFACS model, safety investigators can better understand the existing conditions that contribute to accidents, which then allows for the development and implementation of safety programs to prevent these conditions. In this study, the HFACS framework was utilized to identify the human factors that contributed to the Asiana Airlines flight 214 accident that occurred on July 6, 2013. The results of this study indicate that inadequate pilot training, lack of upper-level supervision, and recurring deviation from standard operating procedures (SOPs) largely contributed to this accident. These findings emphasize the various organizational levels that serve a role in aviation accidents, highlighting the importance of practicing a proactive approach to safety and mitigating hazards within the upper levels of an organization before they lead to disaster on the front line.

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## Keywords

aviation safety, HFACS, human factors, flight 214, civil aviation, Reason model, Boeing 777, human error, organizational factors

## INTRODUCTION

The first plane crash occurred on September 17, 1908, killing its one passenger and injuring the pilot, Orville Wright. Following this accident, Lieutenant Frank Lahm conducted the first airplane accident investigation, identifying the cause of the accident to be an equipment malfunction (Lerner, 2018). During those first few decades of aviation, the majority of accidents were caused by technical factors, meaning the fault often lay within the construction of the aircraft (Rankin, 2008). While technical issues still persist today, the leading cause of accidents has expanded to encompass a much broader scope of contributing factors. Currently, many of those contributing factors are a result of human error stemming from mistakes made within the upper levels of an organization, the safety and financial decisions made by the heads of the company (Shappell et al., 2006). This ever-increasing presence of human factors in aviation accidents necessitates the need for an in-depth and systematic approach to studying the human component of aviation from all perspectives; hence, the Human Factors Analysis and Classification System, or HFACS, was born.

The HFACS framework shown in Figure 1 highlights the latent conditions and active failures responsible for an accident by separating human error into four categories, each of which is then broken down into subcategories in an attempt to better identify all possible problem areas (FAA, 2006). Through the use of this systematic approach to accident investigation, the most unpredictable aspect of aviation—the human component—can be better isolated, analyzed, and even predicted. This study reinforces the benefits of applying HFACS to civil aviation by utilizing the HFACS framework to analyze Asiana Airlines flight 214.

## METHODOLOGY—THE HFACS FRAMEWORK

Dr. Shappell and Dr. Wiegmann developed the HFACS framework in the early 1990s to assist the United States Navy in decreasing its number of aircraft accidents resulting from human error (Wiegmann & Shappell, 2009). It builds off of the Swiss cheese model, also known as the Reason model (Figure 2), which is a visual aid that illustrates the multifaceted relationship between the events leading up to an aircraft accident (FSF, 2016). Figure 1 shows the four main levels of HFACS as well as the branches within each level. Upon implementation in the Navy, the HFACS framework decreased the percentage of accidents related to human factors by approximately 50% (Wiegmann & Shappell, 2009). HFACS has also

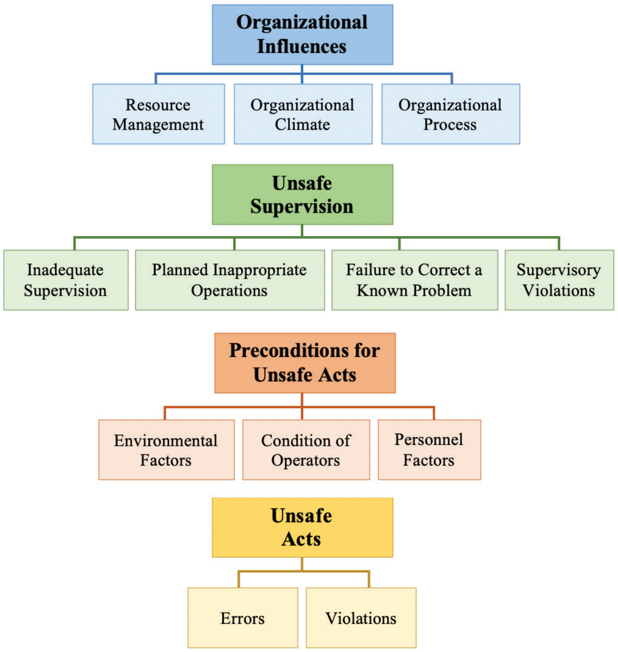


**Figure 1.** The HFACS framework. Adapted from the HFACS model developed by Wiegmann and Shappell (2009).

been used in various non-aviation industries such as healthcare, but it has yet to experience wide-scale implementation in civil aviation.


