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Application of the US Army Accident Causation Model During Combat Operations in Iraq

Lieutenant Colonel James F. Jennings, CSP
United States Army Reserve
101st Sustainment Brigade
101st Airborne Division (Air Assault)
Fort Campbell, KY

Introduction

Safety in combat operations? An oxymoron, right? Safety professionals from the private sector and non-Department of Defense (DoD) agencies of the Federal Government might be surprised to discover that the Army, Navy, Air Force, Marines and Coast Guard each have a Safety Center with the mission to reduce or minimize accidental losses or mishaps. The US Army's Safety Center, recently re-designated the Combat Readiness Center (CRC), is continually integrating safety and Composite Risk Management into all phases of military operations, to include combat in Afghanistan and Iraq. With experience as an Army Safety Officer in Bosnia, Kosovo, and – most recently – Iraq, my purpose today is to present a brief introduction to the newly developed taxonomy for human factors analysis of accidents and apply it to our current challenges as we fight a war in Iraq.

Background

Using the framework of the DoD Human Factors Analysis and Classification System, or DoD-HFACS, accident investigators can analyze the organizational and supervisory aspects of human error in a systematic manner. DoD-HFACS was adopted by the heads of the Safety Centers of all the military services in 2005 as the analytical model for human factors hazards in accident causation. (1) It builds upon the solid foundations of James Reason's "Swiss Cheese" model (2) and Douglas Weigmann and Scott Shappell's extensive work in aviation accident causation and prevention, to include the first HFACS model (3). Although my purpose today is not to describe the DoD-HFACS in detail, I will provide a brief overview of the system and the two models upon which it is based. Then, drawing upon personal experience from accident investigation and prevention during a one-year tour of duty in Iraq from August 2005 to August 2006, I will apply the DoD-HFACS causation model to a fatal accident that claimed the life of an Army Sergeant in Northern Iraq on November 17, 2005.

Reason's influential 1990 work, Managing the Risks of Organizational Accidents, amplified HW Heinrich's "Domino Theory" of accident causation, which proposed that mishaps are the end result of a sequence of errors made throughout a chain of command (4). Reason's model focused not only on the active failures of operators involved in the mishap, but on human error in the management and supervisory realms. His integration of latent failures or conditions into accident causation provided a more complete framework for investigators to identify and mitigate future

accidents. In addition to the first of tier of analysis, Unsafe Acts of Operators, Reason added three more levels, each focused upon the organizational influences on errors. The second, third and fourth tiers, titled Preconditions for Unsafe Acts, Unsafe Supervision, and Organizational Influences, respectively, analyze the latent failures or conditions that may lie dormant or undetected until circumstances are right. Conditions such as fatigue, stress, or complacency may lead to the mishap, but they are not specific actions by an operator, they are preconditions that set the stage for the accident. Unsafe supervisory errors can prompt unsafe acts by operators; poor crew pairing or matching is one example of this failure. And the final analytical tier, Organizational Influences, considers factors such as funding and corporate culture in identifying latent failures that lead to accidents. An effective and thorough investigation considers factors at all four levels.

The investigation process seeks to find the holes, or hazards, in the four levels in the "Swiss Cheese" (see Exhibit 1). When they are aligned, the holes in the process set the stage for a mishap. Unlike the "Domino Theory," in which each domino bumps the other, the holes may not always line up; latent failures or conditions may not always be present.

