Investigation Report

October 27, 2010

Aerial Lift Accident

UNIVERSITY OF NOTRE DAME

April 18, 2011

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UNIVERSITY OF NOTRE DAME
OFFICE OF THE PRESIDENT

Open Letter from Rev. John I. Jenkins, C.S.C.

April 18, 2011

The tragic accident that took Declan Sullivan's life on the afternoon of October 27, 2010, was followed by a profound sense of grief and sadness. Each of us grieves in our own way, and it is important to respect those emotions. At the same time, however, it is critical that we do all we can to understand what led to this accident and what steps we can take to prevent a similar event from happening again. The report we release today is the University of Notre Dame's best effort to understand and craft recommendations that will avoid such a tragedy in the future.

I want to thank Dr. Peter Likins for the time and attention he has given to providing a thorough and independent review of the investigation and this report. Though Dr. Likins and I had never met when I called him last November and asked for his help, I knew that his experience and expertise as an engineer and as a university administrator at a number of distinguished institutions made him uniquely qualified for this role. He has received no compensation of any kind for his work with us, though he has generously spent many hours working on this report, including time spent on campus speaking with those involved in the investigation. In addition to his work on the report itself, Dr. Likins has provided wise counsel to me in dealing with this tragedy, and for that I am deeply and personally grateful.

Dr. John Affleck-Graves, our Executive Vice President, has been diligent in leading and bringing this investigation to a successful conclusion, and I want to thank him, as well. And although I cannot name them all, I appreciate the scores of experts, university staff and students who met with investigators, and administrators and staff members who worked so hard on this investigation.

Through the efforts of all these people we have produced a report that is, I believe, as comprehensive as possible. In addition to the conclusions reached through this investigation, there are eight recommendations, each of which I accept and commit to implement. In particular

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is the recommendation that heeds the words of Declan's parents, Barry and Alison, as well as the Indiana Occupational Safety and Health Administration: to take the lessons learned from this accident to improve, educate and help to ensure an accident such as this one never occurs again. To that end, Notre Dame will work closely with IOSHA and others on a national education campaign that covers the importance of proper safety training related to athletics practices and other events, with respect to this type of tragedy.

Let me briefly and directly address some questions and opinions raised since the early days of this process. In the grief and distress that follows a tragic accident, it is common to seek the individual or individuals responsible and assign blame. After a thorough and painstaking study in which numerous university personnel were interviewed and external experts consulted, we have reached the conclusion that no one acted in disregard for safety. Each individual involved based his decisions and actions that day on the best information available at the time and in accord with the procedures that were in place. The procedures regarding wind safety obviously did not prevent this accident and must be brought up to the more rigorous standards that we have for other weather conditions—such as cold, heat, humidity, and lightning. Many individuals and departments share the collective responsibility for the inadequacy of the procedures that led to this tragedy. The university, then, is collectively responsible. Insofar as the President is responsible for the university as a whole, I am the individual who bears the most responsibility, and I accept that responsibility.

Let me conclude by expressing to the Sullivan family our deepest sorrow for the loss of Declan. You entrusted him to our care, and we failed to keep him safe. Again, I thank you for the graciousness, honesty and courage you have shown in struggling with the aftermath of this tragedy.

Nothing we do can restore Declan to his family and to this community. But one important way to memorialize Declan is to do all we can to understand the factors that led to his death, and take the steps to prevent such an accident from happening again at Notre Dame—or anywhere else.

In Notre Dame,

FORWARD FROM DR. PETER LIKINS

Shortly after the tragic accident that took Declan Sullivan's life, Rev. John I. Jenkins, C.S.C., asked that I review Notre Dame's internal investigation of the events of October 27, 2010, and that I ensure that the accident was examined from every possible perspective, conclusions were reached, and recommendations for the future were made to help prevent a similar tragedy in the future at Notre Dame or anywhere else. As the process unfolded, I provided input and guidance that Notre Dame accepted and adopted. With that process now completed, I have concluded that Notre Dame's inquiry was thorough, unbiased, and accurate.

I had no prior relationship with the University of Notre Dame, so my objectivity was not in any way compromised. In accepting this invitation, I attempted to bring an independent perspective to this investigation, drawing upon my experience as an engineer and a university administrator who has served Columbia as Provost and both Lehigh and the University of Arizona as President. I served also as a member of the Knight Commission on Intercollegiate Athletics. I conducted a meticulously close review of this investigation to ensure its quality and integrity. I reviewed investigation details, the choice of scientific disciplines brought to the process, the qualifications of the experts, and the scientific protocols employed by those experts. I reviewed their work to ensure that appropriate research was undertaken, and that the examination of all data was both neutral and complete, and I met with several of the experts to review the results of their analyses. I assessed the staff interaction within the football program and personally talked to individuals associated with the events of October 27, 2010 who were interviewed as part of the investigation, including Notre Dame Athletic Director Jack Swarbrick, Head Coach Brian Kelly, and members of the videography staff. I reviewed and analyzed relevant documentation, equipment data, weather information, and protocols at Notre Dame and within the football program.

I also reviewed the investigation and findings of the Indiana Occupational Safety and Health Administration ("IOSHA") and can attest that the IOSHA investigation and findings were incorporated and addressed throughout this process.

As reflected in this report, there were a number of issues that led to the loss of a bright and energetic young man, including the implementation of the football program's wind-safety procedure without continuous access to real-time weather information at critical periods of time. These issues interacted in the face of what was a sudden, irregular, and tragically powerful weather event. What is clear, however, is that there were a ***series*** of factors in the aggregate that led to this tragedy. Though a needless loss of life cries out for one to shoulder blame, the facts here do not support any single individual finding of fault. Indeed, Notre Dame personnel followed their customary weather-related procedures faithfully on this occasion, procedures that in retrospect need to be improved. This investigation does not avoid the hard conclusions that must be drawn from the facts, concluding with recommendations that Notre Dame acknowledges must be made to avoid similar tragedies in the future. It is my hope that all NCAA institutions, and those organizations outside the NCAA—ranging from intramural organizations to high school athletic programs to marching bands—review the findings and recommendations of this investigation and develop similar protocols to help ensure a safer future.

Dr. Peter Likins

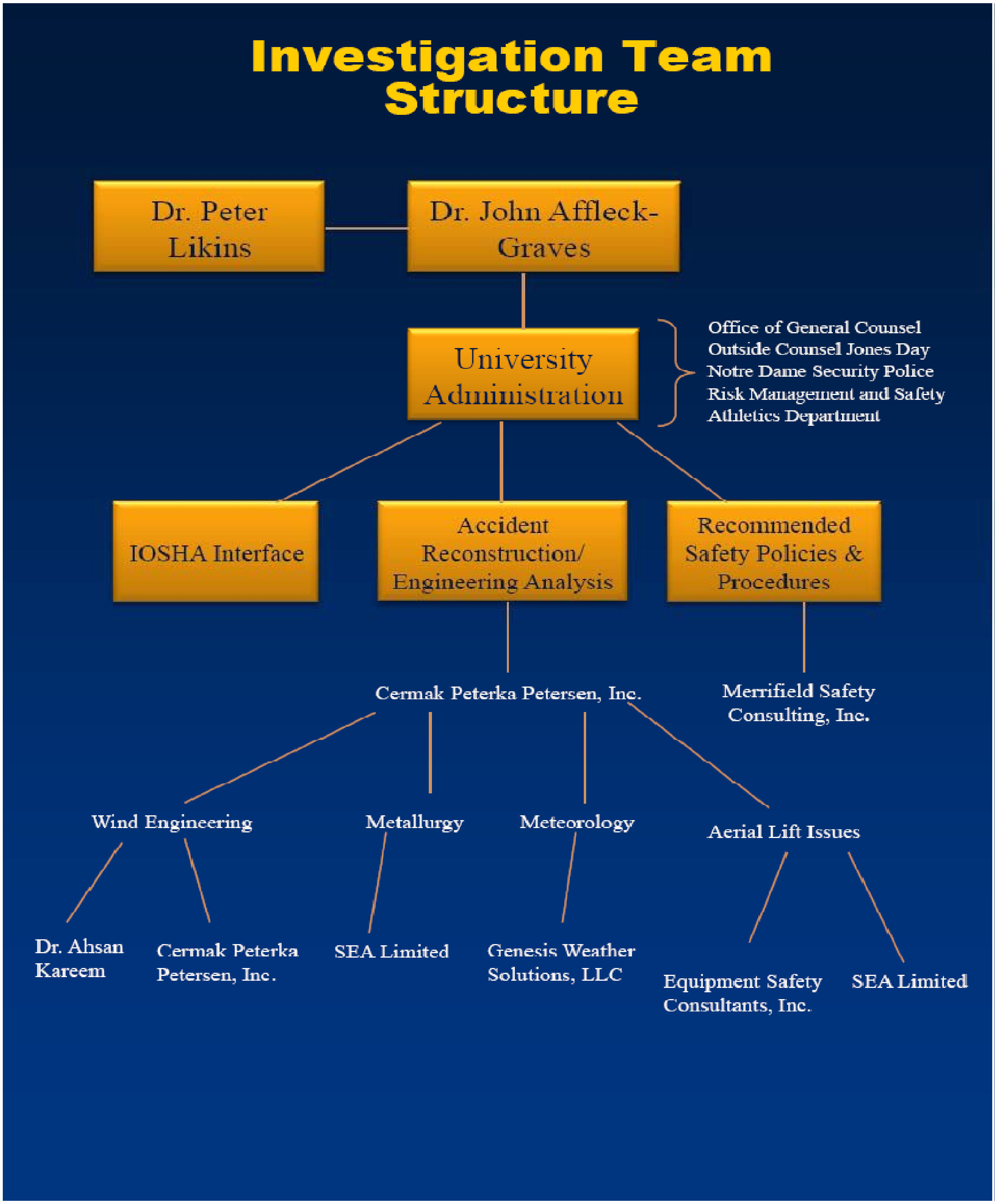
INVESTIGATION PROCESS OVERVIEW

Immediately following the tragic scissor lift accident involving Declan Sullivan on October 27, 2010, Notre Dame began to investigate the circumstances of the accident. The Notre Dame Administration interviewed witnesses and key personnel the morning of October 28 and continued those interviews over the course of the next week. Computer forensics, where available, were used to verify the witnesses' accounts. The results of the interviews were reported to the University's president, Rev. John I. Jenkins, C.S.C.

Notre Dame then sought to conduct a full investigation ("Investigation") as to the potential causes of the accident, including behavior conditions within the football program, to ensure that a similar tragedy would not occur again. The Investigation focused on identifying instances where processes and/or people had failed, and on ways to improve student safety. Dr. John Affleck-Graves, Notre Dame's Executive Vice President, chaired the investigation. He relied on information provided by different disciplines, witnesses, and investigators within the Office of General Counsel, Notre Dame Security Police Department, Notre Dame Department of Risk Management and Safety, and the Athletic Department. Notre Dame engaged outside counsel Jones Day to assist in the investigation. Notre Dame also engaged outside experts to determine the physical cause of the accident and to review Notre Dame's safety policies and procedures.

To ensure that Notre Dame's continuing investigation was thorough, accurate, and unbiased, Notre Dame asked Dr. Peter Likins to provide an external review of the inquiry. Dr. Likins has an impeccable reputation for integrity, intellect, and independence. Moreover, as a world-renowned engineer, a former university administrator who served as provost at Columbia and president at Lehigh and Arizona, a highly-regarded member of numerous NCAA committees, and as a member of the Knight Commission on Intercollegiate Athletics, he was uniquely qualified for this role.

The Indiana Occupational Safety and Health Administration ("IOSHA") also investigated the accident. Notre Dame's Office of General Counsel cooperated with IOSHA and assisted them with the investigation. IOSHA's investigation concluded on March 14, 2011 with the issuance of six safety violations. Notre Dame's investigation, while broader than IOSHA's investigation, considered the information provided by IOSHA and examined whether the conduct underlying the IOSHA violations caused the accident.



Notre Dame interviewed more than 50 witnesses, including all of the relevant decision makers, reviewed hundreds of documents, and engaged industry experts in wind engineering, meteorology, metallurgy, and aerial lift design and safety.

SUMMARY OF CONCLUSIONS

After gaining a full understanding of the facts leading up to the October 27, 2010 scissor lift accident at the University of Notre Dame and analyzing the factors that potentially caused or contributed to the accident, Notre Dame has reached a series of conclusions. Notre Dame's investigation identified several factors that likely caused or contributed to the accident. The Investigation also identified a number of factors that were determined not to have caused or contributed to the accident. Even for those factors that did not cause or contribute to the accident, several flaws were exposed that need to be acknowledged and addressed. Responsibility for these issues is shared by many individuals. Although all factors are extensively discussed in the report, the key factors are summarized below.

I. Factors That Caused or Contributed to the Accident

The Investigation identified several factors that caused or contributed to the accident, including: (1) the presence of unusual wind conditions; (2) staff members' lack of knowledge regarding current and projected weather conditions; (3) characteristics of the lift involved in the accident; and (4) the height of the lift involved in the accident. Each played a role, standing not as a sole cause but rather collectively causing the accident.

A. Presence of Unusual Wind Conditions

Meteorological analysis determined that an unusual weather system moved through South Bend on October 27, 2010. As a low pressure system passed to the north of South Bend, wind speeds from the southwest increased in velocity. While staff members saw reports of 23 mph sustained winds with 30 mph gusts prior to practice, those winds increased, punctuated by an extraordinary 53 mph gust at 4:54 p.m. This wind gust was highly irregular, occurring in South Bend approximately once every three years in non-thunderstorm conditions, and ultimately caused Declan Sullivan's lift to tip over.

B. Staff Members' Lack of Knowledge Regarding Current and Projected Weather Conditions

The staff's lack of knowledge regarding current and projected weather conditions contributed to the accident as well. With no national wind standard to adopt and enforce, the Notre Dame football program developed its own procedure for monitoring wind-safety, governed by a 35 mph lift wind limit learned from third-party sources. That 35 mph limit was not triggered by the wind conditions being reported prior to practice. Nor did the staff understand that the reported wind conditions they were monitoring trailed real-time wind data by as much as one hour. After practice began, wind speeds increased, with reported gusts exceeding 35 mph shortly before the accident. While the staff's weather concerns prompted them to continuously check the weather before practice, they did not consult any weather data while on the practice field despite those pre-practice concerns. Had the staff accessed real-time weather information during practice, they would have learned that wind gusts exceeded the internal 35 mph wind limit and would have grounded the lifts. Moreover, although Declan was aware of a wind warning that day that was later downgraded prior to practice, the staff—despite frequent weather checking—did not access that information when they checked the weather that afternoon. Had staff members been aware of the wind warning and later advisory, they might have acted differently.

The Department of Risk Management and Safety ("Risk Management"), the Athletic Department, the football program, and Notre Dame as a whole did not provide the videography and safety staff with the tools necessary to access real-time weather information continuously through the duration of practice. This failure resulted in decisions based on outdated information, and ultimately contributed to the accident.

C. Characteristics of the Lift Involved in the Accident

The Investigation also sought to understand why the lift involved in the accident—a Marklift MT40G—fell over, but the other two lifts on the practice field—a JLG 4394 RT and a SkyJack SJ 8243—did not. Experts determined that the Marklift's characteristics made it more susceptible to tipping than the JLG and SkyJack lifts. The ability of a scissor lift to resist wind is impacted by the amount of deflection the platform experiences under various wind loads and the weight of the lift itself. Experts conducted testing to determine each lift's resistance to wind. They concluded that characteristics unique to the Marklift—weight, weight distribution, and age—made it more susceptible to wind forces. While a 53 mph wind would cause the Marklift to tip at full extension, the JLG and SkyJack could withstand winds in the 70-80 mph range. This increased susceptibility explains why the wind tipped the Marklift, but did not tip the JLG and SkyJack lifts.

D. Height of the Lift Involved in the Accident

After the accident, experts determined that the Marklift had been extended to its full 40-foot height. Student videographers had been instructed to raise the lifts only as high as they felt comfortable and, in any event, no higher than the 40-foot goal posts. Although the SkyJack and JLG lifts could be extended beyond 40 feet and thus were not fully extended on October 27, 2010, the Marklift was fully extended at goalpost height. Expert analysis confirms that the Marklift would not have fallen over had it been extended only 30 feet. Therefore, the height of the Marklift contributed to the accident.

II. Factors That Did Not Cause or Contribute to the Accident

The Investigation also identified a number of factors that did not cause or contribute to the accident. Although all of these factors are discussed in detail in this report, several reflect flaws in Notre Dame operating procedures that merit highlighting: (1) implementation of the aerial lift training program; (2) lift maintenance and inspection, (3) the football program's wind-safety procedure; and (4) staff understandings of lift restrictions and capabilities. Responsibility for these issues that did not cause the accident is shared by individuals inside and outside Notre Dame.

A. Implementation of the Aerial Lift Training Program

The videography staff, including the student videographers, were not identified as aerial lift employee-operators by Risk Management and, consequently, never received American

National Standards Institute ("ANSI") compliant training offered by the University through the Aerial Lift Platform Policy. The lack of institutional oversight to ensure the videographers' participation in the training program resulted from failures by both Risk Management and the Athletic Department. As the department in charge of training employee-operators, Risk Management should have been aware of all University personnel using aerial lifts on campus. Despite the visible and regular use of the lifts to film football practice, Risk Management never inquired directly to the football or videography staff about the extent to which the program used lifts and the need to train lift operators. Moreover, while members of the Athletic Department were aware of the University lift policy (and some had received training), the Athletic Department never ensured that the football videographers received training. Finally, the football program, while unaware of the University lift policy, should have ensured that the operators were fully trained in the operation and safety of the lifts. Still, even ANSI-standard training would not have provided any clear wind limits to change the program's internal 35 mph procedure. As a result, it is ultimately unclear whether the staff would have acted differently if they had received University aerial lift training.

B. Lift Maintenance and Inspection

The Investigation also closely examined the condition and maintenance history of the Marklift. ANSI standards require aerial lifts to be inspected annually and periodically. While the Marklift passed its annual inspection in 2009, it did not receive annual or periodic inspections in 2010. Risk Management, videography supervisors, and the rental and servicing company all failed to ensure the lift was timely inspected and serviced. Further, the lift's prior inspections—completed by an outside vendor—were deficient. Two maintenance issues—a damaged platform railing assembly and corroded and unpinned outrigger assemblies—should have been discovered by the vendor during previous inspections and prevented the lift from passing inspection. However, as the expert analyses demonstrate, the two deficiencies did not ultimately cause or contribute to the accident.

C. The Football Program's Wind-Safety Procedure

Despite its implementation, the football program's wind-safety procedure did not prevent the accident. The University's procedure involved instructing that the lifts not be used at full extension in winds between 25 mph and 35 mph, and grounding the lifts when winds exceeded 35 mph. This wind-safety procedure was not formalized, in writing or otherwise, such that it could have been vetted, reviewed, or critiqued by others within the football program, the Athletic Department, or Risk Management. Moreover, though learned through third-party instruction, the origin of the 35 mph limit cannot be traced back to any specific written materials. Instead of relying on verbal representations by a third party, staff should have consulted lift-specific sources. To enforce the 35 mph limit, staff members monitored the weather conditions and made subjective judgments based upon those reported conditions, as prescribed by ANSI and industry standards. In retrospect, those standards proved inadequate—lacking specific guidance and allowing for excessive subjectivity.