**Figure 2.** The Reason model. Created by James Reason, this model illustrates the interdependence of latent conditions and active failures in accident causation. Image source: HFACS Inc. (2014). The HFACS Framework. (Used with permission.)

The focus of this study was to emphasize the benefit of applying HFACS to the civil aviation environment. With regard to aviation accident data, government archives were referenced from the National Transportation Safety Board (NTSB), Federal Aviation Administration (FAA), International Civil Aviation Organization (ICAO), and Department of Transportation (DOT). Though HFCAS is traditionally applied as a bottom-up approach, this study was conducted from the top down, starting at the highest organizational level as opposed to the front line. This top-down approach highlighted the impact that the upper levels had on the lower levels, better demonstrating the correlation between upper-level decision-making and frontline consequences. The results of this study indicate the myriad of organizational factors that foreshadowed the Asiana Airlines flight 214 accident, further emphasizing the necessity of implementing safety intervention programs to combat hazards before the culmination of an accident.

## THE ACCIDENT—ASIANA AIRLINES FLIGHT 214

Asiana Airlines flight 214 was a transpacific passenger flight traveling from Seoul, South Korea, to San Francisco, California. The aircraft involved was a Boeing 777-200ER that crashed on final approach, the phase of flight immediately prior to landing. The approach to landing was extremely unstable, resulting in the aircraft impacting the seawall and ripping apart just before the start of runway 28L (Figure 3). On board were 291 passengers, 3 of whom suffered fatal injuries. Forty other passengers were seriously wounded, along with eight flight attendants and one crew member (NTSB, 2014).

**Figure 3.** The crash site. Image courtesy of the National Transportation Safety Board (NTSB). (2013, July 7). View of damage to the fuselage of Asiana flight 214. (Used with permission.)

Upon investigation, the NTSB found that the probable causes of this accident were the flight crew's mismanagement of altitude control, inadequate monitoring of flight instruments, and poor decision-making (NTSB, 2014). Some other contributing factors were the complex but poorly documented autothrottle procedures, the flight crew's deviance from standard communication protocols, inadequate pilot training with regard to visual approaches, inadequate supervision from the captain, and crew fatigue (NTSB, 2014). The root cause behind each of these factors can be traced back to various levels within the organization, meaning that this accident was not an isolated incident due solely to pilot error. Instead, it was the inevitable result of copious unsafe practices being allowed throughout Asiana Airlines, stemming from problems within the organization's upper-level management.

## RESULTS AND DISCUSSION

### Organizational Influences

Organizational influences is the highest level of HFACS, consisting of the following three branches: resource management, organizational climate, and organizational process. Resource management encompasses factors such as human resources, budget restrictions, and equipment issues (Wiegmann & Shappell, 2009). In regard to flight 214, the most applicable issues within this branch were complex aircraft design and inadequate pilot training. As depicted in Figure 4, the Boeing 777-200ER is an extremely complex aircraft, hosting an abundance of complicated technology unique to Boeing aircraft. Unfortunately, Asiana Airlines' training procedures were inadequate, rendering its pilots unaware of the inner workings of the various systems. In the accident report, the NTSB included statements from 777 ground school instructors explaining the training anomalies, confirming that the formal slideshows used by Asiana lacked vital information (NTSB, 2014).

The pilot flying was insufficiently trained on the use of the autopilot and autothrottle systems. During the approach to landing, he initially misprogrammed the autopilot, causing the aircraft to climb instead of descending toward the runway. In response to this, he turned off the autopilot and pulled the throttle to idle. Since all of the systems in this aircraft are interconnected, when the pilot pulled the throttle to idle, he also unknowingly turned off the automatic airspeed control. For the remainder of the approach, the aircraft gradually decreased to dangerously low airspeeds, which went unnoticed and uncorrected up until the crash. These mistakes were a result of inadequate training on aircraft systems as well as approach procedures, emphasizing the impact that upper-level training decisions have in the frontline environment.