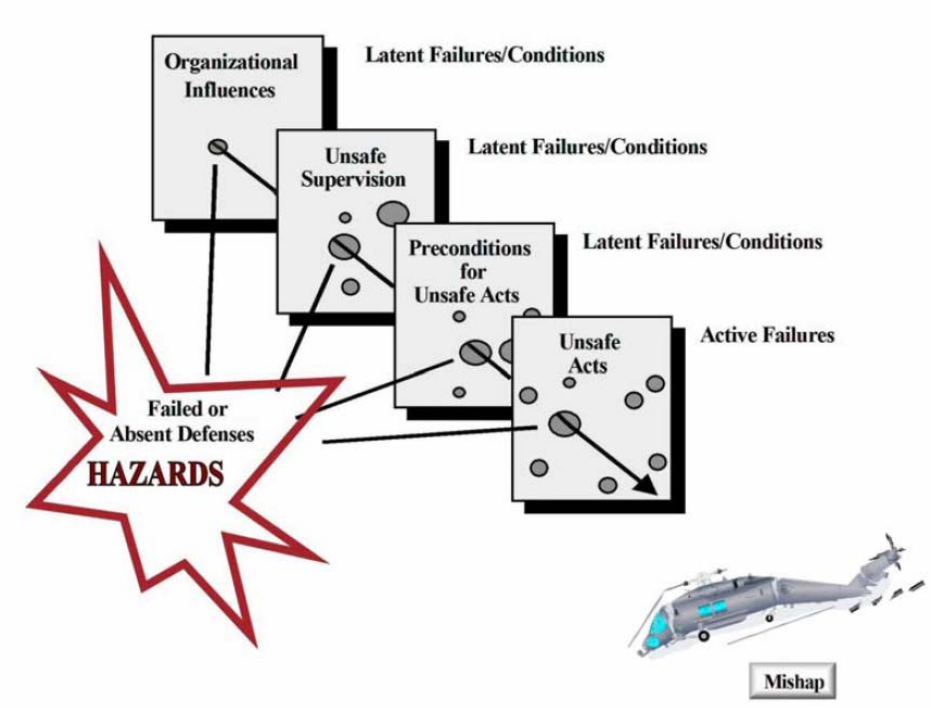

Exhibit 1: Reason's "Swiss Cheese" Causation Model

In their 1998 work A Human Error Approach to Aviation Accidents, Douglas Weigmann and Scott Shappell recognized the value of a unified framework for analyzing human error perspectives at all levels of the organization. However they recognized that the specific nature of the "holes" was ill-defined. If one could identify the failed or absent defense, the hole could be plugged and the mishap prevented.

The Human Factors Analysis and Classification System was specifically developed to define the latent and active failures identified in the "Swiss Cheese" model. After extensive analysis of hundreds of accident reports and thousands of human causal factors, Weigmann and Shappell

designed HFACS for use in aviation accident investigation. Analogous to the "Swiss Cheese" model, HFACS also defined four levels of failure, each of which corresponds to one of Reason's four layers. (see Exhibit 2)

In May 2003, alarmed by the rising number of accidental losses in the Department of Defense, Donald Rumsfeld established a goal of 50% reduction in accidental losses in the following two years (5). The Defense Safety Oversight Council was formed to provide a forum for developing and implementing strategies to achieve the reduction. One of the joint committees, the Human Factors Working Group (HFWG) had a charter to "identify data-driven, benefit-focused, human-factor and human-performance safety strategies designed to identify hazards, mitigate risk and reduce aviation mishaps inherent in aircraft operations throughout DoD." (6) More than 80% of military aviation accidents are caused by human error, a percentage that mirrors civil aviation. Among the goals of the HFWG:

l). Promote common human factors taxonomy, investigation, and analysis system for DoD-wide implementation.
2). Recommend standardization of human factor and human performance terminology.

The services had been collecting human factors data using many different models, resulting in a disparity in data and difficulty in creating joint approaches to mitigating the human factors hazards present in a large majority of mishaps. The recommendation of a Joint Services Safety Chiefs Conference was that the services modify and adopt a version of the HFACS. The DoD-HFACS is the jointly created taxonomy.

The DoD-HFACS is nearly identical to the Weigmann and Shappell model. Some categories have been modified to accommodate the human factors analysis of ground accidents as well as aviation mishaps. The US Army Combat Readiness Center took the lead in developing a foundational training program.

When the accident investigator analyzes human error using the framework of the DoD-HFACS, supervisory and organizational factors – the holes in the cheese – begin to take shape. A practical application of the model is the most effective method of demonstrating its effectiveness.

Consider the following mishap and fatality from November 2005. The names, units, and specific location have been omitted for security reasons, but the circumstances leading up to this event provide an excellent framework for applying the DoD Human Factors Analysis and Classification System.