The wind-safety procedure clearly failed on October 27, 2010. As discussed above, the procedure did not prevent the accident, in part, because the staff's decision to use lifts was informed by outdated weather information. While the Director of Videography, Tim Collins, was concerned about the wind, he did not believe that the winds were strong enough to warrant grounding the lifts. In light of his concerns, Collins and his staff took several precautions, including monitoring the weather throughout the day (from 9:12 a.m. until 2:46 p.m.), applying the 35 mph wind limit, inquiring whether videographers felt safe, and instructing the videographers to go no higher than they felt comfortable and no higher than the goalposts next to the lifts. Ultimately, because staff never saw winds in excess of 35 mph, the lifts were not grounded. Nonetheless, where any person has a subjective concern for safety, protocols should be strengthened to help ensure that such concerns are addressed, even where objective safety procedures (such as the 35 mph procedure here) are not triggered.

D. Staff Understandings of Lift Restrictions and Capabilities

Finally, the Investigation identified a lack of staff knowledge regarding the lifts' restrictions and capabilities. The staff's understanding of a 35 mph wind limit was based solely upon verbal representations by outside parties repeated and relied upon within the staff, which was unchallenged due to the absence of any contrary limit in the Marklift manual, Marklift warning labels, or ANSI standards. That said, the staff had resources available regarding the two other aerial lifts used to film practice. Those other lifts included information, though lacking clarity and not in compliance with ANSI warning criteria, that referenced a 28 mph limit. While industry analysis does not suggest that such resources should have been applied to the Marklift, Risk Management, the Athletic Department, those who provided the lifts, videography supervisors, and all those responsible for safety issues during practice should have ensured that staff considered and understood all available information for the equipment in use at football practice. However, although the staff was unaware of the 28 mph limit for the other lifts, the 35 mph limit used fell well within the Marklift's actual margin of safety (which was determined to be 49-53 mph), and even more so within the margin of safety of the JLG and SkyJack (which was determined to be above 70 mph). Nonetheless, had the staff applied a 28 mph wind limit for the Marklift, the lift likely would have been grounded.

RECOMMENDATIONS

At the Investigation's conclusion, Notre Dame developed a series of recommendations. These recommendations are intended to address not only the issues identified by the Investigation, but also to institute programs and protections to help prevent a similar accident from occurring again—at Notre Dame or anywhere else.[1]

I. Adoption of Specific Wind Limit

The University should set definitive and more stringent wind requirements. Although ANSI generally warns against lift usage in high winds, that warning can prove confusing to those vested with the discretion to determine whether winds are indeed too "high." The ANSI standard thus fails to provide sufficiently clear guidance. The International Standards Organization ("ISO"), in contrast, has adopted a 28 mph wind limit for aerial lift usage. To ensure more predictability in behaviors and uniformity in approach, the University should adopt that 28 mph maximum wind speed standard. With respect to aerial lifts that the University rents or buys in the future, those units should comply with the 28 mph requirement.

II. Access to Real-Time Weather Information During Operation

Operators should have access to real-time weather data during operation of the lifts. Wind-limits and protocols cannot work if the operators are unaware of the wind conditions in their areas. The University should make real-time weather information available to appropriate individuals whenever University-owned or rented lifts are used outdoors, whether through a centrally located anemometer with results relayed as needed, through hand-held anemometers used by lift operators, or through other appropriate systems and procedures that can be implemented as necessary. Weather forecast data and wind advisories, though unreliable, should also be consulted to provide context to real-time weather information and its trends.

III. Development of and Participation in National Educational Effort

As evidenced by the Investigation's peer program review and other media reports, college lift policies lack uniformity and specificity. Most programs have no specific protocols in place, and rarely are they documented or reviewed. Recently, some institutions have begun to develop or implement protocols, though they remain varied.

Notre Dame should collaborate with IOSHA and the Collegiate Sports Video Association ("CSVA") to institute education and training programs. The University also should work with the NCAA and other athletic departments to ensure that safety protocols are developed for collegiate athletic programs and other relevant programs, including, but not limited to, marching band, intramural sports, and high school athletic programs. Most importantly, this effort should: (1) highlight the dangers of wind and the fact that there have been several wind-related accidents throughout the country; (2) underscore the importance of access to real-time weather information

[1] In March 2011, while the Investigation was ongoing, the University announced the installation of a remote video system that it will utilize to film football practice. This system constitutes one step toward minimizing the chance of a similar accident occurring at a Notre Dame football practice.

and projections; (3) caution that ANSI standards remain vague, lack clear guidance, and allow for excessive subjectivity; and (4) encourage all programs to adopt the stricter ISO standards. In sum, Notre Dame should help all NCAA institutions, and institutions outside the NCAA, learn from this tragedy and should encourage such institutions to adopt the recommendations of this Investigation.

IV. Appointment of Athletic Department Safety Contacts

Given the Athletic Department's failure to fully understand the University's policies in this instance, the Athletic Department should identify Safety Contacts who will receive all safety notices and policies and ensure compliance with those notices and policies. The Athletic Department currently has head trainers for each sport. These trainers should be appointed Safety Contacts for their designated sports programs. The Director of Athletic Training and Rehabilitative Services should supervise the Safety Contacts.

Each Safety Contact should receive sport-specific safety training and develop and enforce safety protocols. The Safety Contact should also function as a liaison between Risk Management and his or her sports team, and as an independent resource to whom administrators, staff, and students may report any safety concerns regarding the work or practice environment. Administrators, staff, and students should be provided with contact information for the Safety Contact and informed of their right to confer with the Safety Contact at any time.

The Safety Contact also should have primary responsibility for determining whether lifts can be safely operated outdoors and have ultimate authority to enforce all safety protocols at any time. In light of the inherent difficulties in adequately monitoring real-time weather information while also performing their duties on the field, coaches and filming coordinators should not be tasked with primary responsibility for monitoring weather conditions. Departments utilizing lifts for purposes other than filming sports practices should likewise appoint a Safety Contact. In addition to the Safety Contact, coaches, filming coordinators, videographers, and all other employee-operators should still be encouraged to voice any concerns they may have regarding the propriety of using lifts in certain conditions. Moreover, lift operators should continue to be empowered to ground or lower the lifts if they feel uncomfortable for any reason whatsoever.

V. Establishment of Athletic Department Practice-Safety Protocol

The Athletic Department should establish a written practice protocol to help ensure that practices are held in a safe environment. Although not every potential risk can be foreseen, the protocol should attempt to anticipate relevant potential risks and provide criteria that will allow staff to determine safe practice locations, procedures, and logistics. The practice protocol should be reviewed by Risk Management and all Safety Contacts for comments, revisions, and approval.

VI. New Lift-Identification Protocol

Under Risk Management's current policy, all University personnel who operate lifts are required to be trained. The student videographers did not receive this formal training. Steps should be taken to ensure that Risk Management is aware of all departments operating aerial lifts on campus.

First, Risk Management should circulate a questionnaire regarding the use of aerial lifts to every department. In the event that a department does not respond, Risk Management should follow up. The questionnaire should inquire not only as to lifts within the department, but any other lifts that the department employees may know about. In the event a department identifies a lift used by others on campus, Risk Management should ensure that those lifts are accounted for and are part of its program.

Second, Risk Management should conduct a thorough campus walk-through. Risk Management should visit the departments that identify aerial lifts and ensure that the lifts are accounted for. Risk Management should also determine if there are other lifts that it has not yet identified.

Third, to ensure that Risk Management continues to be apprised of every lift on campus, no aerial lifts should be purchased or rented without first notifying Risk Management. Procurement Services should be informed that all requests for purchasing or renting aerial lifts must first be approved by Risk Management. In addition, individual departments should be banned from purchasing or renting lifts, thereby requiring individuals to go through Procurement Services.

VII. New Inspection Protocol for All Lifts, Including Pre-Operation Checklist

To ensure the safe operation of lifts, the University should adopt a new inspection protocol. The Department of Risk Management and Safety, which currently oversees aerial lift safety, should implement and oversee this protocol.

The proper functioning of lifts is essential to ensuring operator-safety. However, Risk Management currently has no ability to determine if the lifts are being properly inspected and maintained. Under the new protocol, Risk Management, not individual departments, will assume responsibility for lift inspection and maintenance.

Risk Management should ensure that all inspections comply with all ANSI and manufacturer-specific inspection requirements. Per the ANSI standards, periodic inspections should occur every three months, and annual inspections should occur once a year. If any safety issues are identified by periodic or annual inspections, Risk Management should ensure the lift is removed from service until those repairs are made. If a department encounters a problem with a lift, it should contact Risk Management and Safety, which will then coordinate the lift's service.

In addition to requiring periodic and annual inspections, ANSI standards also require operators to conduct pre-operation inspections before using an aerial lift. Risk Management should design and provide Pre-start Inspection Forms for operators to review while conducting their inspection. Risk Management should also include with each operator manual a checklist for operators to date and sign, indicating that they conducted a pre-operation inspection. Risk Management periodically should collect these charts and ensure that the inspections are being completed as required.

Each inspection should ensure that the manufacturer's operating manual is physically located on the lift, that warning stickers remain legible, and that the lift should not be operated if the manual is absent. All records pertaining to lift maintenance and inspection should be retained for a minimum of four years.

VIII. New Training Protocol for All University Personnel Who Use Lifts

Equipped with an accurate count of aerial lifts on campus and the departments using them, Risk Management will be able to ensure that all operators are properly trained. To do so, it should take several steps.

First, Risk Management should provide annual aerial training sessions, supplemented by individualized training sessions when needed. At a minimum, this training should incorporate AWPT (Aerial Work Platform Training), IPAF (International Powered Access Federation), or equivalent training programs, and an AWPT trainer or equivalent should train Risk Management trainers and core operators. In order to enforce this training requirement, Risk Management should present certification cards to those who have completed training. Any person who attempts to use a lift should be required to present that card to his or her supervisor prior to operation. Risk Management should make clear to each individual that to operate a lift he or she must first receive familiarization on the specific lift before operation.

Second, all training should incorporate not only ANSI standards, but also the ISO standard, which provides that lifts should not be used when winds exceed 28 mph. Further, training should reaffirm that individual operators have overriding authority to come down if they determine they should, and should instruct operators that they are required to obey their instincts at all times. Training should also explain to operators the use of wind-monitoring equipment.

Third, Risk Management should be directly involved in familiarization. This is currently delegated to departments. When general lift training is provided, Risk Management should provide necessary familiarization as well. This will only apply to first-time operators who are unfamiliar with the particular lift and does not need to occur each year. Risk Management can supervise an experienced operator who provides this training or can arrange for a vendor to provide it.

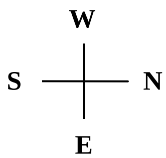
Fourth, AWPT or an equivalent organization should periodically audit the University's training program to ensure that it remains state-of-the-art and is being enforced.

FACTUAL BACKGROUND

I. Notre Dame's Practice Facilities

The University of Notre Dame football team has both indoor and outdoor practice facilities. Construction for the current outdoor practice facility, LaBar Football Practice Fields ("LaBar"), began in October 2007 and concluded before 2008 fall football camp.

As shown below, LaBar has three fields within the facility: two artificial turf fields and one natural grass field.



The Notre Dame football team, as is customary for major college football teams, films its indoor and outdoor practice sessions. Coaches then use the film to critique and teach the players. To be effective, the film should record all of the players involved in the particular drill or play. This is accomplished through filming from elevated heights.

The team's filming needs were considered during the design process. LaBar has two permanent towers used for filming. Tower 1 is on the 50-yard line between Fields 1 and 2, and Tower 2 (pictured below) is on the 50-yard line between Fields 2 and 3.

In addition, concrete pads were poured behind the goalposts of each of the six end zones to accommodate aerial scissor lifts. Below is a picture of the North end zone on Field 1. Behind the goalpost is one of the pads and a compacted scissor lift.

Representatives from the University Architect's Office did not recall any discussion as to whether permanent structures, rather than concrete pads, should be installed behind the end zones. In addition, University employees appreciated the versatility of lifts, which could be moved to different sites to accomplish other tasks when not filming practices.

II. Football Team's Use of Aerial Lifts

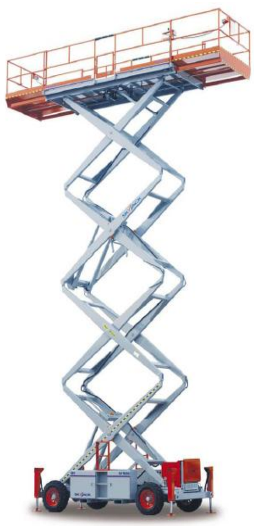
At the time of the accident, Notre Dame owned one scissor lift, a 1989 Marklift MT40G, which it purchased in 1997, and rented two other lifts for use at practice. Notre Dame's custom was to rent the lifts for the duration of the fall football season, acquiring them at the start of fall camp and returning them after the last practice of the season. For spring practice, Notre Dame would again rent two lifts, returning them following the last practice. While the lifts would remain the same throughout a rental period, Notre Dame would not necessarily receive the same lifts every period. The rental company recommended that Notre Dame use scissor lifts over boom lifts because, according to the rental company, boom lifts require strapping students in and boom lifts are generally less wind resistant.

For the 2010 football season, Notre Dame rented a 2008 SkyJack SJ 8243 and a 2005 JLG 4394 RT. The scissor lifts were stationed on concrete pads behind the North and South end zones on Field 1. While the SkyJack lift was not moved during the course of the season, the JLG lift, which was positioned behind the South end zone on Field 1, was occasionally moved to film practice on Field 3.

The team stationed the Marklift behind the North end zone on Field 2. Approximately twice a month, other Athletic Department employees or contractors would borrow the Marklift when not being used by the football team. After use, the Marklift would be returned to the concrete pad behind the North end zone on Field 2.

All three scissor lifts could be extended to heights of 40 feet, with the SkyJack and JLG lifts capable of further extension. The Marklift and SkyJack lifts have "outriggers," metal leg-type devices, on all four corners that lower before the lift is extended to increase stability. The JLG lift does not have outriggers, but instead is stabilized by a significantly heavier base than the other two vehicles. When the lifts are fully extended, according to multiple operators, even slight breezes or walking on the platform may cause the lifts to sway back and forth. Industry experts report that such minor swaying is not itself dangerous and is part of the design attributes of the lifts.

Marklift MT40G



SkyJack SJ 8243

JLG 4394 RT

Tim Collins, the Director of Football Video and Film, coordinates the video and film needs of the entire athletic department. The 2010 football season marked Collins's 20th year in that role. In 2004, the Notre Dame Monogram Club awarded Collins an honorary monogram in recognition of his years of service. A founding member of the Collegiate Sports Video Association ("CSVA"), Collins has been recognized for his leadership in the industry.

Collins compiles video packages for the football coaches in their scouting and game preparation and ensures quality taping of the football team's practices and games. He is assisted in filming football practice by a full-time assistant video coordinator and six part-time student videographers. In addition, he films home hockey games and men's and women's basketball games. Football is the only sport for which Collins uses aerial lifts to film.

Collins monitors the maintenance of the three lifts. He visually inspects each lift before practice—checks for leaks or flat tires and confirms the outriggers are down—and, if he believes a lift is in need of repair, he removes it from service. Collins also coordinates the annual inspection of the lifts by an outside vendor. Records show that the Marklift was annually inspected in 2001 and 2003–2009. The lift's last annual inspection was in August of 2009 and its last service was in October 2009. Although the Marklift's annual inspection was due in August 2010, the inspection never occurred. Collins stated that he forgot to schedule the inspection and the vendor never contacted him to set it up. Periodic inspections—roughly every three months—are also required under American National Standards Institute ("ANSI") regulations. These inspections never occurred.

III. Decision to Practice Outside

Head Coach Brian Kelly makes the initial determination on practice location based on "common sense" as to whether outside practice would be productive. On a typical day, Kelly looks outside at the current weather conditions; if the weather is clear, the decision will be to practice outside. Once Kelly makes the determination to practice outside, he conveys that decision to Chad Klunder, Director of Football Operations.

Klunder reports directly to Kelly and ensures, among other things, that football practice runs smoothly. As part of his responsibility, Klunder considers himself Kelly's weatherman. Klunder looks at the weather to determine whether practice outside would be productive from a football standpoint and advises Kelly to that effect.

After the decision to practice outside is made, Klunder informs Collins and Jim Russ, the Head Athletic Trainer. Collins generally reports to Bill Scholl, the Deputy Director of Athletics, who has administrative responsibilities for the football team. But, for purposes of filming practice, Collins takes direction from Klunder, as Klunder is in charge of practice operations. Collins manages the operation of the lifts at practice and considers the weather before using the lifts to film.

Collins closely monitors the weather if the National Weather Service reports wind speeds, either sustained winds or wind gusts, over 20 mph. If Collins sees reported wind speeds of 25 mph, he informs the students not to fully extend the lifts. Collins tells them not to go any higher than they feel comfortable and, under no circumstances, to go higher than the goalposts. If Collins were to see reported wind speeds of 35 mph or higher (for either sustained winds or wind gusts) close to the time of practice, he would inform Klunder and would not use the lifts at practice. Collins believes the rental company informed him that lifts should not be used if gusts exceed 35 mph. In the past, the program has grounded or lowered lifts in response to weather conditions. On some occasions, the lifts have been grounded and practice has continued outdoors; on other occasions, the lifts have been grounded and practice has been moved indoors where filming could continue.

Russ has been a trainer at Notre Dame since 1986.[2] He reports to Associate Director of Athletics Mike Karwoski. Russ understands his responsibilities to include monitoring the safety of everyone on the practice field, including those operating aerial lifts. If Russ deems it unsafe to practice outside, he tells Klunder, Collins, or Kelly. Russ believes he has the authority to unilaterally take corrective action if conditions are unsafe. He has issued safety directives to head coaches many times throughout his tenure as a trainer.

Russ also monitors the weather on the field. To monitor heat and lightning, Russ follows the University's safety procedures, which are informed by national standards and guidelines. University heat index procedures call for the heat index to be calculated and recorded multiple times at every practice during the month of August and during practices and games when the temperature reaches 75 degrees and/or the humidity reaches 60%. Accordingly, Russ measures the field temperature, takes dry-bulb and wet-bulb readings to determine relative humidity, and calculates the actual heat index. Russ also monitors the players when the heat index is high, paying close attention to those who have had heat problems before. When deciding whether players need a break, he considers how long practice has been going on, the types of activities that have been performed, how many breaks have previously been taken, and the team's remaining schedule for the day. Russ and the head coach work together to ensure that the practice schedule protects players from heat exhaustion.

For lightning, Russ adheres to the University's Lightning Safety Guidelines, which incorporate procedures recommended by the NCAA and the National Athletic Trainers' Association, as well as input received from other universities. Russ typically monitors storms as they move eastward from Chicago. When the forecast calls for a chance of storms, he uses a handheld GPS device that delivers real-time weather information from WeatherData Services, Inc., the National Weather Service, and the National Lightning Detection Network. The device monitors weather conditions up to 250 miles away (but does not include wind data). If lightning is detected within twenty miles of campus, it audibly chimes. Per the University's policy, Russ also employs the "flash to bang" method, which, as its name implies, entails counting the seconds from the time lightning is sighted to when the clap of thunder is heard. The closer the flash and bang are, the closer the lightning. Although the University's policy requires everyone to be off the field if lightning is detected within six miles, the football team usually heads inside if lightning is detected within ten miles.