The next branch is organizational climate, which includes areas such as structure of command, company policy, and company culture, specifically in relation to norms and attitudes toward safety (Wiegmann & Shappell, 2009). At the time, Asiana Airlines lacked a robust safety culture, which allowed for the existence of a myriad of unsafe policies, one of which was its automation policy. Asiana emphasized full use of automation, directly discouraging pilots from manually flying the aircraft. This resulted in skill deterioration throughout the

**Figure 4.** Boeing 777-200ER cockpit. Image source: Rowson, J. (2016, January 15). Boeing 777-200ER flight deck. (Used with permission.)

company, rendering pilots inexperienced in manual flight and over-reliant on automation. A lack of understanding of the pilot-automation interface resulted in an increase in workload and loss of situational awareness, accomplishing the exact opposite of technology's intended purpose (FSF, 2019). It also fostered complacency, creating an environment where the pilots were incapable of manually recovering the aircraft. This also ties into the third branch of organizational influences, organizational process.

Organizational process involves stressors such as deadline pressures, quotas, and standard operating procedures, known as SOPs (Wiegmann & Shappell, 2009). In this scenario, lack of proper oversight coupled with inadequate procedural documentation resulted in a work environment full of ambiguity. The pilots were unprepared to safely respond to this situation because of Asiana's informal policy resulting from ambiguous procedure documentation. There were discrepancies between how the approach was taught during training and how the approach procedures were dictated in the manual. Because of this, pilots created their own informal practices, actively deviating from SOPs and eliminating the possibility for standardization. This contributed to the pilot flying's initial misprogramming of the autopilot since he had no standard set of procedures to reference regarding how the technology should be programmed. This can be traced back to lack of oversight from Asiana Airlines. Through inadequate oversight and lack of enforced standardization, Asiana provided the foundation upon which this accident could unfold.

## UNSAFE SUPERVISION

The second-highest level of HFACS is unsafe supervision, in which there are four branches: inadequate supervision, planned inappropriate operations, failure to correct a known problem, and supervisory violations (Wiegmann & Shappell, 2009). Inadequate supervision refers to a lack of proper guidance or oversight, which was a rampant problem for Asiana Airlines given that the pilots had no authority figure to answer to. In this flight, the pilot flying was new to the aircraft, so his copilot, also known as the pilot monitoring, was training him. The pilot monitoring is responsible for overseeing the flight and providing guidance to the pilot flying; however, this pilot failed to do so because he himself had not received proper training on how to instruct. He was a new instructor who had never supervised a trainee on an actual flight, while also being supervised himself by someone more experienced. This lack of supervision from Asiana Airlines rendered him unprepared for the situation that unfolded. Just as he should have been coaching the pilot flying, Asiana should have supplied someone to coach him on how to properly monitor and instruct his less experienced peers.

Inappropriate operations, the second branch, includes premeditated problems such as not briefing an approach correctly or conducting operations outside of regulations. Upon investigation, the NTSB discovered that the pilots of flight 214 had not conducted an adequate approach briefing (NTSB, 2014). An approach briefing is essential for ensuring that both pilots verbalize their understanding of the sequence of events required within the approach as well as the corrective action to be taken if something were to go wrong (FSF, 2019). Confirming these factors prior to the approach allows for faster reaction time as well as better decision-making since everything had already been discussed during a less stressful phase of flight. Had the pilots briefed their approach correctly, they would have identified the possible risks and preemptively decided a point at which to commence the go-around. Asiana Airlines had SOPs in place requiring pilots to brief their approaches; however, since these SOPs were left unenforced, the company was consistently allowing for inappropriate operations.

The third branch in this level is failure to correct a known problem. Figure 5 depicts an approach resulting in a go-around. During an approach, the flight crew is required to make a decision at 500 feet above ground level (AGL) as to whether the approach is stable, meaning all factors of the descent are set up and maintained as mandated (DOT & FAA, 2017). If the approach is unstable, SOPs require that the pilots immediately go around by adding full power and discontinuing the approach. This is the safest means of recovering during one of the most critical phases of flight, as it extinguishes the immediate danger by leaving the situation while also allowing the pilots to attempt another more stabilized approach.

The pilots of flight 214 failed to conduct a go-around despite the severe instability of their approach. The aircraft's airspeed was dangerously low, and its descent rate was inconsistent and unnecessarily steep. The pilots did not call for a go-around until the aircraft was already below 100 feet AGL, at which point it was no longer possible to recover. In refusing to conduct a go-around at the 500-feet AGL point, the pilots were directly deviating from Asiana's