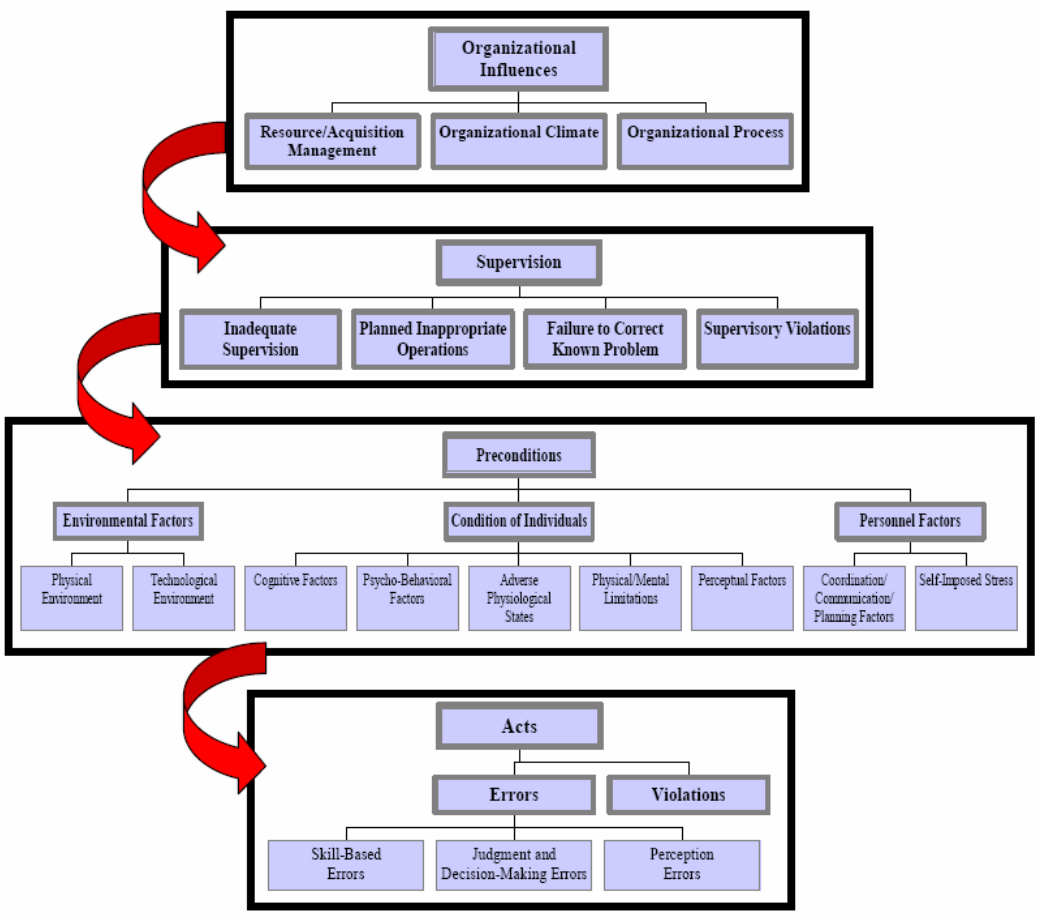

Exhibit 2: The DoD Human Factors Analysis and Classification System (DoD HFACS)

Case Study

November 17, 2005 was a typical late fall day in Iraq. Temperatures were in the mid-80s, visibility was unlimited and the warm desert air was free of dust storms. At 8:30 AM, four desert-tan, armored High Mobility Multi-Purpose Wheeled Vehicles (HMMWVs) departed a Forward Operating Base (FOB), a fortified American military base camp, bound for a larger FOB 50 kilometers to the south. The reason for the mission – regardless of the purpose, they're all 'missions,' as one is in harm's way – was to take a soldier on the first leg of his trip home on rest and recuperation leave and to replenish the supply stocks of multiple commodities on the smaller facility. The potential for enemy activity on the route was considered low for the first 30-35 kilometers, but the convoy would then pass through the city of northern Iraqi city of Tal Afar, a hotbed of insurgent activity. Three vehicles from the FOB's combat unit and a fourth from a tenant combat support element departed at 8:30 AM. The support unit HMMWV was in the second position in the convoy. 45 minutes into the trip, four kilometers north of Tal Afar on a paved asphalt road, the driver of the second HMMWV wildly swerved on a curve and lost control of the vehicle. The HMMWV rolled over, the left rear door came open, and the soldier seated behind the driver was thrown out. He struck the ground with sufficient force to kill him immediately upon impact. The driver and Truck Commander (TC) in the front right seat suffered minor injuries, as they were secured in place by their seatbelts. The third HMMWV came upon

the wreckage moments later and initiated an immediate call for an aero-medical evacuation for the injured soldiers and a maintenance team to recover the overturned vehicle. The convoy never reached its destination and the support unit mourned the loss of one of its own. The causation appears relatively simple on initial glance. However, when this mishap is analyzed through HFACS, a series of latent human errors emerge and provide a tool to begin eliminating systemic short-comings and, more importantly, prevent future accidental losses from the same causes.

The primary act which caused the mishap was the driver's failure to control the HMMWV in the curve. Although there was gravel on the road, it was a gentle turn on a smooth, dry, level road surface. The additional action which directly led to – but did not cause – the death of the passenger in the rear, was his failure to comply with the requirement to wear a safety belt while the HMMWV was in motion. These two operator errors, one of commission and one of omission, were the active failures in this sequence of events. Army Regulation 385-55, Prevention of Motor Vehicle Accidents, outlines specific requirements for vehicle control and the wear of restraints at all times. Within HFACS, these fall into different categories under the Acts tier. The unintended, improper operation of the HMMWV is classified as an Error, specifically a Skill-Based Error. The driver failed to properly execute a commonly practiced skill. Conversely, the passenger's failure to secure his seatbelt is classified as a Violation, as he displayed a lack of discipline in his disregard of a known standard.