Unlike for heat and lightning, there are no national standards or guidelines for wind. When deciding whether to practice in windy conditions, Russ focuses on the safety of the videographers. Russ does not have any instrumentation on the field that he can use to determine

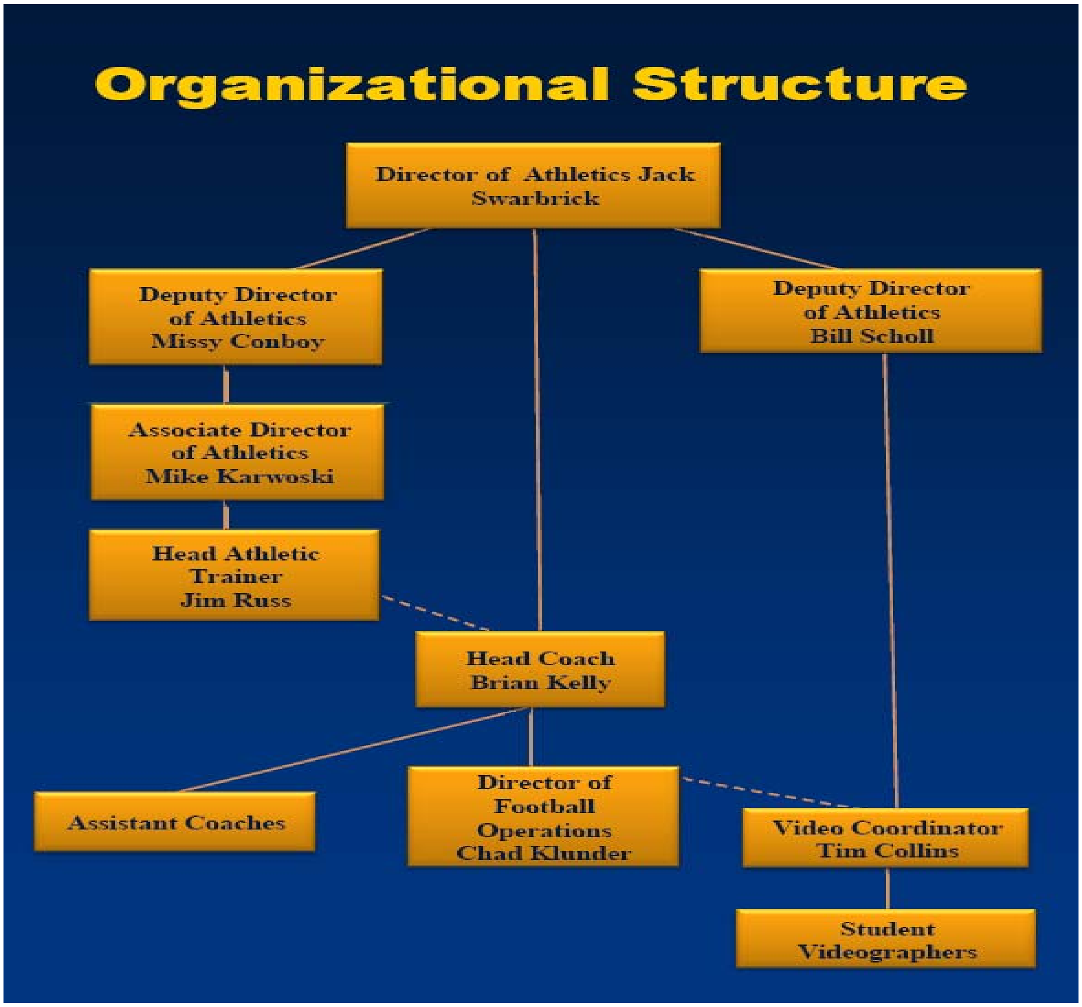
[2] In January 2011, the University named Russ Director of Athletic Training and Rehabilitative Services, a new position in Notre Dame's nascent Sports Performance Division. In his new role, Russ will continue to report to Associate Athletics Director Mike Karwoski, who oversees the division.

wind speeds. Russ understands that the lifts should not be extended in 35 mph winds and has grounded the lifts or otherwise advised previous coaches that practice should be moved inside due to wind.

Kelly depends on Klunder, Collins, and Russ to inform him if the weather will pose a problem or if any precautions should be taken for player safety. When aware of potentially dangerous weather conditions, Kelly has taken action. For example, during one spring practice in 2010, Russ told Kelly that the lifts should be lowered due to storms and Kelly ensured that they were.

Kelly reports to Jack Swarbrick, Director of Athletics. Swarbrick has held that position since the 2008-2009 school year, and was generally aware as of October 2010 that those responsible for making weather-related decisions reported to independent administrators within the Athletic Department rather than to members of the football program. However, he had no specific knowledge of the decision-making process regarding practice location (and lift usage) nor the individuals involved in that process.

The following chart illustrates a partial organizational structure for purposes of the Investigation.



FOOTBALL PRACTICE THE WEEK OF OCTOBER 25

I. No Practice on Monday, October 25, 2010

The football team did not practice on the field on Monday, October 25. In-season Mondays are typically reserved for mental preparation. The players review film and learn the game plan. October 25 was no different, and no lifts were used to film practice.

The Marklift, however, was operated that day. On Friday, October 22, the Loftus Sports Center (the football team's indoor practice facility, hereinafter "Loftus"), borrowed the Marklift for a contractor to use while changing light fixture bulbs. A Loftus employee, trained by Notre Dame's Department of Risk Management and Safety on aerial lift usage, returned the Marklift to the practice field on Monday, October 25. After parking the lift on the concrete pad behind the North end zone of Field 2, the employee lowered the outriggers. There was no indication that the lift was operated improperly or damaged in any way. The Marklift remained parked behind Field 2 until the accident on October 27.

II. Practice on Tuesday, October 26, 2010

On Tuesday, October 26, severe weather hit South Bend, Indiana, prompting the National Weather Service to issue a tornado warning. After Kelly's noon press conference, Klunder discussed the weather conditions with Kelly. Klunder informed Kelly that, although the tornado warning expired at noon, a wind warning remained in effect.

Anticipating that the wind would inhibit the quarterbacks from throwing effectively, Kelly decided to practice inside. He informed Klunder of his decision and Klunder, in turn, notified Loftus, Collins, and the coaches. Practice was held at Loftus and filmed by Collins and several student-employees. No one complained about the decision to practice inside.

III. Practice on Wednesday, October 27, 2010

A. Coaching Staff Decided To Practice Outside

Tuesday's stormy weather gave way to clear skies on Wednesday. Review of the meteorological reports indicates that the weather system was of decreased intensity on Wednesday as compared to Tuesday. Witnesses recall the weather early Wednesday as sunny, but breezy. A picture taken at approximately 3:35 p.m., ten minutes before the start of practice, while obviously not illustrating wind conditions, confirms the sunny skies.

Kelly did not think the wind was as severe as Tuesday, nor as severe as the heavy winds he frequently encountered at Central Michigan, Grand Valley State, Cincinnati, or earlier practice days at Notre Dame. Between 10 and 11 a.m., Kelly notified Klunder that practice would be outside. Klunder checked the weather via an application on his computer. He recalls the application reporting wind speeds in the mid-20s. Klunder then told Russ that the team would practice outside, weather permitting.

Russ checked the weather before practice, as is his custom, and recalls 17 mph wind speeds with gusts up to 27 mph. Computer forensics data corroborates that Russ's computer accessed weather.com at 2:46 p.m. on October 27. Notre Dame was unable to recover the actual page that Russ would have viewed, although the National Weather Service was reporting sustained winds of 23 mph and gusts up to 30 mph from 1:54 p.m. to 2:54 p.m. on October 27. Russ did not object to practicing outside and did not discuss the decision with Collins or Kelly.

After notifying Russ of the preliminary decision to practice outside, Klunder informed Collins. Collins closely monitored the weather on the day of the accident, and noted wind speeds in the "mid-20s range," with gusts "between 29 and 31." Computer forensics data corroborates Collins's general recollection. Collins accessed weather reports from various online weather sources throughout the day, including viewing weather.com at 9:12 a.m., 10:52 a.m., 11:34 a.m., 12:23 p.m., 1:15 p.m., and 2:38 p.m., and National Weather Service information for South Bend via weather.gov at 12:32 p.m. and 2:46 p.m.

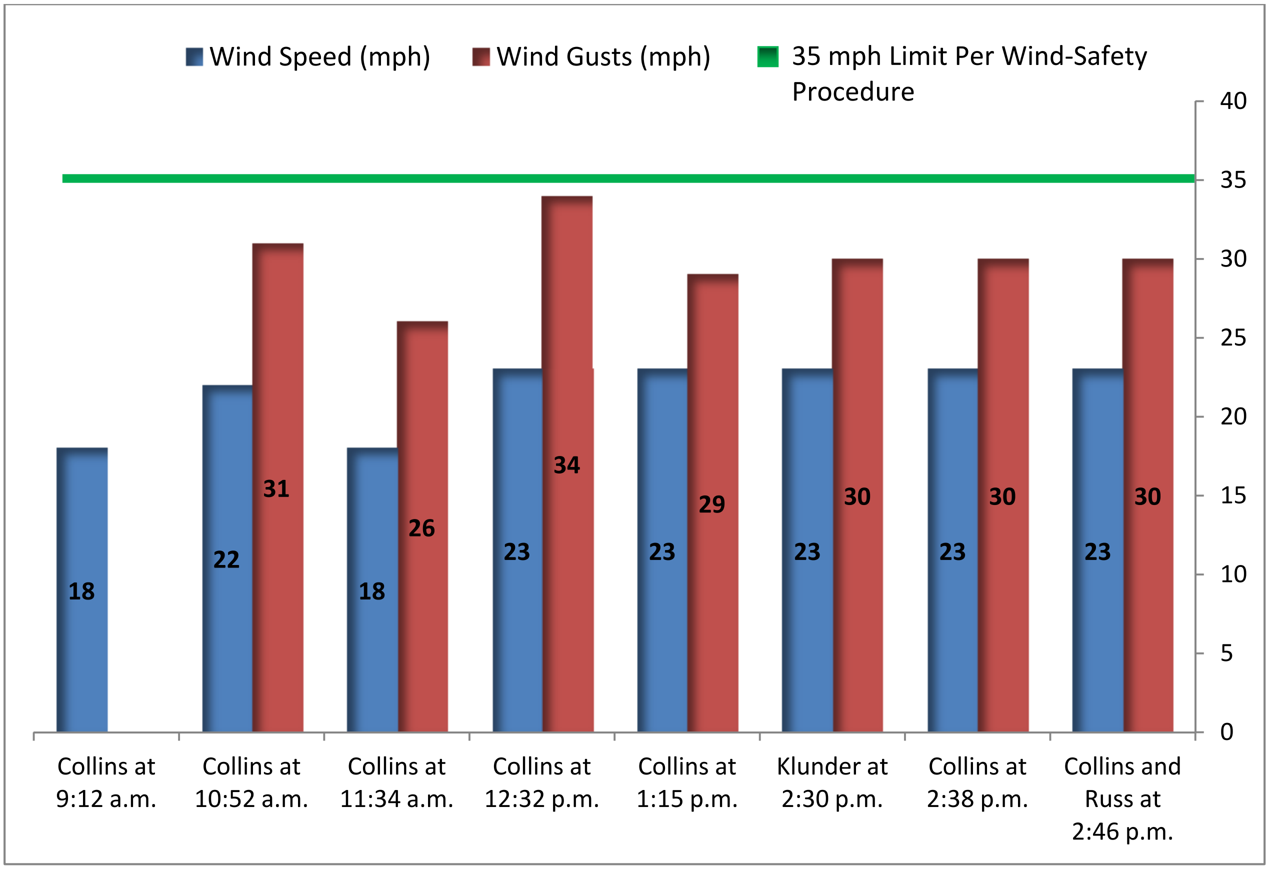
Notre Dame was unable to locate the actual pages Collins viewed, but was able to determine that, between 8:54 and 9:54 a.m., the National Weather Service reported sustained winds in South Bend of 18 mph with no reported gusts. From 9:54 to 10:54 a.m., sustained winds of 22 mph and gusts of 31 mph were reported. Between 10:54 and 11:54 a.m., the National Weather service reported 18 mph wind speeds with 26 mph gusts. From 11:54 a.m. to 12:54 p.m., winds of 23 mph with gusts up to 34 mph were reported. Between 12:54 and 1:54 p.m., the National Weather Service reported 23 mph wind speeds with 29 mph gusts. And, from 1:54 to 2:54 p.m., 23 mph winds with gusts up to 30 mph were reported. Notably, at 2:54 p.m., less than ten minutes after Collins and Russ checked the weather for the last time before leaving for football practice, the National Weather Service updated its data to report winds of 29 mph with gusts up to 38 mph.

Although reported wind speeds and gusts increased after the staff last checked the weather, prior to practice, the National Weather Service Forecast Office ("NWSFO") downgraded a previously-issued wind warning to a wind advisory. Meteorological data shows that, at approximately 4:00 a.m. on October 27, the NWSFO issued a high wind warning valid from 8:00 a.m. until 9:00 p.m. for northern Indiana. However, at 2:44 p.m., before outdoor practice began, the NWSFO canceled the wind warning, downgrading to a wind advisory which was valid until 9:00 p.m. on October 27.

The Investigation found that Declan checked the weather before practice via weather.gov and, from that webpage, accessed the text of the wind warning. The warning indicated the possibility of gusts of up to 60 mph. Klunder, Collins, and Russ did not recall seeing the wind warning when they checked the weather before practice nor accessing the details of that warning. Their focus was the reported wind conditions.

Because Collins did not see winds over 35 mph, he did not relay any weather information to the coaching staff. If he had read reports of actual winds over 35 mph close to the time of practice, he would have informed Klunder. Ultimately, no one—not Collins, Klunder, nor Russ—told Kelly or any coach that practice should be held indoors or that the lifts should not be used.

WIND DATA REPORTED BY NATIONAL WEATHER SERVICE AT TIMES TIM COLLINS, JIM RUSS, AND CHAD KLUNDER CHECKED THE WEATHER



B. Collins Assigned Student Videographers Filming Responsibilities

Four student videographers, including Declan, were scheduled to film Wednesday's practice—three from aerial lifts and one from a permanent tower. The practice schedule did not include film-worthy activity under the South lift until midway through the practice periods. Cognizant of the windy conditions, Collins and his assistant video coordinator decided that the videographer scheduled to film from that lift—who was new, inexperienced, and had only filmed in optimal conditions—would not film until just before those practice periods began.

When the student videographers arrived for work, Collins informed them that practice would be outside. The videographers and staff, as was common, engaged in some lighthearted joking. Upon hearing that practice would be held outside, Declan reportedly commented "Aw man, this sucks," and asked Collins about the wind conditions. Collins, who was checking the weather on his computer, responded that the reports he was viewing showed wind gusts less than 30 mph. After seeing winds over 20 mph in the morning, Collins actively monitored reported wind speeds throughout the day per his procedure, and saw wind gust speeds rise during the morning, but begin to lessen in the early afternoon. Although the wind speeds caused Collins some concern, he never saw reported wind speeds exceed the 35 mph limit, so Collins concluded that the lifts could safely be used. One videographer remembers Collins expressing his concern to him prior to practice, but Collins, though indeed concerned, did not see reported wind speeds in excess of 35 mph—the point at which he would have decided to ground lifts in accordance with the wind-safety procedure.

After they arrived at the practice fields, Collins, pursuant to his usual procedure after seeing winds in excess of 25 mph, instructed the student videographers that the lifts should not be fully extended. Collins and the videographers then boarded a golf cart and Collins proceeded to drop off the videographers at their respective filming stations. Collins dropped off the first videographer at the North lift on Field 1. The videographer subsequently raised the lift to approximately half the height of the goalpost and spoke with Collins via radio. Collins asked how the conditions were in the air and how comfortable he felt. The videographer responded that the lift was not swaying and that he was comfortable going higher. In the presence of all the other videographers, Collins repeated that the videographer should go only as high as comfortable and no higher than the goalpost. Collins believed that the goalpost height restriction was a true limitation for the lifts. It was for the JLG and SkyJack, but not the Marklift. Although the wind was strong, the videographer thought the lift was swaying less than it normally would on a windy day. The videographer reported that he did not feel endangered.

Collins next dropped off Declan at the North lift on Field 2. Declan raised his lift to the approximate height of the 40-foot goalpost. Collins then dropped off another videographer at one of the permanent towers, and finally the last videographer at the South lift on Field 1.

C. Practice Conditions Were Windy, But Not Unusual.

Outdoor practice started at 3:45 p.m. Though windy, practice attendees do not recall the conditions as out of the ordinary. Multiple coaches and staff members remember looking at the light posts and the lifts and discerning no swaying. Collins noticed the special teams net and net posts swaying in the wind, but that was not unusual, as the net posts often swayed in light wind.

According to attendees, the wind did not affect practice. The players made only slight adjustments to compensate for the wind.

Swarbrick also recalls practice proceeding normally during the limited time he was there. As a matter of routine, Swarbrick attends a sampling of Notre Dame’s athletic team practices when his schedule permits. On average, he attends an athletic team practice two or three days a week. On October 27, following the early conclusion of a 4:30 p.m. appointment, Swarbrick left his office to attend football practice. He arrived at the practice field approximately six or seven minutes before the accident, which occurred at 4:54 p.m. While arriving at and watching practice, Swarbrick did not consider the use of the lifts or the fact that practice was being held outside rather than inside.

The student videographers each stated that he or she did not feel unsafe or uncomfortable due to the winds. While one student described practice as the windiest the student had filmed in, the two others described the conditions as not unusually windy and like other days. None of the students told anyone that the winds were too strong or that he or she was uncomfortable filming from the lifts. All of the students reported that they had the right to lower their lifts if they ever felt unsafe.

Declan posted tweets prior to and during practice regarding the weather conditions. Prior to practice, at 3:22 p.m., Declan tweeted: "Gust [sic] of wind up to 60 mph well today will be fun at work . . . I guess I've lived long enough :-/." Later, at 4:06 p.m., he wrote: "Holy fuck holy fuck this is terrifying." Declan never radioed or otherwise communicated with anyone on the field that he was uncomfortable on the lift.

D. An Extraordinarily Strong Wind Gust Blew Through Practice Field

At 4:54 p.m., a sudden, strong burst of wind blew. Although it had been consistently breezy, this gust was significantly more powerful than any prior gust. The wind was so strong that it lifted one videographer's tripod in the air, moved a heavy metal box across another videographer's lift, and sent debris flying onto the field. Klunder saw the light posts above him violently sway in a manner he had never seen before.

Everyone was surprised by the extreme change in wind speed. According to Defensive Coordinator Bob Diaco, the gust was "of hurricane significance." Kerry Cooks, outside linebackers' coach,[3] described the wind as the most powerful gust he had ever felt and stated that the gust picked up a mesh bag containing 15-20 footballs into the air and blew it across the field. Swarbrick explained that, when the gust came through, "Gatorade bottles, plastic bottles the players use, footballs, articles of clothing" flew by him, creating noise as they hit the fence and punting machine. Ed Warinner, the offensive line coach, described the wind as double any prior wind gusts. Collins deemed the gust "greater than anything he had ever experienced before" in his twenty seasons filming practice at the University.