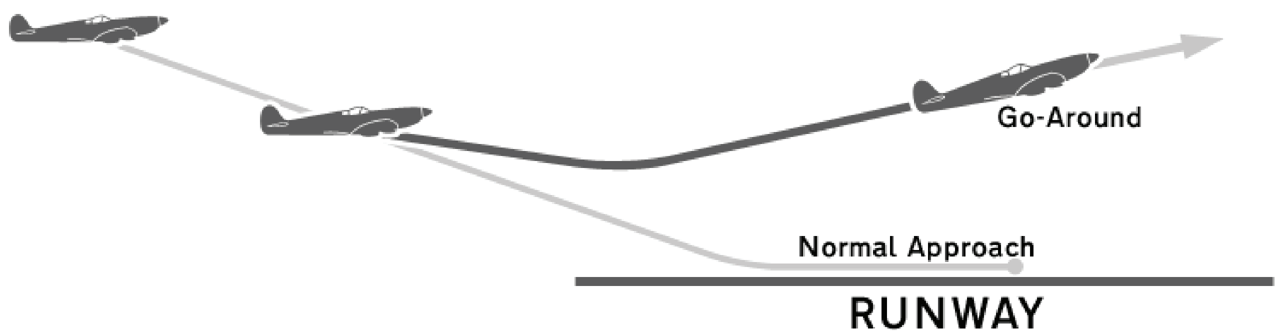


**Figure 5.** Go-around procedure. A go-around is the recovery procedure used when a landing cannot be performed. This maneuver involves applying full power and configuring the aircraft to climb, essentially re-creating takeoff. Image source: "Go-Around." (2005, December 18). Retrieved from Wikipedia. (Used with permission.)

SOPs, which, upon investigation, was found to be a common problem within the company (NTSB, 2014). SOP deviation is a major safety hazard, yet Asiana made no attempts to implement corrective action. This disregard for continual SOP deviation indirectly encouraged pilots to take unnecessary risks throughout the flight, meaning that the poor decision-making of the pilots during this flight can be attributed to the company's failure to resolve known safety issues throughout the airline.

The last branch within unsafe supervision is supervisory violations, which overlaps with the previous branches to better isolate risks related to unenforced rules and regulations as well as SOP deviation. The pilots of this flight had not adequately briefed their approaches, nor had they complied with the mandated go-around procedures. Within the investigation, the NTSB confirmed that these were not isolated incidents (NTSB, 2014); therefore, although the pilots were the ones directly deviating from regulation, in neglecting to enforce SOPs, Asiana Airlines committed various supervisory violations.

## PRECONDITIONS FOR UNSAFE ACTS

The third level of human error analyzed by HFACS is preconditions for unsafe acts, which is divided into three categories: environmental factors, condition of operators, and personnel factors. Environmental factors encompass both the physical environment and the technical environment. At the time of the accident there were light winds, great visibility, and few clouds, so poor weather was not a factor in this accident (NTSB, 2014). The technical environment posed the bigger issue. As previously discussed, technology plays an immense role in the cockpit. When used properly, technology greatly decreases the workload for crews, allowing for a decrease in stress paired with superior task management (FSF, 2019); however, the misuse of technology will produce the opposite effect, increasing the stress levels of crew and creating more work to be done, which is what occurred in flight 214. Unless used correctly, automation can have a severe negative impact on the mental conditions of the operator, further increasing the risk for an unsafe act (FSF, 2019).

The stressful conditions resulting from technology complications led to substandard conditions of operators, creating adverse mental and physiological states for the pilots. Both pilots experienced a complete loss of situational awareness, in addition to channelized attention and task saturation. These three conditions built up to cause significant mental fatigue that then brought on the adverse physiological state of physical fatigue and stress. Figure 6 demonstrates the relationship between performance and stress level. During this approach, the stress level of the pilots was far beyond the optimum amount. This is essentially what caused such poor responses to the situation—an immense overload of information coupled with a stress-induced breakdown of performance capability.

The final branch in this level is personnel factors, which includes crew resource management (CRM) as well as personal readiness. CRM involves how the crew work together to ensure the safety of a flight, including communication procedures and task sharing. In this accident, CRM was rendered entirely ineffective due to the various SOP deviations, which is further evidenced by the inability of these pilots to successfully work together. They both failed to adequately communicate and back each other up, and the pilot monitoring failed to fulfill his leadership responsibilities of providing guidance and supervision to the pilot flying.