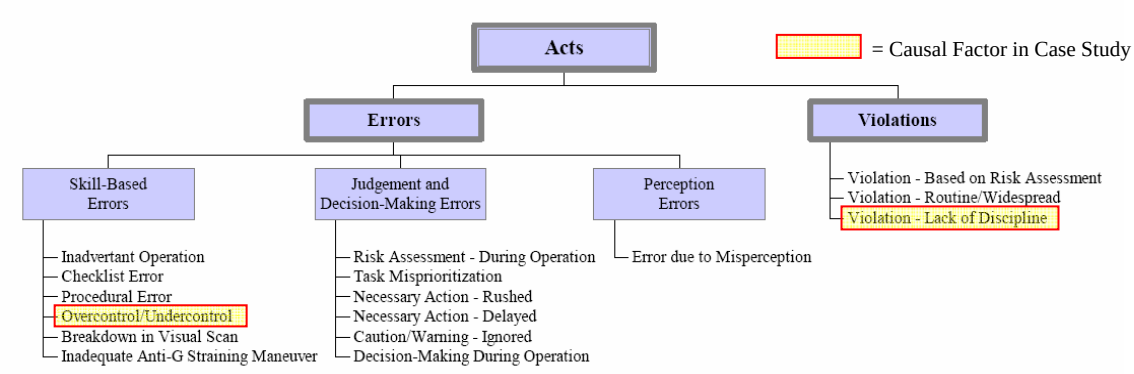

Exhibit 3: DoD HFACS Tier 1 – Categories of Unsafe Acts

Exhibit 4: The unsecured soldier seated behind the driver was thrown out of the open rear passenger door. Had he been secured with a seatbelt, he would have walked away.

Without a systemic approach to causal analysis, many accident investigators would go no further. However, the three additional tiers for analysis in HFACS provide a framework for focusing on management responsibility in the sequence of events and causation. Within the military structure, management is the chain of command.