In response to the gust, Russ immediately turned to the North lift on Field 1. He saw the lift swaying back and forth and yelled, "Get Down!" Like Russ, Offensive Coordinator Charley Molnar instinctually turned to the Northwest lift. When he saw the videographer trying to secure his camera, he yelled for the videographer to forget about the camera and get down immediately. Mike Elston, the defensive line and special teams coach, saw the same lift swaying out of the corner of his eye. He ran toward Field 1 and yelled, "Get that lift down," pointing at the lift.

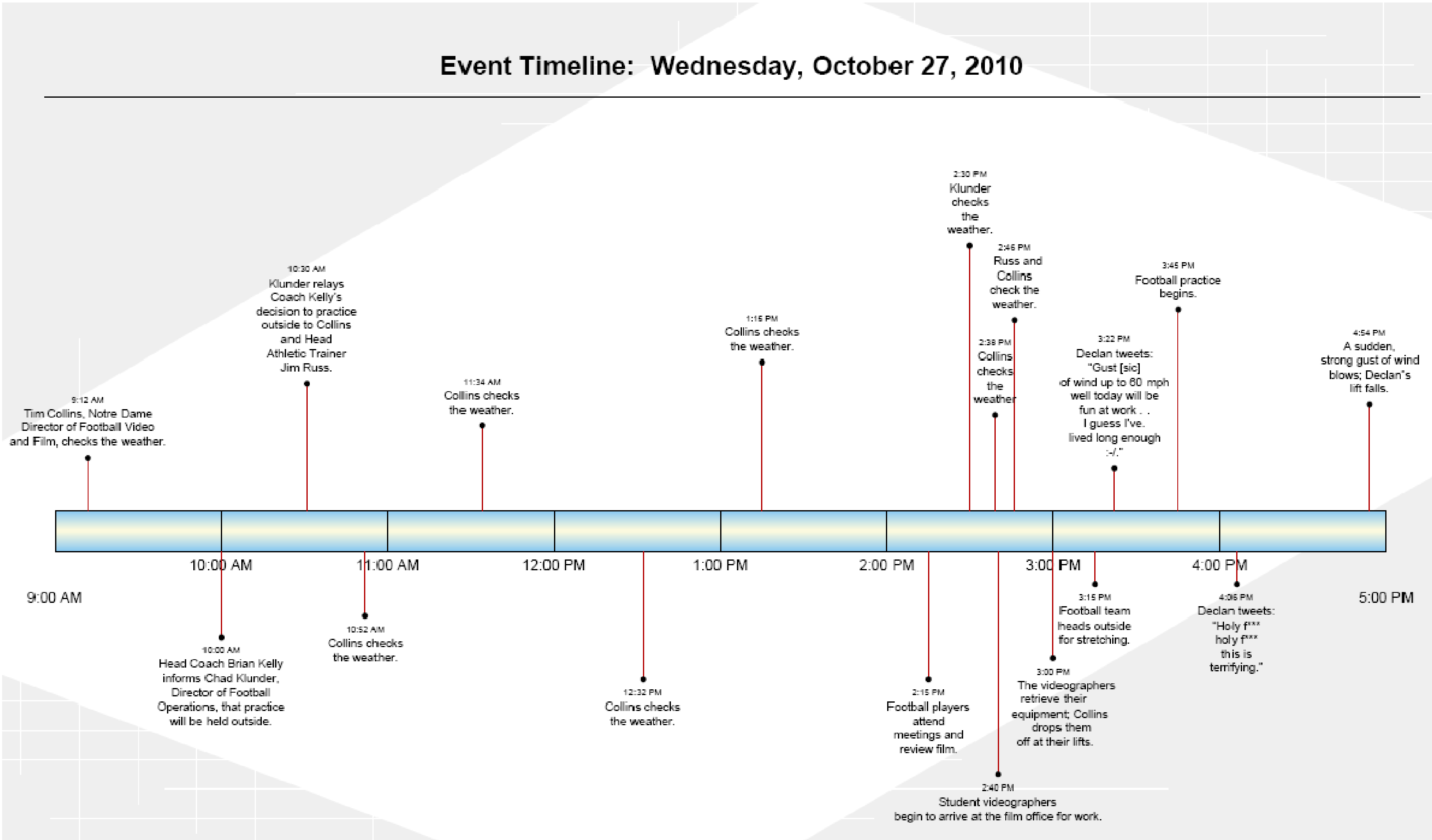
[3] This report reflects coaching positions effective for the 2010 season.

After Russ yelled to the videographer on the Northwest lift, he turned to yell at the videographer on the Northeast lift, but the lift was gone. Declan's lift had fallen.

E. Response to Tip-Over

Immediately after the lift fell, several people called 911, and many rushed to the scene. Kelly, Russ and several other trainers, Klunder, Collins, and Swarbrick were among the first to arrive. Kelly instructed the coaches to keep the players from crowding the accident site, so the team continued to practice. The Assistant Video Coordinator instructed the student videographers to go to the video room. Russ and the trainers attended to Declan until the paramedics arrived.

After Declan was put in the ambulance, Kelly returned to the field. He gathered the team and informed them that Declan had sustained a severe injury. The team prayed at midfield and Kelly ended practice early. Swarbrick later relayed the news of Declan's death to Kelly. That night, Kelly called a team meeting to share the news. The atmosphere was emotional.


Event Timeline: Wednesday, October 27, 2010
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
9:12 AM Tim Collins, Notre Dame Director of Football Video and Film, checks the weather.
10:00 AM Head Coach Brian Kelly informs Chad Klunder, Director of Football Operations, that practice will be held outside.
10:30 AM Klunder relays Coach Kelly's decision to practice outside to Collins and Head Athletic Trainer Jim Russ.
10:52 AM Collins checks the weather.
11:34 AM Collins checks the weather.
12:32 PM Collins checks the weather.
1:15 PM Collins checks the weather.
2:15 PM Football players attend meetings and review film.
2:30 PM Klunder checks the weather.
2:38 PM Collins checks the weather
2:40 PM Student videographers begin to arrive at the film office for work.
2:46 PM Russ and Collins check the weather.
3:00 PM The videographers retrieve their equipment; Collins drops them off at their lifts.
3:15 PM Football team heads outside for stretching.
3:22 PM Declan tweets: "Gust [sic] of wind up to 60 mph well today will be fun at work . . I guess I've. lived long enough :-/."
3:45 PM Football practice begins.
4:06 PM Declan tweets: "Holy f*** holy f*** this is terrifying."
4:54 PM A sudden, strong gust of wind blows; Declan's lift falls.

EXPERT ANALYSIS OF LIFT ACCIDENT

An unusually strong gust of wind appeared to be the primary cause of the accident. Nonetheless, Notre Dame sought to fully understand how the accident happened. In particular, Notre Dame wanted to understand why the Marklift tipped over, but the other two lifts, the JLG and the SkyJack, did not.

I. Independent Expert Team

As a first step, world-renowned wind engineer Dr. Jon Peterka was hired to independently analyze the accident and to ensure that the correct disciplines were involved in the Investigation. Peterka, President of Cermak Peterka Petersen, Inc., and Professor Emeritus of the Fluid Mechanics and Wind Engineering Program at Colorado State University, has over 40 years of wind engineering experience. In 2010, the American Society of Civil Engineers ("ASCE") honored his distinguished contributions in wind engineering by awarding him the Jack E. Cermak Medal. Throughout his career, Peterka has defined the wind loads for over 1,000 buildings and structures. His work in wind engineering includes membership on the ASCE committee that writes the national wind load standard. Recently, Peterka was consulted in two wind-related aerial crane accidents, one at the Milwaukee Brewers' Miller Park and the other at a power plant in Missouri. Peterka analyzed both accidents, determining the wind speed and winds loads for both cranes. He also was fundamental in designing the tornado portion of the "Twister" ride at Universal Studios theme park. *See* Exhibit 1 (Peterka's CV).

Dr. Ahsan Kareem, a member of Notre Dame's faculty, was consulted to assist Dr. Peterka and review his work. Kareem, the Robert M. Moran Professor of Engineering at the University of Notre Dame, has extensive experience in wind engineering and his contributions to wind engineering have been nationally and internationally recognized. Kareem has developed, improved, and implemented current and past versions of the ASCE Standard of Wind Loads. The ASCE awarded him the Cermak and R.H. Scanlan Medals for distinguished contributions in wind engineering and engineering mechanics, and the International Association for Wind Engineering named him the inaugural recipient of the A.G. Davenport Medal for fundamental contributions to quantification, modeling, simulation, and analysis of wind load effects for structural design. The ASCE also honored him with the 2008 State-of-the-Art of Civil Engineering Award. And, in 2009, Kareem was elected a member of the National Academy of Engineering, one of the highest professional distinctions that can be bestowed upon an engineer. *See* Exhibit 2 (Kareem's CV).

Dr. Peterka wanted to ensure that he understood the nature of the wind that was on-site and that there were no unusual aspects to the wind that could affect his analysis. To that end, Dr. Peterka recommended the hiring of Bryan Rappolt, the owner of Genesis Weather Solutions, LLC. Rappolt has nearly 20 years of meteorological experience, having served as an expert meteorologist on over 65 projects for both public and private sector clients. He also has extensive experience in weather event reconstruction. *See* Exhibit 3 (Rappolt's CV).
Mr. Rappolt examined radar and gathered independent weather data to analyze the conditions on the practice field on October 27, 2010.

Notre Dame also needed experts who specialized in the area of aerial scissor lifts. Because the Marklift was manufactured in 1989 and had not been inspected in 2010, Notre Dame sought to investigate whether the condition of the lift had any effect on the accident. Mark Recard, President of Equipment Safety Consultants, Inc., and an engineering expert with a background in aerial lift maintenance and performance, was engaged. Recard has over 25 years of experience in the design, manufacture, maintenance, and safety procedures of aerial lift platforms. A member of the American Society of Safety Engineers ("ASSE") and American Society of Mechanical Engineers ("ASME"), Recard has developed, reviewed, and approved technical and safety manuals for hydraulic cranes and aerial work platforms. Recard also has significant experience analyzing the effects of wind on aerial work platforms. At Grove Manufacturing and JLG, Recard oversaw the structural and stability testing of aerial lifts. He also established wind protocols for oil rigs in the North Sea. *See* Exhibit 4 (Recard's CV). As an independent consultant, Recard has investigated over 400 aerial lift accidents.

Finally, Notre Dame learned that Declan had not received aerial lift training offered by the University. Accordingly, David Merrifield, Principal of Merrifield Safety Consultants and a lift-safety training expert, was consulted. Merrifield is a Certified Safety Consultant and approved Aerial Lift Instructor by the International Powered Access Federation. He is the Chairman of ANSI's committee for aerial work platforms and peer reviewer for the National Institute for Occupational Safety and Health ("NIOSH") study of scissor lift tip-overs. Merrifield also serves on the U.S. Technical Advisory Group for the International Standards Organization ("ISO"), the international organization that produces safety and training standards for aerial lifts. *See* Exhibit 5 (Merrifield's CV).

II. Expert Analysis and Review of the Accident

The experts collaborated to conduct a thorough, multi-faceted investigation. To begin, Peterka and Recard traveled to Notre Dame's campus to consult with Kareem, examine the lifts, and investigate the accident site. Recard, relying on pre-accident images of the lift on the day of the accident, post-accident inspection of the lift, and post-accident measurements of the lift, determined that the Marklift had been extended to 40 feet when it tipped over. Recard went on to analyze the Marklift itself, schematics, and service records to understand whether the pre-accident condition of the lift contributed to the accident.

Peterka, for his part, analyzed the wind at the time of the accident. Accordingly, he transferred wind speeds recorded on a minute-by-minute basis at South Bend Regional Airport to Notre Dame. He then calculated the wind speeds at the practice field on October 27, 2010. Working in conjunction with meteorologist Bryan Rappolt, Peterka concluded that a 53 mph three-second wind gust blew from the southwest through the practice field at the time the accident occurred. Their analysis considered many factors, including the wind direction, potential barriers to wind on the field, and the possibility of localized weather systems.

After understanding the direction and speed of the wind on the day of the accident, Peterka sought to determine the strength of wind ("tipping-point speed") that caused the Marklift to tip over and the reasons why the Marklift tipped over, but the other two lifts did not. Because the Marklift involved in the accident was not in condition suitable for testing, the experts requested that Notre Dame purchase a Marklift of roughly the same condition and age. Per their request, Notre Dame purchased a used 1991 Marklift in January 2011. Because an aerial lift's ability to resist wind is influenced by lift platform deflection, Peterka and Recard, with Kareem's input, then designed a protocol for testing lift deflection and response to wind loads.

For peer review and aid in implementing this testing protocol, Notre Dame engaged SEA Limited engineers Brian Tanner and Mike Dorohoff. SEA specializes in accident reconstruction and engineering analysis. Tanner, an engineer at SEA for 17 years, has extensive experience designing, implementing, and executing testing procedures. Peterka, Recard, and members of SEA met at an aircraft hangar in Columbus, Ohio, where the engineers performed lift-deflection testing on the Marklift exemplar and the SkyJack and JLG lifts that stood on the field the day of the accident. The team extended the lifts to varying heights, applied a series of horizontal forces to the lifts' platforms to simulate wind loading on the lifts, and measured the corresponding deflections. SEA used a state-of-the-art laser-based three-dimensional measurement system to monitor the overall geometry of the lifts during the loading experiments. SEA then utilized the generated data to develop three-dimensional models of the lifts.

Through state-of-the-art wind-loading analysis, Peterka used the generated models and deflection data to determine the three lifts' tipping-point speeds when raised to heights of 40, 35, 30, and 25 feet. He concluded that 49-53 mph winds would cause the Marklift to tip over when fully extended to 40 feet. The SkyJack and JLG lifts, however, were more stable. When extended to 40 feet, winds of 70-76 and 75-81, respectively, were required to cause a tip-over. Ultimately, the 53 mph gust that occurred at the practice fields was sufficient to tip the Marklift when extended to 40 feet, but not the SkyJack or JLG lifts.

Marklift under 200 lbf load at zero degrees

SkyJack under 200 lbf load at 45 degrees

JLG under 200 lbf load at zero degrees

While Peterka performed wind-engineering analysis, the other experts conducted simultaneous analyses of the Marklift's condition, the University's aerial lift training program, and the weather, sharing expertise with one another when necessary. Merrifield met with Collins and with Notre Dame Risk Management and Safety, the department in charge of the University's aerial lift policy and training program, to analyze Notre Dame's aerial lift training program. And Rappolt studied the weather system that affected South Bend on the day of the accident. The complete expert analyses of Peterka, Recard, Merrifield, and Rappolt are attached as Exhibits 6–9, respectively.

EXAMINATION OF POTENTIAL CAUSES OF THE ACCIDENT

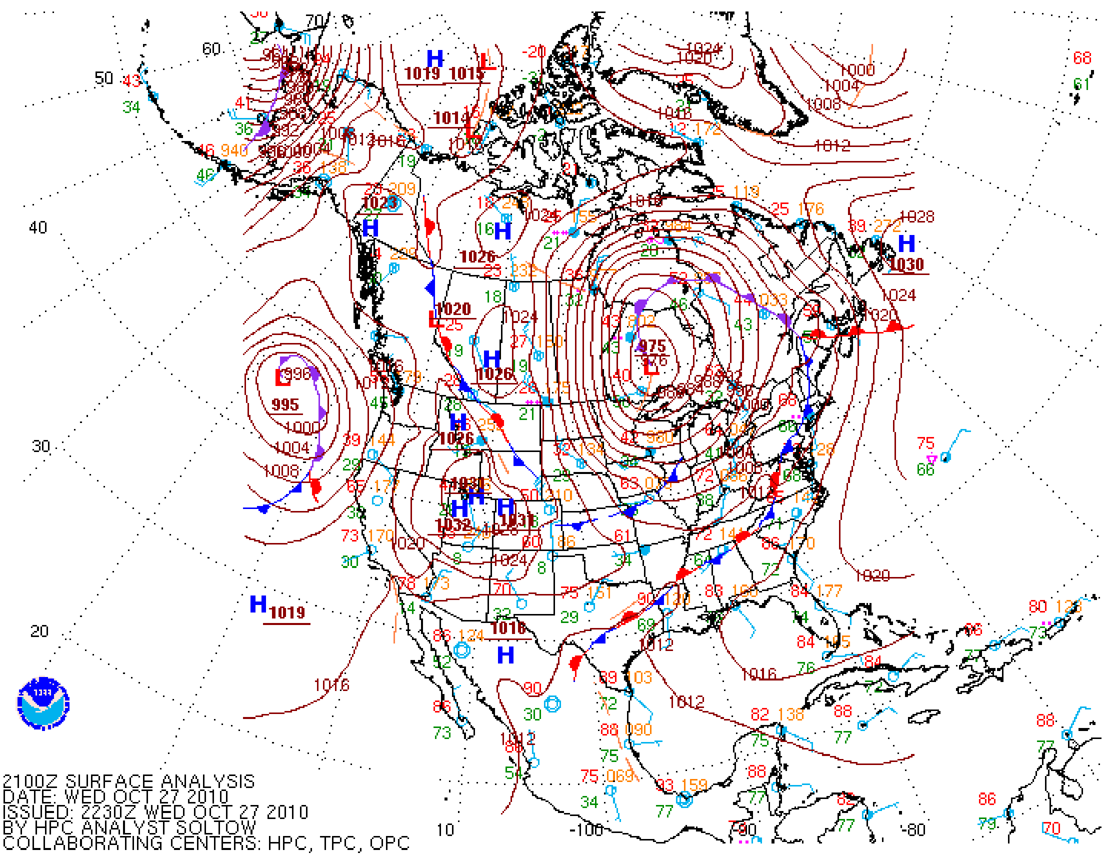
Relying on the experts' analyses and the facts revealed through document review, witness interviews, and forensic computer analysis, Notre Dame attempted to determine which factors potentially contributed to the accident. Several factors were investigated, considered, and excluded as causes of the accident. Other factors were identified as potential causes. Ultimately, one particular factor alone did not cause the accident. Rather, the accident was caused by a confluence of unrelated events and issues.

I. Potential Causes of the Accident

The Investigation identified several factors that likely caused or contributed to the accident: (1) the presence of unusual wind conditions; (2) characteristics of the Marklift; (3) staff members' lack of knowledge regarding current and projected weather conditions; and (4) the height of the Marklift. Each factor will be discussed in turn.