The pilots also struggled in terms of their personal readiness, which is what ensures that an individual

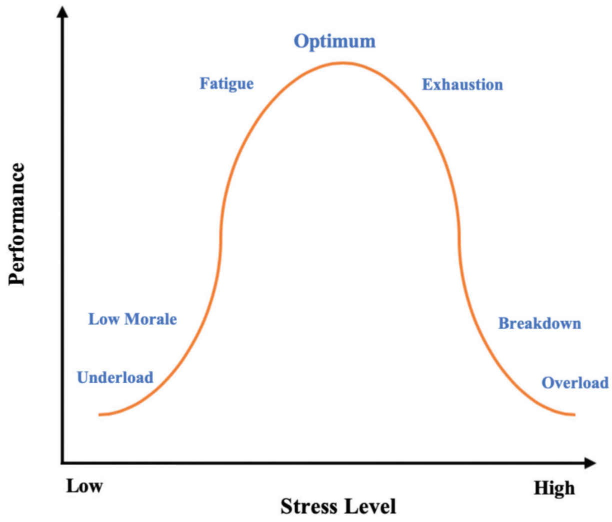


**Figure 6.** Performance vs. stress. This graph demonstrates the relationship between performance and stress level. Image source: Ranamourtada. (2018, October 18). Allostatic load. (Adapted with permission.)

is personally ready for a flight in terms of their physical, mental, and emotional states. During this flight the pilots were fatigued. The pilot flying had only gotten five and a half hours of sleep the night before, and the pilot monitoring had a poor quality of sleep due to nonconsolidated sleep sessions (NTSB, 2014). Fatigue was further worsened due to circadian rhythm disruption, as this flight was conducted during a time period when the pilots normally would have been asleep. All of these factors culminated to greatly reduce cognitive performance, increasing the pilots' likelihood of committing an unsafe act.

## UNSAFE ACTS

The lowest level of human error analyzed by HFACS is the unsafe acts of operators. This focuses on the actions and decisions made by the flight crew themselves. These unsafe acts can be divided into two categories: errors and violations, which can be distinguished based upon intent. According to the FAA (2006), "errors represent authorized behavior that fails to meet the desired outcome. . ." whereas ". . . violations refer to the willful disregard of the rules and regulations" (pp. 2–3); however, in the case of overlap, there is a certain degree of subjectivity regarding the identification and classification of an unsafe act.

After categorization, an unsafe act can be broken down even further into a specific type of error or violation. An error may be classified into three possible types: decision errors, skill-based errors, and perceptual errors (FAA, 2006). Decision errors are often the result of poor judgement; the error is made with good intent but poor planning. In this accident, the decision not to go around would be classified as a decision error. The second type of error, skill-based error, lies on the other end of the error spectrum. It involves little to no thought but is instead the result of a muscle memory type of response, similar to the human equivalent of autopilot. Unfortunately, these routine behaviors are often subject to complacency-related issues. An operator committing a skill-based error may do so unknowingly, failing to realize the mistake until already committing the unsafe act. In this accident, some skill-based errors were the overall poor control of the aircraft, the inappropriate visual approach technique, and the unintentional deactivation of the automatic airspeed control.

The last type of error is perceptual errors, which result from a person's decreased ability to adequately perceive his or her surroundings. Inaccurate sensory information may lead to poor judgment, causing an operator to make a misinformed decision resulting in an unsafe situation. Figure 7 shows the flight path of flight 214. Instead of making a consistent descent, these pilots descended significantly lower than intended, emphasizing their complete loss of situational awareness.

On the other end of the unsafe acts spectrum is violations, of which there are two types: exceptional and routine. Exceptional violations did not play a large role in this accident as they cannot be traced back to upper management. Routine violations, on the other hand, are predictable and often develop after a continual bending of the rules (Shappell et al., 2006). Complacency, invulnerability, and unsafe company culture commonly foreshadow the occurrence of routine violations. Their habitual nature further increases the feeling of invulnerability, making pilots complacent and rendering the unsafe act as a new norm within the company.