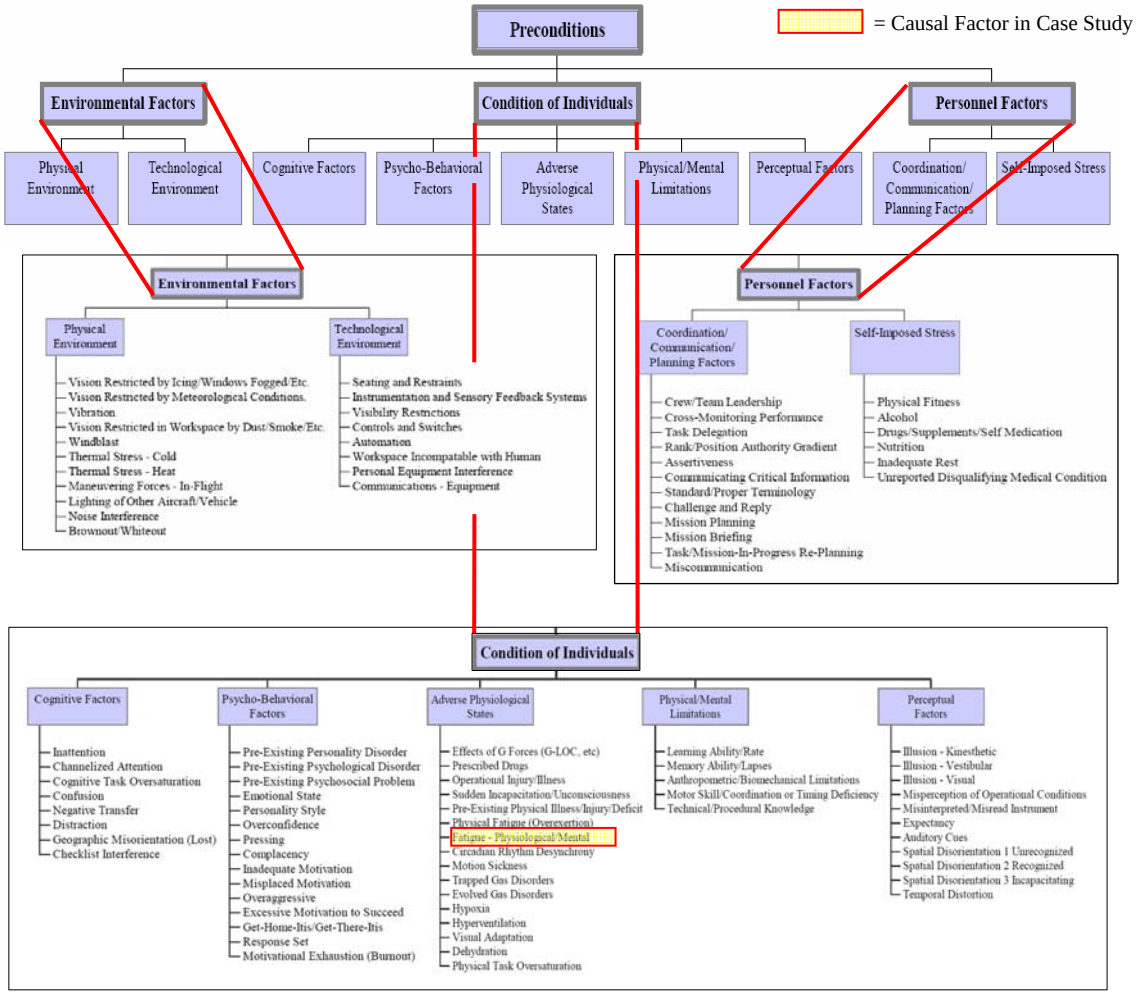

Exhibit 5: DoD HFACS Tier 2 – Categories of Preconditions for Unsafe Acts

If active and/or latent preconditions result in human error or an unsafe situation, preconditions may be causal factors in a mishap. These latent factors are not actions, but circumstances which compromise human performance. They comprise Preconditions, the second HFACS tier. The November 17th HMMWV rollover and fatality occurred in the most stressful imaginable operational work environment, active armed combat. Unlike previous military conflicts, combatants in Iraq are subject to hostile actions at all times, as there are no traditional front lines. Night and day, mortars and rockets drop at random on FOBs and convoys are routinely peppered by bullets and rocket-propelled grenades. But the low-tech weapon of choice for insurgents is the Improvised Explosive Device (IED) or the roadside bomb. The constant threat of IEDs creates conditions in which every convoy is a high-stress, life-threatening event. On the day of the mishap, the crew of the second HMMWV had been in Iraq for less than two months and the vehicle operator had driven through Tal Afar on only one previous occasion. In addition, unlike the three HMMWVs from the combat unit, the HMMWV from the support unit was not equipped with a radio. This was not an oversight or error; there were simply not enough radios to distribute

to all vehicles in the convoy. This additional analysis helps complete an emerging picture of a significant latent precondition, an exceptionally high-stress environment. The driver, a recent arrival to Iraq with very little experience at the wheel of a HMMWV, drove through a very dangerous area with which he was unfamiliar, and he had no means to communicate with the lead vehicle.

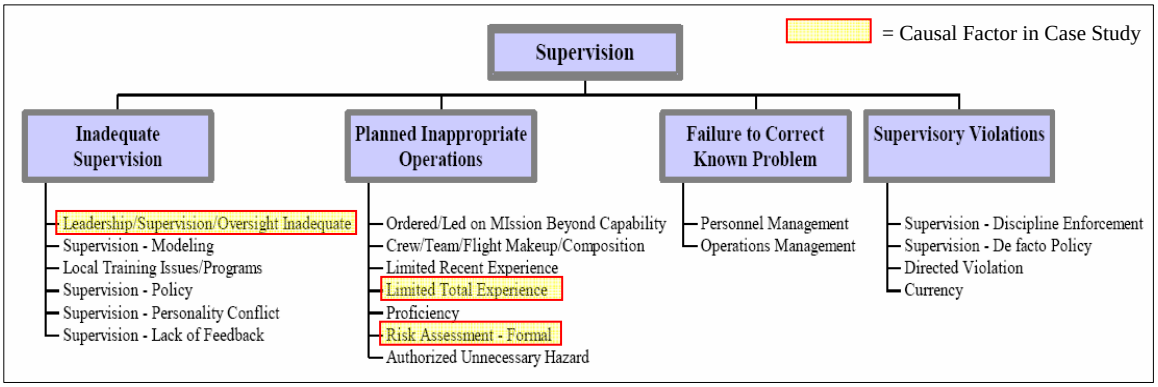

Exhibit 6: DoD HFACS: Tier 3 – Categories of Unsafe Supervision

Unsafe supervision often plays a role in mishap causation. There were significant latent human supervisory errors leading to the HMMWV rollover and fatality, including factors from two of the four categories under the HFACS third tier, Supervision. The senior occupant of an Army vehicle is responsible for enforcement of all policies and procedures relating to its safe operation. This includes the use of restraints. Although the rear passenger failed to buckle his seatbelt, the TC as senior occupant failed to check and enforce compliance. The HFACS model categorizes this deficiency as Inadequate Supervision. A second category under Supervision, Planned Inappropriate Operations, addresses two additional supervisory shortcomings from the November 17 mishap. The driver had little experience at the wheel. He had driven the HMMWV to the FOB when his combat support unit initially set up operations, but had not driven since. The supervisor's choice to have him drive was ill-advised, as new vehicle operators should not gain experience on equipment in an active combat zone. In addition, a second supervisor, the convoy commander in the first vehicle, planned inappropriate operations which led to the accident. The convoy consisted of four vehicles, three from the combat unit on the FOB and one from the support unit. The officer in charge of the convoy was from the combat unit. He opted not to follow standard convoy procedures, which require a pre-departure convoy briefing with all participants present and the completion and approval of a Risk Assessment for the operation. These omissions, likely a function of complacency, denied the support unit HMMWV driver a map review of the route. The convoy commander missed a final opportunity to reinforce the requirement to wear restraint systems. In addition, the officer in charge failed to check the