A. Presence of Unusual Wind Conditions

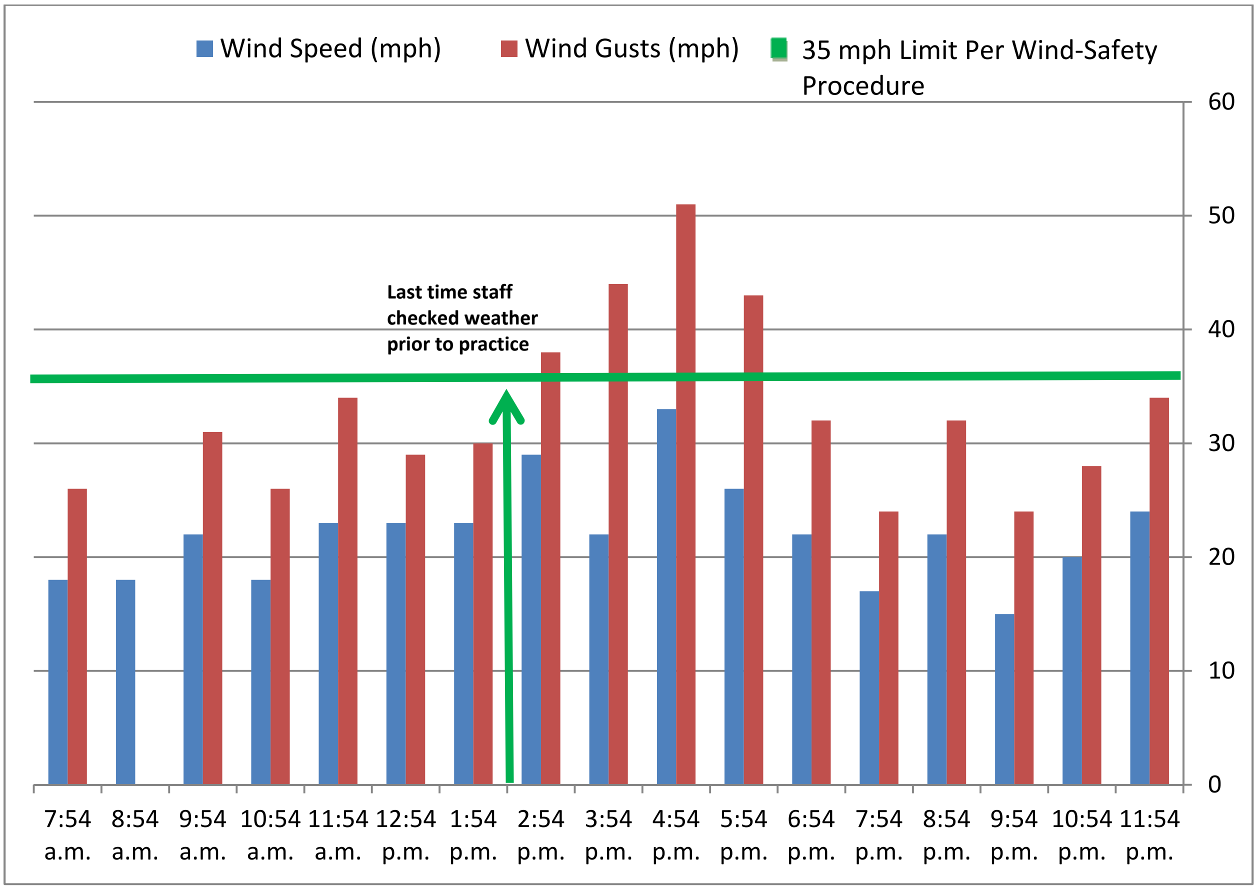
On October 27, an unusual weather system affected South Bend. According to Rappolt, at the time of the accident, an intense low pressure system, depicted below, centered over south central Ontario, Canada.



As the low pressure system passed to the north of South Bend, wind speeds from the southwest increased in velocity, although no thunderstorms occurred. Because the weather system was moving from west to east, wind speeds on campus lagged behind those at the airport. Thus, according to experts, while the strongest gust at the airport occurred at 4:29 p.m., the strongest gust on campus did not occur until approximately 4:55 p.m. when the lift fell over.

As illustrated by the bar graph below, wind speeds increased significantly from the time the staff last checked the weather and went outside for football practice to the time of the accident.

WIND SPEEDS REPORTED AT SOUTH BEND REGIONAL AIRPORT BY NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION: WEDNESDAY, OCTOBER 27, 2010[4]



When staff members checked the weather prior to practice, they saw reports of 23 mph sustained winds with 30 mph gusts. But wind speeds increased during practice, punctuated by

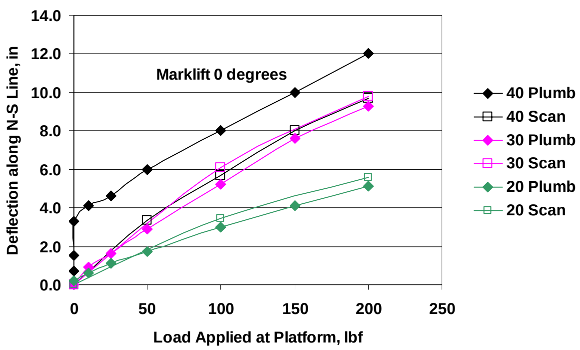
[4] Due to the lag in reporting time, the charts depicting NWS wind data do not illustrate real-time gusts. For example, the 51 mph gust at 4:54 p.m. in this chart does not reflect the gust that caused the accident. Rather, the 51 mph gust depicted above occurred between 4:44 and 4:54 p.m. at the South Bend Regional Airport. Experts determined that the gust that caused the accident, which was 53 mph, occurred at the airport at 4:29 p.m. and, on the field, at approximately 4:55 p.m.

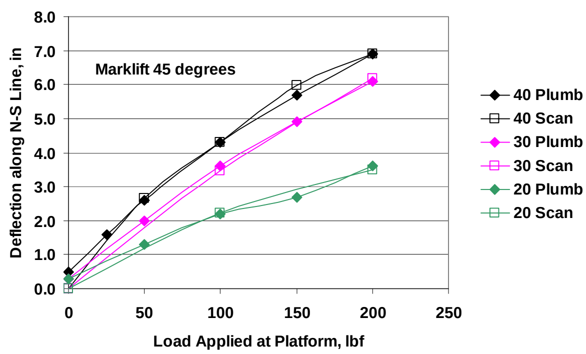
what experts determined to be a 53 mph gust at the time the lift fell over. The intensity of the gust was highly irregular. Indeed, according to Rappolt, gusts of similar speeds occur in non-thunderstorm systems in South Bend, on average, only once every three years; and, of course, the likelihood that the one-time gust in three years would occur during football practice is far less. As Peterka's analysis demonstrated, the Marklift, when fully extended, was susceptible to tipping at wind speeds between 49-53 mph.

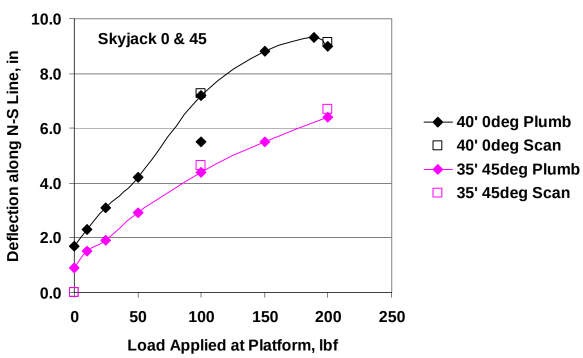
B. Characteristics of the Marklift

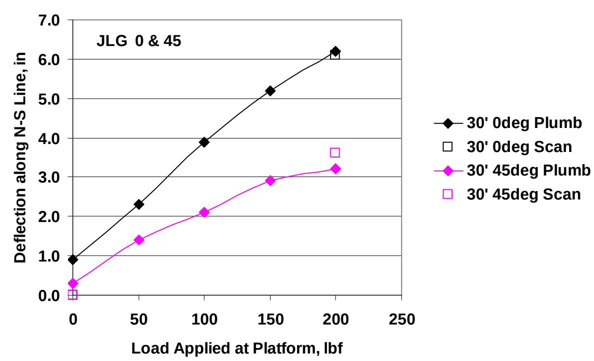
Experts determined that the Marklift's characteristics made it more susceptible to tipping than the SkyJack and JLG lifts that were also on the practice field. The ability of a scissor lift to resist wind is impacted by the amount of deflection the platform experiences under various wind loads and the weight of the lift itself. As a lift deflects (such that the platform moves in wind while the base remains on the ground), the lift's ability to resist overturning decreases. To determine lift resistance to such forces, the experts conducted testing.

Each lift was tested by applying a series of horizontal forces to the lift's platform at zero degrees (perpendicular to the long axis of the lift), and at 45 degrees to simulate southwest winds. Results of the deflection tests were measured both with a manual plumb bob hung from the platform and with a laser scanning instrument. The laser scans were then assembled into 3-dimensional computer-based drawings that Peterka could use to measure platform displacement and rotation. When raised to similar heights and placed under similar forces, the Marklift experienced more deflection than the SkyJack and JLG lifts, as depicted by the graphs below.









Peterka then used the deflection data, combined with the wind load analysis he had previously performed, to calculate the lifts' different tipping points. He separated the wind gust speed into North-South and East-West components for application to the scissor lift structures and applied the wind to various elements of the lift, including the platform, lifting section members, and base section, to obtain forces on those individual objects. He then calculated the wind force for each section, and balanced the wind-applied forces against the weight of the lifts. Ultimately, Peterka concluded that the lifts had significantly different tipping points, as illustrated below.

Wind Speeds Required to Overturn Each Lift

	Tipping-Point Speed Mph	Estimated Gust Wind Speed At Accident Site, mph
Marklift at 40 ft	49 – 53	53
Marklift at 35 ft	50 – 54	53
Marklift at 30 ft	55 – 59	53
Marklift at 25 ft	59 – 64	53
Skyjack at 40 ft	70 – 76	53
JLG at 40 ft	75 – 81	53

The experts identified characteristics unique to the Marklift that likely caused its different tipping point. First, at 7,700 pounds, the Marklift weighed approximately 3,000 pounds less than the SkyJack and 8,000 pounds less than the JLG. Second, the Marklift not only weighed less than its two counterparts, its weight distribution also differed. The Marklift's base—essential for stability—comprised a smaller proportion of the lift's total weight. Further, the Marklift was older than its two counterparts and, as noted by Recard, "[e]xtended use of a scissor lift . . . over a long period of time may cause more flexibility in a lift's structure." In sum, the Marklift was more susceptible to wind forces, and its increased susceptibility to wind likely contributed to the accident.[5]

C. Decision Makers' Lack of Knowledge Regarding Current and Projected Weather Conditions

The decision makers lacked knowledge regarding current and projected weather conditions and the nature of online weather reports. Collins, Klunder, and Russ all reviewed what they believed were current weather reports for wind speeds when deciding to practice outside. The data each reviewed, however, likely was provided by the National Weather Service, which typically updates its wind speeds once an hour. At 1:54 p.m., the National Weather Service reported wind speeds for South Bend of 23 mph, with gusts up to 30 mph. These speeds

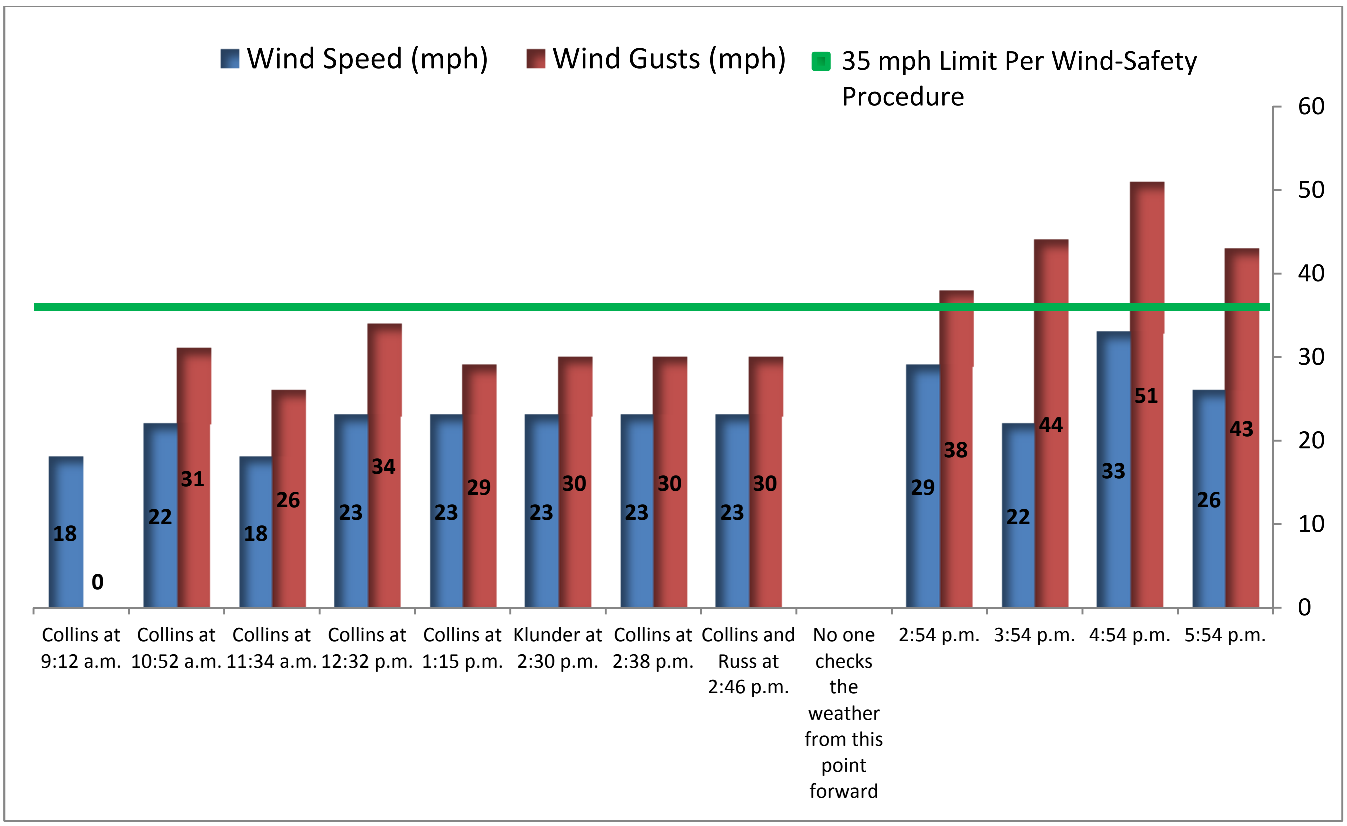
[5] Mark Industries, which designed and manufactured the Marklift, filed for bankruptcy in 1991 and is no longer in business. The University neither owns nor rents any other Marklift scissor lifts.

were within Collins's and Russ's range of acceptable lift use and were not updated until 2:54 p.m.—approximately eight minutes after Collins and Russ had checked the weather for the last time prior to practice. At 2:54 p.m., the National Weather Service updated its reported wind speeds for South Bend as 29 mph, with gusts up to 38 mph. In addition to relying on outdated weather data, the staff also was unaware that a wind advisory was in effect.

Although outdoor practice started at 3:45 p.m., Collins, Klunder, and Russ left their offices to begin practice preparations around 3:00 p.m. After leaving their offices, they did not continue to monitor weather reports. Instead, the staff depended on their own perceptions of the wind. According to interviews, no one perceived the wind as unusual and no one discerned that wind speeds were increasing in severity during practice. Consequently, no further precautions were taken with regard to the lifts.

Notably, no IOSHA or ANSI standard requires the use of a wind anemometer or other real-time weather device while operating aerial lifts. In fact, according to industry experts, the use of such devices in the United States currently is rare.

ONLINE WIND DATA GENERALLY AVAILABLE ON OCTOBER 27, 2010[6]



The lack of real-time weather information on the practice field played a role in the accident. After practice started, wind speeds increased at a steady pace, with reported gusts reaching 38 mph and 44 mph before the accident. Had Collins or Russ accessed real-time

[6] *See* footnote 4.

weather information during practice, the staff would have learned that wind gusts exceeded their internal 35 mph limit. In such a case, Collins or Russ would have had the lifts grounded and the accident would not have occurred.

D. The Height of the Marklift

After the accident, Recard determined that Declan's lift had been extended to its full 40-foot height. His conclusion rested on images of the lift prior to tip-over, which showed the work platform even with the top of the 40-foot goalposts, post-accident inspection, and post-accident measurements of the lift. Because the Marklift's scissor arms remain locked absent a hydraulic failure and there was no evidence of such a failure, Recard confirmed the reliability of these post-accident measurements.

The results of Peterka's analysis revealed that winds of 49-53 mph were sufficient to cause the Marklift to tip at its 40-foot extension. Collins had instructed the students to raise the lifts no higher than they felt comfortable and, under no circumstances, higher than the goalposts. Although the SkyJack and JLG lifts could be extended beyond 40 feet, the Marklift was fully extended at that height.

The Marklift likely would not have tipped over if it had been partially extended to 30 or 25 feet. As noted above, according to Peterka, at the 30-foot height, wind speeds between 55 and 59 mph were required to tip the Marklift and at the 25-foot height, wind speeds between 59 and 64 mph were required. These tipping-point speeds exceeded any recorded wind speeds on October 27 and estimated wind speeds on campus during practice.

II. Factors That Did Not Cause or Contribute to the Accident

In contrast, the Investigation concluded that the following factors did not cause or contribute to the accident: (1) the videographers' lack of formal training; (2) the culture of the football program; (3) maintenance of the Marklift; (4) use of the outriggers; (5) Notre Dame's wind-safety procedure; (6) the decision makers' lack of knowledge regarding lift capabilities; and (7) the design of the LaBar practice fields. Each factor will be discussed in turn.

A. Videographers' Lack of Formal Training

Notre Dame closely examined its Aerial Lift Platform Policy and training as part of the Investigation. Collins never received any formal University training and was unaware that the University required training before operating aerial lifts. However, he received instruction on lift operation from a rental company and he also attended an aerial lift training session provided by the CSVA. Although he received some training, Collins primarily learned how to operate the lifts through using them over the last twenty years.

Collins, in turn, then instructed the student-employees on how to use the lifts. Collins's instruction was limited to how to raise and lower the lifts. The students did not review the operators' manuals and did not receive any formal safety training on the lifts. The University's policies clearly prohibited operating the lifts in such a manner, but it is unlikely that the football program's failure to follow the policy contributed to the accident.

In 2004, the Department of Risk Management and Safety released a formal Aerial Lift Platform Policy, which, according to the policy, is designed to ensure the consistent, safe operation of University lifts. The policy assigns specific responsibilities to three different groups: (1) the Department of Risk Management and Safety; (2) the individual departments that operate aerial lift platforms; and (3) the individual lift users. The policy gives the Department of Risk Management and Safety general oversight duties, including training lift operators, maintaining training records, revising the aerial platform lift policy, and providing technical support to departments and employees when needed. The various departments using the lifts are charged with more wide-ranging responsibilities, including performing a series of safety checks upon acquiring a lift; arranging for the training of all employee-operators; overseeing lift maintenance, inspection, and repairs; and retaining records. Finally, the policy requires that employees review the operating manual and sign a form acknowledging their review, understand a lift's basic functions, and perform pre-start and workplace inspections before operating a lift.

To implement the policy, Risk Management distributed a January 27, 2004 memo to certain University directors and administrators. The memo asked recipients to identify the department or building represented, the contact person in charge of the lift equipment, the number of aerial platforms used, and the number of employees who operated them. The memo was sent to those members of the Athletic Department whom Risk Management deemed most likely to have information regarding the use of aerial lifts.

The responses received from those within the Athletic Department did not identify the use of aerial lifts at football practice. Relying on the surveys received, Risk Management compiled a list of 16 University departments or locations in need of training. The football program was not among the departments identified. On October 11, 2004, Risk Management held an introductory meeting for the supervisory staff of those 16 departments or locations. Later that month, and in November, it held additional training sessions for all employees responsible for operating aerial lifts. Although the Athletic Department was not one of the departments designated for training, multiple Athletic Department employees attended the session and were trained on the use of aerial lifts. However, none of those employees' duties included day-to-day responsibilities within the football program.

In 2007, Notre Dame revised the policy as part of a regular review. The review took into account then-existing OSHA and ANSI standards. Risk Management believes the 2007 revised policy likely was distributed only to those supervisors and directors who responded to the 2004 memo and indicated that their department or unit operated an aerial lift. Accordingly, while some Athletic Department employees may have received the policy, no one specifically associated with the football team received the updated policy.