In this accident, the routine pilot deviations from SOPs acted as the main violation. Pilots commonly deviated from communication SOPs put in place by Asiana Airlines. For example, SOPs mandated that pilots make a callout verbalizing any changes made to the technology settings. This would require proper communication, ensuring that both pilots maintained situational awareness throughout each phase of flight. The pilots of flight 214 failed to do this, which is one reason that neither pilot realized the manual control setting of the airspeed. Company culture also added to this in the form of external pressures

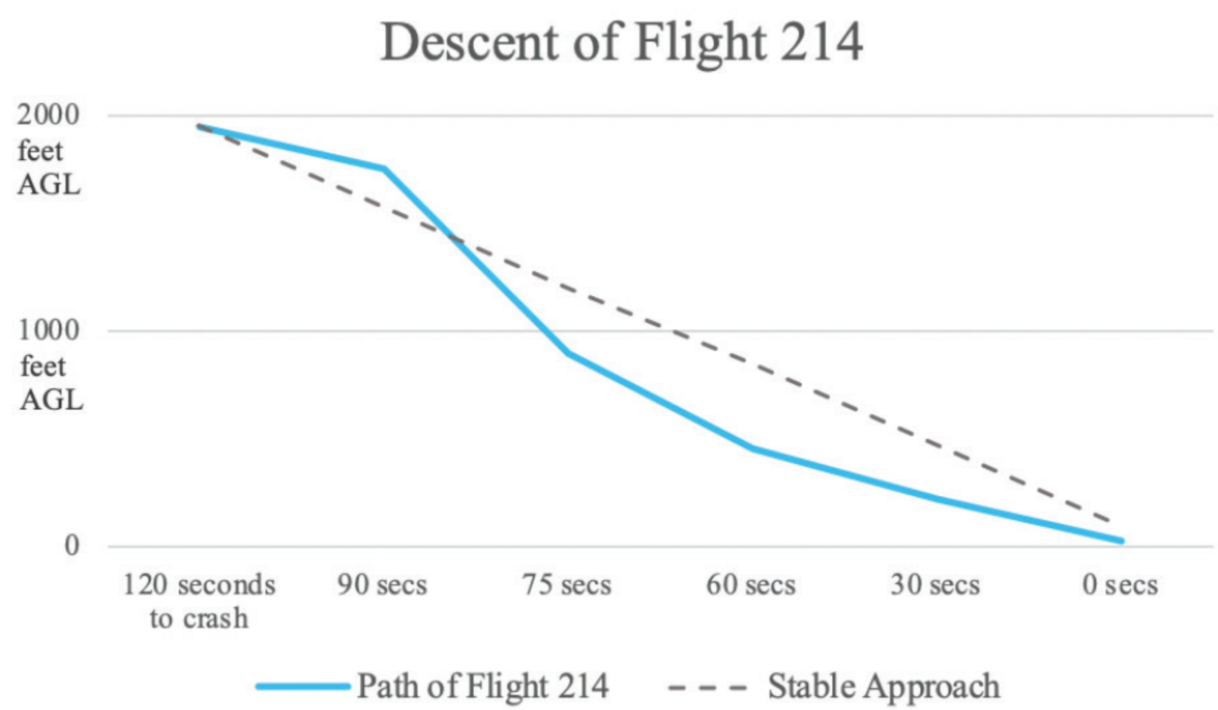


**Figure 7.** Flight path of Asiana Airlines flight 214. This graph shows altitude and timing approximations based on data from the cockpit voice recording (CVR) and NTSB Accident Investigation Report (Gregor, 2013; NTSB, 2014).

and questionable policy. Asiana Airlines contributed to these violations by failing to standardize its procedures, instead allowing for the creation and use of informal policies and SOP deviations.

## CONCLUSION

Asiana Airlines flight 214 should not have crashed. As evidenced by this accident analysis, there were a plethora of contributing organizational factors that could have been eliminated prior to the accident. Civil aviation accidents are not due to isolated incidents; therefore, most can be prevented using HFACS. Throughout history, industry-wide change has only been brought on after disasters or after the loss of lives. The HFACS model presents the opportunity to proactively change this mindset. By using this systematic approach to hazard identification, safety risk data can be collected and studied without the need for an accident to occur. The findings of this study emphasize the various organizational levels that serve a role in aviation accidents and especially highlight the role of the highest tiers of an organization in the safety process. By starting accident investigations at the top of an organization, the implementation of HFACS can prevent the culmination of hazards from trickling down to the lower levels. This study also highlights the necessity of practicing a proactive approach to safety, mitigating hazards within an organization before they can lead to disaster.

When the United States Navy first implemented this framework in the late 1990s, it found a significant improvement in the safety of its aviation program. In fact, the percentage of accidents related to human error was essentially cut in half within a few years of its implementation (Wiegmann & Shappell, 2009). These results can be achieved on a much larger scale by applying the HFACS framework to civil aviation. Doing so will lead to a substantial decrease in the number of aviation accidents, saving thousands of lives and millions of dollars in the process.

## ACKNOWLEDGMENTS

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