Exhibit 7: After the area was secured, recovery of the wreckage began. A static operation such as a vehicle recovery is a magnet for insurgents in search of targets.

experience level of the driver. Had he followed standard supervisory procedures, he might have selected a different vehicle operator whose capabilities were more suitable for the mission.

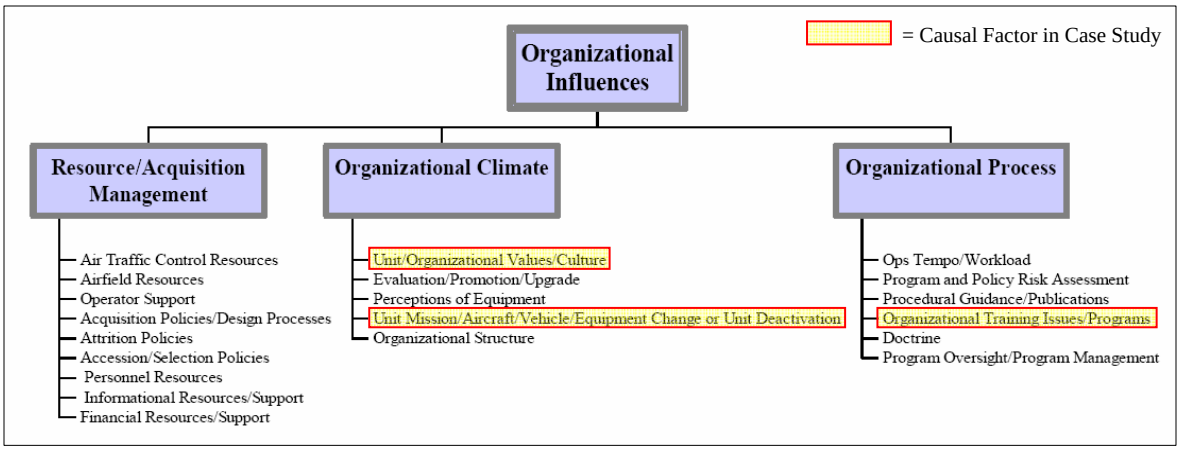

Exhibit 8: DoD-HFACS Tier 4 – Categories of Organizational Influences

Supervisory practices are heavily influenced by organizational pressures, especially in rigid hierarchical structures like military services. The November 17, 2005 mishap was no exception. The legacy of changing standard practices during the first three years of Operation Iraqi Freedom, the evolving combat role of the HMMWV and the standards of the Army-level vehicle licensing program: all played a key role in shaping the decisions of the driver, passenger, and first-line supervisor.

Exhibit 9: The canvas-covered M-998 HMMWV with "soft-skinned" top and sides provided little to no protection from insurgent IEDs, shrapnel and bullets.

The US Army was not fully prepared to combat the insurgency which erupted in the wake of the successful 2003 invasion of Iraq. Many units were equipped with the M-998 HMMWV, a stripped-down, generic variant of the Army's workhorse vehicle. The M-998 had canvas doors, sides and top. It had no armor plating and, in many cases, no structural platform upon which to mount an automatic weapon. It provided occupants with little to no protection from bullets, shrapnel, and other combat hazards. The two-point seatbelts were flimsy, extremely difficult to reach, and often not long enough to reach around the torso of a soldier wearing Army-issue body armor. Although maintenance personnel had guidance to install a longer, three-point seatbelt system, this upgrade was not a high priority. Blasted by IEDs, small arms fire, and other dangers, soldiers began to improvise, adding metal plating to the top and sides and placing sandbags to the floor. In December 2004, when Secretary of Defense Donald Rumsfeld famously stated, "You go to war

with the Army that you have," it was in response to a concern about the lack of armor protection on HMMWVs. In the immediate post-war period, when attacked by insurgents, soldiers dismounted from the vehicles and pursued the enemy on foot, usually to no avail. The poorly constructed seatbelt became a liability, an obstacle to a swift dismount under fire. As a result, commanders in many units – and at the highest levels of the chain of command – specifically ordered soldiers ***not*** to wear seatbelts in HMMWVs. The results were somewhat predictable. Although troops were not delayed by entanglement in their restraint systems while responding to enemy attacks, injuries from both major and minor HMMWV accidents caused hundreds of casualties. Operated at higher speeds to reduce exposure to the IED threat, HMMWVs with ad-hoc armor – and a corresponding increase in the vehicle center of gravity – began to roll over at an alarming rate. Young, inexperienced drivers under great stress were unprepared to safely operate the vehicle at 80-100 mph, even on paved roads. It was not uncommon for a HMMWV driver to rapidly overcorrect with the steering wheel in a panic, initiating a self-induced rollover. This was exacerbated by the addition of metal plating, dubbed "hillbilly armor" by soldiers. To make matters worse, the armor was made of every imaginable shape and size of metal, which often spalled and created more fragments when struck with enemy fire or shrapnel.