The Aerial Lift Platform Policy requires all operators and users of aerial platform lifts to attend a training session. After attending a training session, employees receive a card certifying their training, which allows them to operate an aerial lift. Employees must attend an additional training session every three years to renew that card. The policy prohibits employees who do not have a current card certifying their training from operating or using the lifts. Managers are instructed to ask for a certification card before allowing employees to operate lifts.

Since the inaugural 2004 training sessions, Risk Management has held group training sessions every three years. Topics addressed at the training sessions include: purpose and use of manuals; pre-start inspection process; identification of malfunctions and problems; factors affecting stability; purpose of placards and decals; workplace inspections; and safety rules and regulations. Independent of the three-year group training cycle, newly-hired employees, whose supervisors notify Risk Management that the employees' responsibilities will include utilizing aerial lifts, receive individual training on the same topics covered in group training.

Most of the University's aerial lifts are used indoors. Thus, although Risk Management's training instructs employees to "check the area . . . for possible hazards," including "wind and weather conditions," before operating a lift, it does not provide specific wind-safety parameters. According to Merrifield, "training that includes wind and weather conditions as a topic but does not . . . attempt to quantify a maximum wind speed . . . is entirely consistent with the standard and practice in the industry" to rely on "subjective judgments" regarding weather conditions.

While Collins and the student videographers should have been trained in accordance with the University's policy, expert review concluded that their lack of formal training did not cause or contribute to the accident. Merrifield reviewed Risk Management's training program and concluded that the program, which did not provide a specific wind threshold, "would not have improved [the staff's] understanding of how to deal with the wind hazard" or "have changed their operation of the lifts that day." Indeed, Collins and Russ were already aware of the potential dangers of operating lifts in "high winds" and likely would have grounded the lifts if they had seen reports of winds over 35 mph.

Although Merrifield's opinions relate to industry practice, the University's behaviors remain troubling nonetheless. For example, despite the visible and regular use of the lifts to film football practice, Risk Management never inquired directly to the football or videography staff about the extent to which the program used lifts and the need to train lift operators. Moreover, while members of the Athletic Department were aware of the University lift policy (and some had received training), the Athletic Department never ensured that the football videographers received training. Finally, the football program, while unaware of the University lift policy, should have ensured that the operators were fully trained in the operation and safety of the lifts.

B. Culture of the Football Program

Notre Dame also examined whether the culture of the football program discouraged safe practices. The program has no history of safety complaints and the Investigation found no evidence that the program discouraged safe practices or cut corners. Indeed, there are numerous examples of athletics officials proactively considering safety. Moreover, Russ, who is in charge of safety-related decisions for everyone on the practice field, makes decisions independent of the coaching staff. And his decisions are followed by the coaches and the team. Russ could have, and had previously, asked the head coach to have the lifts brought down. There is no indication that Russ was intimidated in any regard and would not have acted here had he believed that the lifts should be lowered. Collins, for his part, also regularly dictated the use of the lifts, and confirmed that he did not feel intimidated by the coaching staff and would have grounded the lifts if he had seen winds in excess of 35 mph.

Notre Dame cannot conclusively determine whether Declan, himself, felt unsafe and pressured to stay in the lift. While on the lift, Declan posted two tweets, one of which stated: "This is terrifying." Student videographers indicated their belief that the tweets likely reflected his joking nature, adding that his use of that word was common. The student videographers also stated that they did not believe they were in real danger. Further, the videographers unanimously affirmed that Collins always was clear that each operator had the ability to lower the lift if he or she felt uncomfortable or unsafe.

In order to gain a more comprehensive understanding of the student-videographer experience and more closely examine whether the football program discouraged safe practices, the Investigation conducted a series of interviews with a cross-section of former videographers. The interviewees attended the University between 1998 and 2010. Although they filmed under various head coaches, all were directly supervised by Collins.

The former student videographers, like the current videographers, unanimously stated that they possessed the authority to lower the lifts if they felt uncomfortable or unsafe. In fact, several reported instances where they lowered their lifts without having been instructed to do so. One former videographer remembered a few instances of tension between Collins and a prior coaching staff regarding the students' lowering of the lifts, but reinforced that Collins always supported the videographers and that the lifts remained lowered.

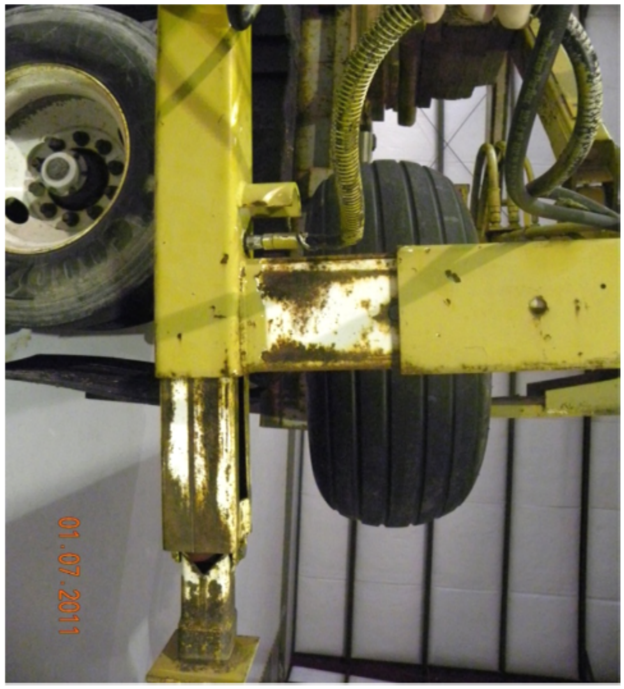
All but one of the interviewees stated that they felt safe while filming. The former student videographer who reported "occasionally" feeling unsafe indicated that he felt comfortable raising any concerns with Collins. Indeed, every interviewee recalled feeling comfortable raising concerns with Collins and feeling confident that those concerns would be listened to and addressed. The Investigation thus found no evidence that the football program pressured students into unsafe positions.

C. Maintenance of the Marklift

Notre Dame also considered the condition of the lift and, accordingly, asked Recard to examine whether it caused or contributed to the accident. After inspecting the lift on two separate occasions and reviewing annual inspection reports, Recard identified three potential maintenance issues: (1) damage to the platform railing assembly; (2) corroded and unpinned outrigger assemblies; and (3) a fractured center pivot shaft.

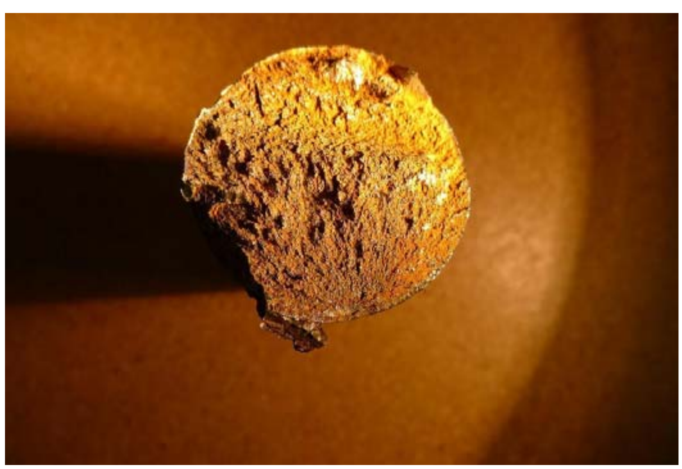
First, two pins securing the platform railing were fractured. The corroded condition of the pins' fractured surfaces indicated that the fractures preexisted the accident by a significant period of time such that the fractures should have been detected at a prior annual inspection. However, because the fractured pins did not decrease the lift's stability, Recard concluded that they did not cause the tip-over.

Second, four pins normally attached to the outrigger beams were missing and the outrigger sockets were corroded such that the beams were "frozen" 1-5 inches beyond the normal position.



Similar to the fractured railing platform pins, the corroded condition of the outrigger beams indicated that the pins had been missing for a significant period of time and should have prevented the lift from passing inspection, most recently in 2009. However, "because the beams were extended beyond the normal pinned position[,] the stability footprint of The Lift was increased and thus its resistance to tip-over was increased due to the somewhat larger base." Therefore, the unpinned outrigger assemblies in no way caused or contributed to the accident.

Finally, Recard's post-accident analysis revealed that the center pivot shaft was fractured. Because a fractured pivot shaft can decrease lift stability, Recard deemed it necessary to determine whether the fracture preexisted the accident or occurred as a result of the accident. Unable to determine when the fracture occurred through visual inspection, Recard recommended metallurgical evaluation to verify the age and extent of the cracking. Accordingly, the University asked SEA metallurgist Dr. Nicholas Biery to examine the shaft's surface. *See* Exhibit 10 (Biery's expert analysis).



Based on his examination of the fracture surface, Biery concluded that "[t]he pin most likely broke due to impact of the platform and scissor assembly with the ground." Because the fracture did not preexist the accident, it was also excluded as a cause.

D. Use of Outriggers

Notre Dame sought to determine if the outriggers were appropriately deployed for use at elevated heights. Designed to extend horizontally and vertically when the lift is raised above 30 feet, the outriggers function to increase the base's surface area and improve the lift's lateral stability. Thus, if the outriggers were not extended at the time of the accident, the lift could have been more prone to tip over. After examining post-accident pictures, performing a post-accident inspection, and observing witness marks on the concrete pad where the Marklift was stationed, Recard determined that, at the time of the accident, the Marklift's outriggers were extended even beyond their normal fully extended position and they were properly vertically deployed, such that the lift's resistance to overturning was fully developed.

E. Wind-Safety Procedure

Notre Dame also looked at whether its wind-safety procedure contributed to the accident. There are no uniform industry standards for deciding when wind conditions create an unsafe environment for aerial lift use. The ANSI/SIA A92.6-2006 Self-Propelled Elevating Work Platforms standard governs the operation of aerial lifts like the Marklift. The ANSI/SIA standard cautions lift users and operators to "check the area in which the aerial platform is to be used for possible hazards such as . . . wind and weather conditions," but it provides no specific wind guidance. The NCAA, likewise, has not identified any specific precautions programs should take with regard to wind.

With no national standard to adopt and enforce, Notre Dame developed its own wind-safety procedure, which included a 35 mph wind limit. As noted by Merrifield, the procedure consisted of "consulting weather information, instructing operators to lower . . . the lifts if they felt uncomfortable, and calling operators down if the wind exceeded [the] adjudged maximum." According to Merrifield, this procedure conformed to "the industry standard and practice for dealing with the wind hazard," which is "to follow the ANSI standard [to check the area for wind and weather hazards] and make a subjective judgment."

In light of the lack of specific wind-safety standards, Notre Dame sought to determine if other football programs followed wind-safety procedures and, if so, the contents of those procedures. Accordingly, Deputy Director of Athletics Bill Scholl surveyed sixteen peer programs regarding aerial lift usage. Fifteen of the sixteen programs regularly use lifts to film practice. However, at the time of Declan's accident, only seven of the fifteen schools had wind-safety procedures in place; and only one of those seven procedures was formalized in a written policy. Moreover, most schools surveyed reported providing only minimal training for the student videographers. Following the accident, several of the schools surveyed drafted policies with specific wind limits, while others formalized already-existing wind-safety procedures.

Notre Dame also reviewed media reports and articles discussing the use of aerial lifts by additional college football programs. While these reports have not been confirmed, they do further suggest that college lift policies lacked uniformity and largely lacked specificity prior to Declan's accident. Of the 30 college football programs discussed in the reports, four exclusively used permanent towers to film practice.

Among the 26 programs that reportedly utilized aerial lifts in some capacity, only a minority reported any specific wind-safety guidance, and that guidance widely varied. For example, while some schools reportedly required lifts to be lowered when winds exceeded as low as 10-15 mph, others reportedly did not ground lifts until winds reached 40 or 50 mph. However, of those schools with specific wind limits, most limits fell below the 35 mph limit Notre Dame applied.

Ultimately, Notre Dame's wind-safety procedure fell within the lift's margin of safety and did not cause the accident. Indeed, Collins and Russ both indicated that they would have likely lowered the lifts if they had seen winds above 35 mph and, according to engineering analysis, wind speeds significantly higher than 35 mph were necessary to tip the lift.

F. Decision Makers' Lack of Knowledge Regarding Lift Capabilities

The Investigation also revealed that no one involved in the decision to practice outside fully understood the Marklift's capabilities. Indeed, some of the staff believed the lifts had sensors that would automatically lower the lifts if the wind blew too hard and the lifts began to shake, such that the lifts could not tip over. This was not true. The Marklift was equipped with sensors that would automatically lower the lift if it became out of level, but, according to experts, that function was not designed to, nor would it, lower the lift in the event of high winds. A wind-related tip-over simply happens too fast. Both the JLG and the SkyJack are equipped with tilt sensors that light up to notify the operator that the lift is out of level, but neither automatically lowers when tilted.

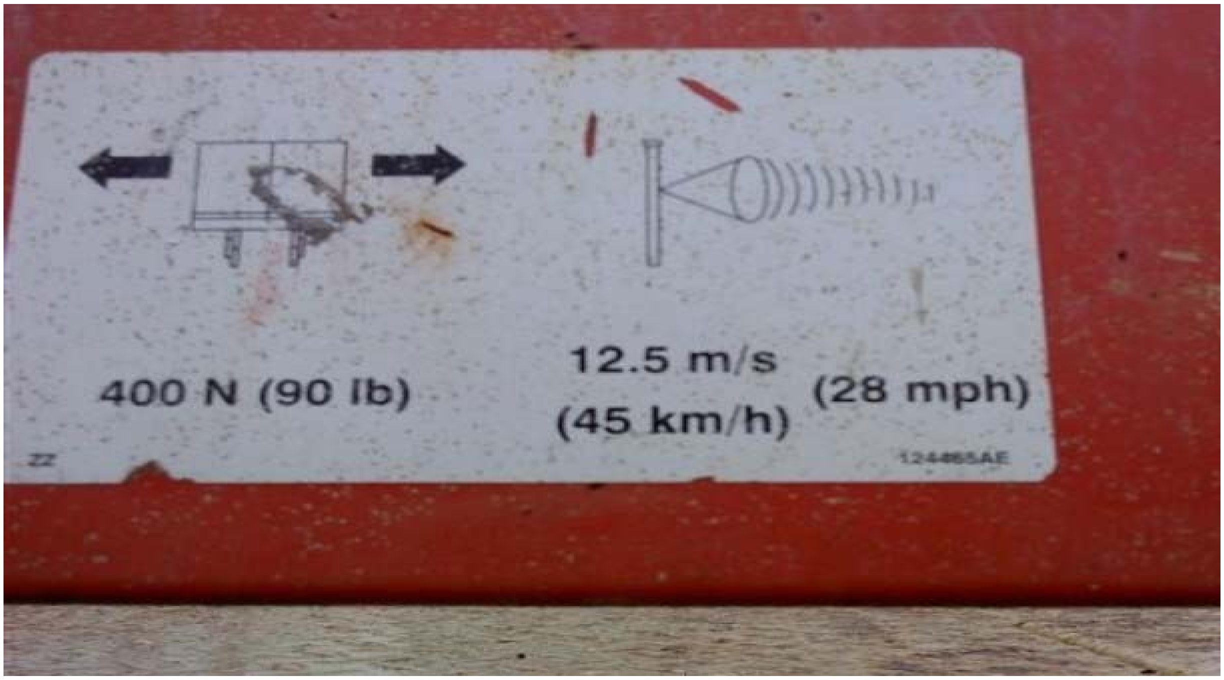
Even while some believed the lifts had automatic lowering sensors, the football program still used a 35 mph wind limit for lifts. That limitation was based on word-of-mouth, however, and not any industry standard. Collins believes he heard from the rental company that lifts generally should not be extended if wind gusts exceed 35 mph. Russ also heard (he thinks from Collins) that the lifts should not be extended in 35 mph winds.

The Marklift's manufacturer materials were not helpful in explaining potential dangers related to wind. The Marklift, itself, includes dozens of warnings. *See* Exhibit 11 (warning stickers on Marklift). None of the warnings, however, relate to use in windy conditions, and none provide a specific wind speed at which the lift should not be used. The Marklift's manual does not mention wind at all.

Unlike the Marklift, the JLG lift contains a warning label that states: "Do not expose platform to high winds or horizontal forces." The JLG lift label includes no reference to a specific wind limit. While the label does not provide a specific wind speed limit, the JLG's manual references a 28 mph wind limit.

The SkyJack's manual, for its part, includes a general warning "not [to] raise the aerial platform in windy or gusty conditions" that does not provide a specific wind limit. The manual also includes a section which directs the operator to check the lift's serial number nameplate for the maximum wind speed. However, the SkyJack's nameplate lacks that information, and lists no wind limit at all.

The SkyJack does include a label that references 28 mph, and that label (with some variations), along with all other labels, is depicted in the manual.



According to expert David Merrifield, the label "is not a warning according to ANSI" because it fails to meet ANSI's safety label criteria. Indeed, according to Merrifield, "[i]t is not clear that a user would have recognized the symbol on the label as an indication of wind speed." Moreover, after examining the SkyJack's manual, Merrifield concluded that "it is not immediately apparent that 28 mph is the proper maximum wind speed for that machine." However, even if the staff concluded that a 28 mph wind limit should be applied to the SkyJack, Merrifield stated that the staff had no reason to apply that limit to different machines like the Marklift. Ultimately, Merrifield "would not expect the SkyJack machine, manual and placards, taken in their entirety," to have changed "the behavior of Notre Dame vis-à-vis the Marklift."

The overall lack of knowledge regarding aerial lifts within the football program is too speculative to identify as a cause of the accident. The staff were more familiar with the Marklift than the SkyJack and JLG and were unaware of any 28 mph limit that applied to either of the rented lifts. While the team's 35 mph wind standard was not based on any manufacturer's recommendations, that standard was well within the Marklift's margin of safety and had winds not well exceeded 35 mph, the lift would not have tipped over. That said, knowledge and application of the 28 mph limits could have made a difference. Although Merrifield states that, as a matter of industry practice, there is no expectation that operators should transfer the wind limits of one lift to another, had the staff understood the limits of the SkyJack and JLG, they might have applied a 28 mph limit for all of the lifts at football practice. Ultimately, it is unclear whether the program would have created a new wind limit for the Marklift that would have triggered additional action had the program known more about the Marklift's capabilities or other lifts' wind warnings.

G. Practice Field Design

Notre Dame examined whether LaBar's practice field design contributed to the accident. In particular, Notre Dame examined the concrete pads that were installed behind the North and South end zones. During the design process, an outside architect requested information regarding the aerial lifts that would be used for filming. Collins provided specifications for the JLG lift and the architect designed the pads to accommodate the weight and dimensions of the lift. The pads are level and are large enough to accommodate the Marklift with its outriggers deployed as designed. There is no indication that field design or the concrete pads contributed to the accident.

IOSHA VIOLATIONS

On March 14, 2011, IOSHA fined Notre Dame $77,500 for six safety violations. The violations include: (1) failing to properly train student employees in the operation and use of lifts; (2) failing to keep a copy of the operator's manual on the Marklift; (3) allowing warning labels on the Marklift to become faded, weathered, or lost; (4) failing to ensure an annual inspection of the Marklift in 2010; (5) failing to ensure proper service according to the manufacturer's Preventive Maintenance Schedule; and (6) instructing untrained employees to elevate scissor lifts to film football practice while knowing that sustained winds were in the mid-20s with gusts ranging between 29 and 31 miles per hour and a wind advisory was in effect. The violations are items of concern to Notre Dame and the Investigation examined whether they caused or contributed to the accident. Regardless of whether the violations caused or contributed to the accident, the University has continually worked with IOSHA since the accident to address IOSHA's concerns and will continue to work to proactively educate others on these issues. In examining IOSHA's findings, the Investigation has determined that, while the first five violations did not cause or contribute to the accident, the operation of the lift in high winds was a cause.

Several safety violations can be definitively excluded as causes of the accident. For example, neither the Marklift operator's manual nor the stickers for the Marklift contained any wind-related warnings. Consequently, their presence would not have impacted the decision to raise the lifts in windy conditions. And while the student videographers should have been identified as employee-operators by Risk Management and Safety and trained in accordance with the Aerial Lift Platform Policy, the training sessions only generally warned of operating the lifts in windy conditions and lacked any specific wind-safety guidelines. Indeed, as Merrifield indicated, the common industry practice relies upon some level of subjective judgment as to wind safety conditions. Whether complete ANSI-standard training would have changed the decision to use lifts that day is too speculative to identify as a cause of the accident.

The lack of a 2010 annual inspection as of October 27, 2010, also can likely be excluded as a cause of the accident. Recard confirmed that while some issues with the Marklift's condition should have been discovered by a prior inspection, none affected the lift's stability in wind. Further, an outside vendor had inspected the lift in 2009 and not discovered the issues, so it is not clear that additional inspections in 2010 would have discovered the issues at all.

Finally, IOSHA cited Notre Dame for knowingly operating the lift in windy conditions. Although the University respects IOSHA's view, the Investigation did not find any evidence that University employees knew they were using lifts in wind speeds which exceeded lift capabilities. Although employees monitored wind data frequently throughout the day prior to leaving for practice, they never saw reported wind speeds that exceeded the 35 mph wind-safety procedure. In addition, the Marklift itself contained no wind warnings, and employees were unaware of any specific warnings for the JLG and SkyJack lifts. Moreover, no one recalled seeing a wind advisory when they checked the weather prior to practice. The staff made a subjective, good faith judgment based upon the weather information they had reviewed in implementing the 35 mph wind-safety procedure, which they understood to be in compliance with the requirements for safe lift use. Still, while the Investigation did not find that Notre Dame employees knowingly used the lifts in high winds such that injury was likely, the expert analyses outlined in prior sections make clear that high winds caused the lift to tip over.

CONCLUSIONS

After gaining a full understanding of the facts leading up to the accident and the potential causes of the accident, Notre Dame has reached a series of conclusions. As discussed throughout the report, the Investigation identified factors that contributed to the accident and factors that did not. Even for those factors that did not cause or contribute to the accident, several flaws were exposed that need to be acknowledged and addressed. Responsibility for these issues is shared by many individuals.

I. Factors That Caused or Contributed to the Accident

The Investigation identified several factors that contributed to the accident, including: (1) the presence of unusual wind conditions; (2) staff members' lack of knowledge regarding current and projected weather conditions; (3) characteristics of the lift involved in the accident; and (4) the height of the lift involved in the accident. Each played a role, standing not as a sole cause but rather collectively causing the accident.

A. Presence of Unusual Wind Conditions

Rappolt determined that an unusual weather system moved through South Bend on October 27. As a low pressure system passed to the north of South Bend, wind speeds from the southwest increased in velocity. While staff members saw reports of 23 mph sustained winds with 30 mph gusts prior to practice, those winds increased, punctuated by a 53 mph gust at 4:54 p.m. This wind gust was highly irregular, occurring approximately once every three years in non-thunderstorm conditions, and ultimately caused the lift to tip over.

B. Staff Members' Lack of Knowledge Regarding Current and Projected Weather Conditions

The staff's lack of knowledge regarding current and projected weather conditions likely contributed to the accident as well. With no national wind standard to adopt and enforce, the Notre Dame football program developed its own procedure for monitoring wind-safety, governed by a 35 mph wind limit learned from third-party sources. That 35 mph limit was not triggered by the wind conditions being reported prior to practice. Nor did the staff understand that the reported wind conditions they were monitoring trailed real-time wind data by as much as one hour. After practice began, wind speeds increased, with reported gusts exceeding 35 mph shortly before the accident. While the staff's weather concerns prompted them to continuously check the weather before practice, they did not consult any weather data while on the practice field despite those pre-practice concerns. Had the staff accessed real-time weather information during practice, they would have learned that wind gusts exceeded the internal 35 mph wind limit and would have grounded the lifts. Moreover, although Declan was aware of a wind warning that day that was later downgraded prior to practice, the staff—despite frequent weather checking—did not access that information when they checked the weather that afternoon. Had staff members been aware of the wind warning and later advisory, they might have acted differently.

Risk Management, the Athletic Department, the football program, and Notre Dame as a whole did not provide the videography and safety staff with the tools necessary to access real-time weather information continuously through the duration of football practice. This failure resulted in decisions based on outdated information, and ultimately contributed to the accident.

C. Characteristics of the Lift Involved in the Accident

Engineering experts determined that the Marklift's characteristics made it more susceptible to tipping than the JLG and SkyJack lifts. The ability of a scissor lift to resist wind is impacted by the amount of deflection the platform experiences under various wind loads and the weight of the lift itself. Experts conducted testing to determine each lift's resistance to wind. They concluded that characteristics unique to the Marklift—weight, weight distribution, and age—made it more susceptible to wind forces. While a 53 mph wind would cause the Marklift to tip at full extension, the JLG and SkyJack could withstand winds in the 70-80 mph range. This increased susceptibility explains why the wind tipped the Marklift, but did not tip the JLG and SkyJack lifts.

D. Height of the Lift Involved in the Accident

After the accident, experts determined that the Marklift had been extended to its full 40-foot height. Student videographers had been instructed to raise the lifts only as high as they felt comfortable and, in any event, no higher than the 40-foot goal posts. Although the SkyJack and JLG lifts could be extended beyond 40 feet and thus were not fully extended on October 27, 2010, the Marklift was fully extended at goalpost height. According to Peterka, the Marklift would not have fallen over had it been extended only 30 feet. Therefore, the height of the Marklift contributed to the accident.

II. Factors That Did Not Cause or Contribute to the Accident

The Investigation also identified a number of factors that did not cause or contribute to the accident, but nevertheless reflect flaws in Notre Dame operating procedures that need to be rectified: (1) implementation of the aerial lift training program; (2) lift maintenance and inspection; (3) the football program's wind-safety procedure; and (4) staff understandings of lift restrictions and capabilities. Responsibility for these issues that did not cause the accident is shared by individuals inside and outside Notre Dame.

A. Implementation of the Aerial Lift Training Program

The videography staff, including the student videographers, were not identified as aerial lift employee-operators by Risk Management and, consequently, never received ANSI compliant training offered by the University through the Aerial Lift Platform Policy. The lack of institutional oversight to ensure the videographers' participation in the training program resulted from failures by both Risk Management and the Athletic Department. As the department in charge of training employee-operators, Risk Management should have been aware of all University personnel using aerial lifts on campus. Despite the visible and regular use of the lifts to film football practice, Risk Management never inquired directly to the football or videography staff about the extent to which the program used lifts and the need to train lift operators. Moreover, while members of the Athletic Department were aware of the University lift policy (and some had received training), the Athletic Department never ensured that the football videographers received training. Finally, the football program, while unaware of the University lift policy, should have ensured that the operators were fully trained in the operation and safety of the lifts. Still, even ANSI-standard training would not have provided any clear wind limits to change the program's internal 35 mph procedure. As a result, it is ultimately unclear whether the staff would have acted differently if they had received University aerial lift training.

B. Lift Maintenance and Inspection

The Investigation also closely examined the condition and maintenance history of the Marklift. ANSI standards require aerial lifts to be inspected annually and periodically. While the Marklift passed its annual inspection in 2009, it did not receive annual or periodic inspections in 2010. Risk Management, videography supervisors, and the rental and servicing company all failed to ensure the lift was timely inspected and serviced. Further, the lift's prior inspections—completed by an outside vendor—were deficient. Two maintenance issues—a damaged platform railing assembly and corroded and unpinned outrigger assemblies—should have been discovered by the vendor during previous inspections and prevented the lift from passing inspection. However, the two deficiencies did not ultimately cause or contribute to the accident.

C. The Football Program's Wind-Safety Procedure

Despite its implementation, the football program's wind-safety procedure did not prevent the accident. The University's procedure involved instructing that the lifts not be used at full extension in winds between 25 mph and 35 mph, and grounding the lifts when winds exceeded 35 mph. This wind-safety procedure was not formalized, in writing or otherwise, such that it could have been vetted, reviewed, or critiqued by others within the football program, the Athletic

Department, or Risk Management. Moreover, though learned through third-party instruction, the origin of the 35 mph limit cannot be traced back to any specific written materials. Instead of relying on verbal representations by a third party, staff should have consulted lift-specific sources. To enforce the 35 mph limit, staff members monitored the weather conditions and made subjective judgments based upon those reported conditions, as prescribed by ANSI and industry standards. In retrospect, those standards proved inadequate—lacking specific guidance and allowing for excessive subjectivity.

The wind-safety procedure clearly failed on October 27, 2010. As discussed above, the procedure did not prevent the accident, in part, because the staff's decision to use lifts was informed by outdated weather information. While Collins was concerned about the wind, he did not believe that the winds were strong enough to warrant grounding the lifts. In light of his concerns, Collins and his staff took several precautions, including monitoring the weather throughout the day (from 9:12 a.m. until 2:46 p.m.), applying the 35 mph wind limit, inquiring whether videographers felt safe, and instructing the videographers to go no higher than they felt comfortable and no higher than the goalposts next to the lifts. Ultimately, because staff never saw winds in excess of 35 mph, the lifts were not grounded. Nonetheless, where any person has a subjective concern for safety, protocols should be strengthened to help ensure that such concerns are addressed, even where objective safety procedures (such as the 35 mph procedure here) are not triggered.

D. Staff Understandings of Lift Restrictions and Capabilities

Finally, the Investigation identified a lack of staff knowledge regarding the lifts' restrictions and capabilities. The staff's understanding of a 35 mph wind limit was based solely upon verbal representations by outside parties repeated and relied upon within the staff, which was unchallenged due to the absence of any contrary limit in the Marklift manual, Marklift warning labels, or ANSI standards. That said, the staff had resources available regarding the two other aerial lifts used to film practice. Those other lifts included information, though lacking clarity and not in compliance with ANSI warning criteria, that referenced a 28 mph limit. While industry analysis does not suggest that such resources should have been applied to the Marklift, Risk Management, the Athletic Department, those who provided the lifts, videography supervisors, and all those responsible for safety issues during practice should have ensured that staff considered and understood all available information for the equipment in use at football practice. However, although the staff was unaware of the 28 mph limit for the other lifts, the 35 mph limit used fell well within the Marklift's actual margin of safety (which was determined to be 49-53 mph), and even more so within the margin of safety of the JLG and SkyJack (which was determined to be above 70 mph). Nonetheless, had the staff applied a 28 mph wind limit for the Marklift, the lift likely would have been grounded.

The recommendations that follow look to address and remedy these issues.

RECOMMENDATIONS

At the conclusion of the Investigation, after gaining a full understanding of the facts leading up to the accident and analyzing the factors that potentially caused or contributed to the accident, Notre Dame developed a series of recommendations. While some recommendations are broad and forward-looking—intended to improve safety beyond Notre Dame's campus—other recommendations are University-specific—intended to address the issues uncovered by the Investigation.

I. Adoption of Specific Wind Limit

The University should set definitive and more stringent wind requirements. Although ANSI generally warns against lift usage in high winds, that warning can prove confusing to those vested with the discretion to determine whether winds are indeed too "high." The ANSI standard thus fails to provide sufficiently clear guidance. The International Standards Organization ("ISO"), in contrast, has adopted a 28 mph wind limit for aerial lift usage. To ensure more predictability in behaviors and uniformity in approach, the University should adopt that 28 mph maximum wind speed standard. With respect to aerial lifts that the University rents or buys in the future, those units should comply with the 28 mph requirement.

II. Access to Real-Time Weather Information During Operation

Operators should have access to real-time weather data during operation of the lifts. Wind-limits and protocols cannot work if the operators are unaware of the wind conditions in their areas. The University should make real-time weather information available to appropriate individuals whenever University-owned or rented lifts are used outdoors, whether through a centrally located anemometer with results relayed as needed, through hand-held anemometers used by lift operators, or through other appropriate systems and procedures that can be implemented as necessary. Weather forecast data and wind advisories, though unreliable, should also be consulted to provide context to real-time weather information and its trends.

III. Development of and Participation in National Educational Effort

As evidenced by the Investigation's peer program review and other media reports, college lift policies lack uniformity and specificity. Most programs have no specific protocols in place, and rarely are they documented or reviewed. Recently, some institutions have begun to develop or implement protocols, though they remain varied.

Notre Dame should collaborate with IOSHA and the Collegiate Sports Video Association ("CSVA") to institute education and training programs. The University also should work with the NCAA and other athletic departments to ensure that safety protocols are developed for collegiate athletic programs and other relevant programs, including, but not limited to, marching band, intramural sports, and high school athletic programs. Most importantly, this effort should: (1) highlight the dangers of wind and the fact that there have been several wind-related accidents throughout the country; (2) underscore the importance of access to real-time weather information and projections; (3) caution that ANSI standards remain vague, lack clear guidance, and allow for excessive subjectivity; and (4) encourage all programs to adopt the stricter ISO standards. In sum, Notre Dame should help all NCAA institutions, and institutions outside the NCAA, learn from this tragedy and should encourage such institutions to adopt the recommendations of this Investigation.

IV. Appointment of Athletic Department Safety Contacts

Given the Athletic Department's failure to fully understand the University's policies in this instance, the Athletic Department should identify Safety Contacts who will receive all safety notices and policies and ensure compliance with those notices and policies. The Athletic Department currently has athletic trainers for each sport. These athletic trainers should be appointed Safety Contacts for their designated sports programs. The Director of Athletic Training and Rehabilitative Services should supervise the Safety Contacts.

Each Safety Contact should receive sport-specific safety training and develop and enforce safety protocols. The Safety Contact should also function as a liaison between Risk Management and his or her sports team, and as an independent resource to whom administrators, staff, and students may report any safety concerns regarding the work or practice environment. Administrators, staff, and students should be provided with contact information for the Safety Contact and informed of their right to confer with the Safety Contact at any time.

The Safety Contact also should have primary responsibility for determining whether lifts can be safely operated outdoors and have ultimate authority to enforce all safety protocols at any time. In light of the inherent difficulties in adequately monitoring real-time weather information while also performing their duties on the field, coaches and filming coordinators should not be tasked with primary responsibility for monitoring weather conditions. Departments utilizing lifts for purposes other than filming sports practices should likewise appoint a Safety Contact. In addition to the Safety Contact, coaches, filming coordinators, videographers, and all other employee-operators should still be encouraged to voice any concerns they may have regarding the propriety of using lifts in certain conditions. Moreover, lift operators should continue to be empowered to ground or lower the lifts if they feel uncomfortable for any reason whatsoever.

V. Establishment of Athletic Department Practice-Safety Protocol

The Athletic Department should establish a written practice protocol to help ensure that practices are held in a safe environment. Although not every potential risk can be foreseen, the protocol should attempt to anticipate relevant potential risks and provide criteria that will allow staff to determine safe practice locations, procedures, and logistics. The practice protocol should be reviewed by Risk Management and all Safety Contacts for comments, revisions, and approval.

VI. New Lift-Identification Protocol

Under Risk Management's current policy, all University personnel who operate lifts are required to be trained. The student videographers did not receive this formal training. Steps should be taken to ensure that Risk Management is aware of all departments operating aerial lifts on campus.

First, Risk Management should circulate a questionnaire regarding the use of aerial lifts to every department. In the event that a department does not respond, Risk Management should follow up. The questionnaire should inquire not only as to lifts within the department, but any other lifts that the department employees may know about. In the event a department identifies a lift used by others on campus, Risk Management should ensure that those lifts are accounted for and are part of its program.

Second, Risk Management should conduct a thorough campus walk-through. Risk Management should visit the departments that identify aerial lifts and ensure that the lifts are accounted for. Risk Management should also determine if there are other lifts that it has not yet identified.

Third, to ensure that Risk Management continues to be apprised of every lift on campus, no aerial lifts should be purchased or rented without first notifying Risk Management. Procurement Services should be informed that all requests for purchasing or renting aerial lifts must first be approved by Risk Management. In addition, individual departments should be banned from purchasing or renting lifts, thereby requiring individuals to go through Procurement Services.

VII. New Inspection Protocol for All Lifts, Including Pre-Operation Checklist

To ensure the safe operation of lifts, the University should adopt a new inspection protocol. The Department of Risk Management and Safety, which currently oversees aerial lift safety, should implement and oversee this protocol.

The proper functioning of lifts is essential to ensuring operator-safety. However, Risk Management currently has no ability to determine if the lifts are being properly inspected and maintained. Under the new protocol, Risk Management, not individual departments, will assume responsibility for lift inspection and maintenance.

Risk Management should ensure that all inspections comply with all ANSI and manufacturer-specific inspection requirements. Per the ANSI standards, periodic inspections should occur every three months, and annual inspections should occur once a year. If any safety issues are identified by periodic or annual inspections, Risk Management should ensure the lift is removed from service until those repairs are made. If a department encounters a problem with a lift, it should contact Risk Management and Safety, which will then coordinate the lift’s service.

In addition to requiring periodic and annual inspections, ANSI standards also require operators to conduct pre-operation inspections before using an aerial lift. Risk Management should design and provide Pre-start Inspection Forms for operators to review while conducting their inspection. Risk Management should also include with each operator manual a checklist for operators to date and sign, indicating that they conducted a pre-operation inspection. Risk Management periodically should collect these charts and ensure that the inspections are being completed as required.

Each inspection should ensure that the manufacturer’s operating manual is physically located on the lift, that warning stickers remain legible, and that the lift should not be operated if the manual is absent. All records pertaining to lift maintenance and inspection should be retained for a minimum of four years.

VIII. New Training Protocol for All University Personnel Who Use Lifts

Equipped with an accurate count of aerial lifts on campus and the departments using them, Risk Management will be able to ensure that all operators are properly trained. To do so, it should take several steps.

First, Risk Management should provide annual aerial training sessions, supplemented by individualized training sessions when needed. At a minimum, this training should incorporate AWPT (Aerial Work Platform Training), IPAF (International Powered Access Federation), or equivalent training programs, and an AWPT trainer or equivalent should train Risk Management trainers and core operators. In order to enforce this training requirement, Risk Management should present certification cards to those who have completed training. Any person who attempts to use a lift should be required to present that card to his or her supervisor prior to operation. Risk Management should make clear to each individual that to operate a lift he or she must first receive familiarization on the specific lift before operation.

Second, all training should incorporate not only ANSI standards, but also the ISO standard, which provides that lifts should not be used when winds exceed 28 mph. Further, training should reaffirm that individual operators have overriding authority to come down if they determine they should, and should instruct operators that they are required to obey their instincts at all times. Training should also explain to operators the use of wind-monitoring equipment.