Due in great part to mounting losses from small arms fire and shrapnel and serious public outcry with accompanying congressional pressure, the Army directed substantial resources to providing greater protection for soldiers in HMMWVs. Engineers from the Army's Tank and Automotive Command (TACOM) immediately set to work designing standardized templates and an approved materials list for armor plating. Utilizing guidance and materials in the newly developed and implemented Add-On Armor (AOA) program, soldiers and contractors on FOBs began upgrading non-armored M-998 HMMWVs. The addition of nearly 1,000 lbs of armor

An "up armored" M998 HMMWV. Note the ballistic windshield and armored doors added in Iraq.

Inset: Two-inch thick ballistic glass can withstand a direct hit from IEDs and machine gun fire.

Exhibit 10: Throughout 2005, soldiers and contractors secured Add-On Armor kits to convert soft-skinned HMMWVs to uparmored HMMWVs. Note the armored doors and thick windows. A plate was added to the undercarriage and the suspension was upgraded.

plating necessitated an upgrade to the suspension system, door hinges, and windows. Sealing the metal cab created an oven on wheels, so air conditioners were added – not as a creature comfort measure, but to keep soldiers from suffering heat injuries inside the vehicles, where air temperatures sometimes exceeded 130º.

The uparmored HMMWVs dramatically improved survivability. Simultaneously, newly fielded electronic countermeasure devices decreased the effectiveness of remotely detonated IEDs. As a result, the Army's standard tactical response to an IED attack changed. Rather than stopping, dismounting, and pursuing an elusive enemy, convoy commanders were directed to push through the IED "kill box" and leave the danger area as soon as possible. All soldiers stayed inside vehicles, now the safest place to be during an attack. Getting entangled in a seatbelt was no longer a major concern, as occupants were not required to dismount. Units ordered seat belt extensions to accommodate the larger torso circumference of body armor and maintenance crews put new urgency into the Maintenance Work Order to replace the two-point seatbelt with the three-point version. Now that seatbelts were available, fit around the occupant, and were accessible, soldiers had no logical reason to avoid wearing them. But getting them into the habit of buckling up proved a significant challenge. Two major obstacles hindered compliance: the legacy of "no-seatbelt" orders and the lingering perception that seatbelt use is an administrative requirement not applicable to combat.

As soldiers return for their second and third tours of duty in Iraq and Afghanistan, the advice of the "old veteran" can be counterproductive to safe vehicle operation. The "that's the way we do it here" problem so familiar to safety professionals in the public and private sectors can undermine standardization and change in any organization. In the initial stages of a deployment, younger soldiers naturally look up to the older hands who served a combat tour or two. All too often, the old hand will discourage the newcomers from wearing seatbelts, because "I survived without them on my first tour." Despite the fact that tactics have changed and occupants no longer dismount and counterattack, distain for the seatbelt persists. The urban legend about the soldier who was trapped in a burning HMMWV when he couldn't unbuckle his seatbelt has remarkable resiliency as well. No one seems to know this fellow, but they're certain that their number is up if they strap in. This is in many respects a function of the Army organizational culture, which encourages bold, audacious, and decisive action. Most successes in improving individual compliance with use of restraints have been directly tied to constant command emphasis from the top of the organization.

The administrative flavor of buckling up is yet another organizational human factor that discourages adherence to safe practices. Despite pre-deployment presentations of numerous comparisons and percentages showing that survival in a rollover is linked to seatbelt use, there is still skepticism. No doubt this is also a function of the population of the Army today, primarily 18 to 24-year-old males, a demographic group that is soaked with testosterone and a corresponding sense of invincibility and immortality.

Investigators could never confirm whether the dead soldier's decision to violate the seatbelt regulation was influenced by these two organizational factors. However, other soldiers in Iraq in 2005 indicated that securing seatbelts was not part of a standard pre-movement check. And, as previously noted, the TC did not enforce the requirement.

Like most well-run fleet management operations, the Army has a proven system for ensuring drivers are qualified to drive safely, even in a combat zone. Every driver of an M-998 HMMWV

is licensed by a unit Master Driver. This process involves a written examination and standardized road test. Electronic quality control prohibits a soldier from dispatching (military parlance for being handed the keys) a vehicle for which he is not licensed. If there is not an M-998 qualification entry beside the operator's name in the computer, he will not be given the keys to the vehicle. However in 2005 the Army's standardized vehicle licensing and quality control system failed to keep pace with TACOM's rapid upgrades to the M-998 HMMWV. As AOA kits were added, the weight and handling characteristics of the vehicle changed dramatically. Many unit Motor Sergeants and Master Drivers recognized this issue and provided drivers refresher training on the heavier vehicles. However, this could not be done during pre-deployment training, as all uparmored HMMWVs were in Iraq, where the need was greatest. The first time a soldier might be given the opportunity to drive the heavier HMMWV variant was during a brief training period in Kuwait as the unit passed through on its way to Iraq. Unfortunately, most HMMWV drivers did not gain an appreciation for the different handling characteristics and higher center of gravity of an uparmored HMMWV until they were on a FOB in Iraq executing the change-out with the departing unit. The operator of the vehicle which rolled over November 17th had driven an uparmored HMMWV once in Kuwait. But his M-998 qualification on his vehicle license made him an approved operator. The 15-20% increase in the weight of the HMMWV with AOA should have prompted an additional nomenclature and a corresponding licensing procedure, refresher, or upgrade. But this never happened. The end result was a system which provided insufficient training for the task to be performed. On November 17, 2005, the licensing system failed the driver, who did not possess the proper skills to handle an uparmored HMMWV.

Summary

The case study analyzed in this presentation included specific unsafe actions of commission and omission by the operators. However it is clear that management-level human factors played a key role in the mishap causation. A comprehensive analysis using the DoD-HFACS framework identified both the "holes in the Swiss Cheese" and the multiple management levels at which mitigating efforts can be focused. The rapid changes in supervisory and organizational dynamics during a fluid wartime environment create innumerable Preconditions, Supervisory challenges, and Organizational influences. To ignore these management human failures, even during a mishap in a combat zone, is to miss myriad latent causal factors. DoD-HFACS is an effective tool to identify and mitigate the accidental losses that can degrade the combat effectiveness of a military unit.

Afterword

A year and a half has passed since the November 17, 2005 accidental fatality analyzed in this presentation. In the months since the mishap, the Army solved some of the organizational human factor issues identified in the DoD-HFACS, but others management issues remain.

In 2005, the Army had not fielded enough factory-built uparmored M-1114 HMMWVs to equip all units in Iraq. The M-1114 has armor plating, bullet-proof glass, heavy suspension, air conditioning, a roof weapons mount – and it requires a separate operator licensing process. Since there were not enough M-1114s available, M-998 HMMWVs with Add-On Armor were used on convoys. After the highly publicized – and politicized – remarks by the Secretary of Defense in December 2004, factory production and fielding of M-1114s increased dramatically, providing soldiers in Iraq with better protection from IEDs and enemy attacks. Unfortunately, the pressing

need to ship M-1114s to combat continues to deny Army units the opportunity to train on the heavier uparmored HMMWVs before deployment. Units must maximize the final train-up time in Kuwait – where M-1114s and M-998s with AOA are available – to ensure vehicle operators gain driving experience in a controlled environment. Significant numbers of soldiers are returning for their second and third tours of duty in Iraq or Afghanistan. In some cases, over 60% of unit personnel are on a second, third, or fourth combat tour. This increases the experience base of HMMWV drivers and – in many cases – their first-person tales of rollovers and subsequent casualties.

Command emphasis on the importance of seatbelts and reduction of convoy speeds has increased compliance and supervisory enforcement. The improved survivability of the more protective HMMWVs allows convoys to slow speeds and decrease the potential for panic or overcorrection-induced rollovers. Accident statistics clearly reflect this success story. Between Calendar Year 2005 (CY 05) and CY 06, there was a 56% decrease in vehicle rollovers in Iraq. There was a corresponding 46% decrease in fatalities that occurred during these rollovers, the vast majority involved HMMWVs. This measurable success story is encouraging and commanders at all levels are taking note. A decrease in accidental losses increases combat readiness and capability.

There are some Army organizational and management human error factors that remain and many cannot be effectively mitigated. Combat will always be a high-stress environment. Increasing the experience level of deployed soldiers decreases the stress level, but as long as one's personal survival is at risk, stress will always be present. And – as in every military conflict – resources will be stretched. Unlike a controlled industrial environment, the workplace hazard – the enemy – has a vote and the ability to adapt. Lastly, armies are staffed predominantly by young men, a group predisposed to accept increased risk. That organizational dynamic will probably never change.

Exhibit 11: The author straps in for one of his 36 convoys during a one-year tour in Iraq.

Endnotes

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