Third, Risk Management should be directly involved in familiarization. This is currently delegated to departments. When general lift training is provided, Risk Management should provide necessary familiarization as well. This will only apply to first-time operators who are unfamiliar with the particular lift and does not need to occur each year. Risk Management can supervise an experienced operator who provides this training or can arrange for a vendor to provide it.

Fourth, AWPT or an equivalent organization should periodically audit the University's training program to ensure that it remains state-of-the-art and is being enforced.

Exhibit 1

JON A. PETERKA

Co-founder and President, CPP, Inc. (also known as Cermak Peterka Petersen, Inc.), Wind Engineering Consultants, Fort Collins, Colorado.
Professor Emeritus, Fluid Mechanics and Wind Engineering Program, Department of Civil Engineering, Colorado State University, Fort Collins, Colorado.

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CPP, Inc.
1415 Blue Spruce Drive
Fort Collins, CO 8524
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EDUCATION

Ph.D.	Fluid Mechanics and Thermodynamics, Brown University, 1968
M.S., B.S.	Civil Engineering, Colorado State University, 1964, 1965

EXPERIENCE

Approximately 40 years experience in wind-engineering applications and research. Evaluated over 1000 buildings and structures for wind loads (local cladding pressures and/or frame forces and moments) primarily through wind tunnel testing; evaluated pedestrian wind climate for many of these buildings; measured forces on numerous other structures including towers, stacks, bridges and solar collectors; defined snow loads for many structures; investigated pollutant dispersion from buildings and stacks; determined heat transfer rates from structure surfaces in the wind; helped define siting criteria for wind energy projects as well as wind tunnel and field testing to assist in the development of wind turbine technology; developed meteorological analysis procedures for power line rating. Forensic investigation of meteorological conditions during past events.

Dr. Peterka's work in wind engineering includes membership on the national committee which writes the national wind load standard ASCE 7, development of the new wind hazard map for the national wind load standard, consulting for the FAA on aircraft wind shear, participation in a National Research Council report to the U.S. Congress on wind damage, and Board of Directors of the Wind Engineering Research Council. He is currently chairman of an ASCE Standards committee on wind tunnel testing of structures. Research in wind engineering includes statistical characteristics of fluctuating pressures, adjacent building effects, wind flow around and downwind of buildings, natural ventilation, transport of snow and sand, and siting criteria for anemometers. Other experience includes three years experience in development of liquid rocket propulsion systems for the U.S. Army Missile Command.

PROFESSIONAL ACTIVITIES/AWARDS

Registered Professional Engineer in Colorado, Florida and Mississippi. Organizational memberships include the American Society of Civil Engineers, American Association of Wind Engineers, American Society of Mechanical Engineers, American Institute of Aeronautics and Astronautics, and National Society of Professional Engineers. Professional committee activities within the American Society of Civil Engineers includes: ASCE-7 Wind Load Subcommittee, member (1985-present); Aerodynamics Committee, member (1978-2008), chairman (1984-1988); Task Committee on Microclimate of Buildings, member (1980-1983);

Task Committee on Wind-Tunnel Testing of Structures, member (1981-1986, 1991-1994); Task Committee on Wind Forces on Solar Collectors, member (1982-1988); Task Committee on Mitigation of Severe Wind Damage, member (1985-1988); Task Committee on Modeling of Blowing Snow and Sand, member (1985-1989); Committee on Wind Effects, member (1982-1985, 1987-1993); Executive Committee, Aerospace Division, member (1987-1992), chairman (1991); Standards Committee on Wind Tunnel Testing (1993-present), chairman (1993-present). Other professional activity includes Secretary/Treasurer of the Wind Engineering Research Council (predecessor of the American Society of Wind Engineers (1979-1985), and board of directors (1979-1989); National Research Council Panel on Wind Engineering (1987-1990). Honorary societies include Sigma Xi, Phi Kappa Phi, Sigma Tau and Chi Epsilon; awards include two awards for excellence in teaching at Colorado State University, ASCE 1989 Aerospace Science and Technology Award, Wind Engineering Research Council 1990, Outstanding Wind Engineering Research Award, the ASCE 1999 Raymond C. Reese Research Prize, Engineering News Record Top 25 Newsmakers of 2006 award, American Society of Civil Engineers 2010 Cermak Medal.

An incomplete list of some specific activities related to Wind Hazard Assessment and Mitigation –

Developed an anemometer siting guide for the Federal Aviation Administration

Developed the 3-second gust wind map that permitted ASCE 7 national wind load standard to move from a fastest mile map to a gust map – awarded the 1999 ASCE Raymond C. Reese Research Prize

Developed a 3-second gust design wind map of the down-slope windstorm region of northeast Colorado for use in local building codes

Assessment of wind damage at the Limon Tornado site

Assessment of wind damage at the Pingree Park tornado site

Assessment of wind damage after Hurricane Andrew

Participated in a National Research Council report to Congress on Natural Hazards

Lead investigator to develop a Monte Carlo simulation for design level hurricane winds in Hawaii and Guam under NASA sponsorship

Routinely develop risk analyses for clients for design against hurricanes and tornadoes

Developed terrain-induced impacts for design against hurricane winds in Hawaii

Member of the ASCE 7 Wind Load Sub-committee that writes the national wind load standard ASCE 7, and that forms the basis for the wind load provisions for the IBC building code

Chairman of the ASCE standards committee writing a standard of practice for wind tunnel testing of buildings for design wind loads

Lead investigator in development of a wind uplift model for asphalt shingles, permitting the development of high-wind resistant shingles

Lead investigator to develop a wind uplift test for asphalt shingles for Underwriters Laboratory

References for last 10 years

Cochran, L. S., J. A. Peterka, and R.L. Petersen, *Physical Modeling of Roof-Top Helicopter Exhaust Flow Dispersion*, Proceedings of the Fourth Asia Pacific Symposium on Wind Engineering, Surfers Paradise, Australia, July 1997.

Seong, S. H. and J. A. Peterka, *Computer simulation of non-Gaussian multiple wind pressure time series*, Journal of Wind Engineering and Industrial Aerodynamics, Vol. 72, (1997), pp 95-105.

Peterka, J. A., J. E. Cermak, L. S. Cochran, B. C. Cochran, N. Hosoya, R. G Derickson, C. Harper, J. Jones, and B. Metz, *Wind Uplift Model for Asphalt Shingles*, Journal of Architectural Engineering, Vol. 3, No. 4, (December 1997), pp 147-155.

Peterka, J. A. and S. Shahid, *Design gust wind speeds for the U.S.*, Journal of Structural Engineering, Vol. 124, No. 2, (February 1998), pp 207-214.

Seong, S. H. and J. A. Peterka, *Digital generation of surface-pressure fluctuations with spiky features*, Journal of Wind Engineering and Industrial Aerodynamics, Vol 73, (1998), pp. 181-192.

Peterka, J. A., N. Hosoya, S. Dodge, L. Cochran, J. E. Cermak, *Area-average peak pressures in a gable roof vortex region*, Journal of Wind Engineering and Industrial Aerodynamics, Vol. 77 & 78, (1998), pp. 205-215.

Heaney, James P., Jon Peterka, and Leonard T. Wright, *Research Needs for Engineering Aspects of Natural Disasters*, Journal of Infrastructure Systems, Vol. 6, No. 1, (March 2000), pp. 4-14.

Seong, S. H. and J. A. Peterka, *Experiments on Fourier Phases for Synthesis of Non-Gaussian Spikes in Turbulence Time Series*, Journal of Wind Engineering and Industrial Aerodynamics, Vol 89, (2001), pp. 421-443.

Banks, D. and J.A. Peterka, Tropical Storm Track Prediction Using Autoregressive Time Series Analysis, Americas Conference on Wind Engineering, Clemson University, (2001).

Peterka, J. A. and David Banks, *Wind Speed Mapping of Hawaii and Pacific Insular States by Monte Carlo Simulation*, Report for NASA Contract NASW-99046, NASA Goddard Space Flight Center, CPP Inc. Project 99-1773, (March 2002).

Chock, Gary Y. K., Jon A. Peterka, and Leighton Cochran, Orographically Amplified Wind Loss Models for Hawaii and Pacific Insular States, Report for NASA Contract NASW-99045, NASA Goddard Space Flight Center, (March 2002).

Chock, Gary, Peterka Jon, and Yu, Guangren, Topographic Wind Effects and Directionality Factors for Use in the City & County of Honolulu Building Code, 10th Americas Conference on Wind Engineering, Louisiana State University, Baton rouge (June 2005).

Peterka, Jon A, Colorado Front Range Gust map, CPP, Inc. Report endorsed by Structural Engineers Association of Colorado (2006).

Revised 2010-11

PROFESSIONAL HISTORY – J.A. PETERKA

1959 – 1964	B.S. Civil Engineering, Colorado State University, Fort Collins, CO
1964 – 1965	M.S. Civil Engineering (Engineering Mechanics), Colorado State University, Fort Collins, CO
1965 – 1968	Ph.D. Engineering (Fluid Mechanics and Thermodynamics), Brown University, Providence, RI
1968 – 1970	1st Lt. And Capt. U.S. Army, Missile Development, Army Missile Command, Huntsville, AL
1970 – 1971	Research Engineer, Rocket Propulsion Laboratory, Army Missile Command, Huntsville, AL
1971 – 1976	Assistant Professor of Civil Engineering, Colorado State University, Fort Collins, CO
1976 – 1983	Associate Professor of Civil Engineering, Colorado State University, Fort Collins, CO
1983 – 1993	Professor of Civil Engineering, Colorado State University, Fort Collins, CO (½ time 1985 – 1993) Retired 1993. Emeritus status 1993-present.
1981 – 2008	Vice President, Cermak Peterka Petersen, Inc., Fort Collins, CO (called Cermak/Peterka & Associates, Inc. 1981 - March 1987)
2008 – Present	President, Cermak Peterka Petersen, Inc., Fort Collins, CO

Wind Engineering – Years of Experience
1963 - 1965 (2 Years) M.S. level research in physical modeling of atmospheric winds and dispersion of pollutants.
1971 - 2010 (39 years) Research and applied studies in physical modeling of atmospheric winds; wind loads on buildings, bridges, stadia, arenas and towers; dispersion of pollutants; pedestrian wind environment; snow loads; wind structure downwind of obstacles; wind-tunnel instrumentation. Wind loads defined for over 1000 buildings; pedestrian wind evaluation for over 500 buildings; wind loads on numerous bridges, towers and stacks; dispersion measured for several power plant stacks and numerous laboratory or industrial buildings; analysis of meteorological data.

Exhibit 2

Ahsan Kareem

Professional Preparation

B.Sc., Civil Engineering (With Distinction), W. Pakistan Univ. of Engrg. and Tech., 1968
M.Sc., Civil Engineering (Structural Engineering; GPA 4.0) Univ. of Hawaii (joint program at MIT), 1975
Ph.D., Civil Engineering (Structural /Fluid Dynamics; GPA 4.0), Colorado State University, 1978

Appointments

1999-present	Robert M. Moran Professor of Engineering, Univ. of Notre Dame (Dept. Chair 99-02)
2006-present	Advisory Professor, Tongji University, PROC
2009-present	Guest Professor, Tokyo Polytechnic University, Tokyo, Japan
1990-1999	Professor, Dept. of Civil Engrg. and Geological Sciences, Univ. of Notre Dame
1990-1990	Visiting Professor and Research Fellow, University of Tokyo, Tokyo, Japan
1978-1990	Asst. Prof., Assoc. Prof., Prof. and Director Structural Aerodynamics & Ocean Systems Modeling Laboratory, Dept. of Civil Engrg., Univ. of Houston
1988-1990	Visiting Lecturer, Dept. of Civil Engrg., Rice University

Honors & Affiliations

2009 Member National Academy of Engineering, for contributions to analyses and designs to account for wind effects on tall buildings, long span bridges, and other structures
2009 Research Achievement Award, University of Notre Dame
2008 ASCE State-of-the-Art Civil Engineering Award for scholarly contribution to full-scale monitoring of tall buildings
2007 Alan G. Davenport Medal, IAWE for outstanding contributions to wind load effects on structures
2005 Robert H. Scanlan Medal ASCE for outstanding contributions to engineering mechanics
2002 Jack E. Cermak Medal ASCE for outstanding contributions to wind engineering
2003 Distinguished Service Appreciation as Chair of the Executive Committee of the Engineering Mechanics Division of ASCE, Washington, D.C., 2003.
1999 Munro Prize for the best paper in *Engineering Structures*, an International Journal, Elsevier
1998 Achievement in Academia Award, College of Engineering, Colorado State University
1997 Engineering Award, *National Hurricane Conference*
1997 American Association for Wind Engineering Award in appreciation for the many contributions to the development of the ASCE7-95 Wind Load Standard
1984 Presidential Young Investigator Award, White House Office of Technology/NSF
1983 Halliburton Young Faculty Research Excellence Award, University of Houston
Chair, Advisory Board and Ex-Com. *Engrg. Mechanics Division, ASCE,* 2006-7; 2002-03
President, *American Association for Wind Engineering,* 1994-1998
Regional Coordinator, North & South America, IAWE
Editor-in-Chief, North & South America, *Wind & Structures*, (International. J.), 1998-2006
Associate Editor/Guest Editor, *J. of Engrg. Mech.*, ASCE 1998-2000; *J. of Struct. Engrg.*, ASCE, 1987-1997/*J. of Wind Engrg. and Indust. Aerodyn.*, Vol. 36, 1990; *Structural Safety*, 2001
Member Editorial Board *J. of Wind Engrg. and Indust. Aerodyn.; Probab. Engrg. Mech.; Struct. Safety; Engineering Structures; Applied Ocean Research; Journal of Engineering Mechanics; Journal of Structural Engineering Natural Disaster Studies; Structures & Infrastructure Engineerinmg; Computer-Aided Civil & Infrastructural Engineering*
UNDP Consultant to the SERC, Government of India
Advisor/Consultant/Examiner Universities in Malaysia; Korea; Japan; China; India; Hong Kong; Australia; Canada
Member Advisory Board, 21st Century Center of Excellence on the Effects of Wind on Buildings. & Urban Environment, Tokyo, Japan, 2004-2008.

Conference Chair, The *Sixth U.S. Nat'l Conf. on Wind Engrg.*, Houston, TX, 1989 and ASCE Specialty Conference, "*Hurricane Alicia: One Year Later*", Galveston, Texas, August 16-17, 1984; 8th ASCE Specialty Conference on Probabilistic Mechanics and Structural Reliability, Notre Dame, IN, July 24-26, 2000. *NSF Workshop on Wind Engineering: Planning for the Future; NSF Workshop on Planning for the Wind Hazard Reduction Program; NSF/NIST Workshop on Large Scale Test Facilities for Wind*
Martin Minta Award of the American Institute of Aeronautics and Astronautics, 1977
Greaves Cotton & Co., UK, Gold Medal, 1968, for being the Best Civil Engineering Graduate
Presidential Award, 1968, The Office of the President of Pakistan, awarded to the top graduates in Engineering/Science/Humanities
Habib Bank Gold Medal (First-class-First) in the Graduating Class of 1968 in Civil Engineering
Habib Bank Gold Medal for the Highest Standing in Structural Engineering Area, 1968
Pak-Techno Consultants Gold Medal for the Highest Standing in Water Res. and Env. Engineering, 1968
Nominated for Esquire Magazine's search for the Best of the New Generation Men & Women under Forty Who are Changing America, April 1984
Finalist Rhodes Scholarship from Pakistan (two finalists), 1968
Best All Round Scholar, 1962, Don Bosco High School, Lahore, Pakistan

Merit Scholarships

East West Center Scholarship (a Fulbright Hayes Program) for Graduate Studies at the University of Hawaii/MIT, 1971-73
British Commonwealth Scholarship for Graduate Studies at the Imperial College of Science and Technology, University of London, London, England, 1971-74 (did not avail)
Asian Institute of Technology, Scholarship, Bangkok, for Graduate Studies, 1971-73 (did not avail)
Saigol Foundation Merit Scholarship in Engineering, 1964-68
National Merit Scholarship, Department of Education, Government of Pakistan, Pre-Engineering and Engineering Studies, 1962-68.

Major Research Contributions (Representative examples of significant contributions work are provided below:)

Dynamic Wind Load Effects
Developed prediction methods for evaluating the response of tall buildings; long-span cable-supported bridges; complaint offshore structures under extreme environments and service loads.

Examples:

- Developed advanced analysis framework for coupled response analysis of building utilizing synchronous multi-point pressure measurement (SMPM) system or high frequency base balance (HFBB) derived data and pointed out and corrected the common problem with recent wind tunnel practice in combining modal contribution using earthquake engineering based CQC method as unlike earthquake loads components the wind loads components are partially correlated **(Buildings Dynamic Analysis).**
- Developed a new framework for equivalent static wind loads (ESWL) on buildings including coupled cases and bridges based on HFBB and SMPM **(Buildings and Bridges Analysis)**
- Developed advanced coupled flutter and buffeting response analysis framework for long-span bridges that takes into account nonlinearities of both aerodynamic and structural origins. **(Long-Span Bridges Dynamic Analysis).**
- Unveiled underlying mechanisms in multi-modal coupled flutter through curve veering analysis of eigenvalues and vectors and developed closed form solutions. **(Dynamics of Long-span Bridges).**
- Developed a closed-form formula for estimating critical flutter wind speed of generic long span bridges that not only provides, for the first time, a theoretical basis of the well-known empirical

"Selberg's formula", which is limited to bridges with flat plate sections, but also serves as its important extension to commonly used bridge deck sections **(Bridge Design)**.

- Experimentally measured for the first time the spatial correlation of self-excited forces which plays a major role in flutter estimation and cataloged the influence of turbulence on the correlation **(Long-Span Bridges/ Experimental)**.
- Introduced verification of in-situ behavior via full-scale monitoring of tall buildings using advanced technologies such as GPS and networked sensors, to validate design procedures. Developed ***SmartSync*** technologies to monitor dynamics of some of the tallest structures in the world in real-time **(Full-Scale Monitoring of Dynamic response)**
- Conducted and/or investigated hurricane induced damage to high-rise cladding/envelope in Hurricanes: Alicia; Andrew; York; Katrina, Ike and established wind speed damage correlation **(Hurricanes & Structures)**
- Developed physical benchtop facility involving a multi-fan wind tunnel for the generation of gust front winds. Developed improved understanding of transient loads and their quantification through experiments and data-driven models._**(Gust Fronts/ Load Effects)**.
- Established the need and significance of the dynamic response of offshore structures to wind loads and developed an analysis framework starting with the first paper at OTC in 1980 **(Offshore Structures)**

Dynamics/System Identification and Control

Conducted research in a wide range of topics in the areas of dynamics, system identification and control.

Examples:

- Established in mid eighties a systematic analysis procedure for compliant offshore platforms (TLPs) subjected to simultaneous action of wind, waves and current loads including hull and tethers coupled dynamics involving nonlinearities of aerodynamic, hydrodynamic and structural origins in both time and frequency domain **(Dynamics of Coupled Systems)**.
- Advanced the frequency domain approach for these complex nonlinear systems, a first in the offshore industry that captured all significant nonlinear effects, e.g., drag induced, diffraction, drift and splash zone load effects at the instantaneous position of the platform utilizing equivalent quadratization and cubicization **(Dynamics of Deepwater Offshore Platforms)**.
- Utilized tri-variate Hermite polynomials in tandem with Volterra series expansion to model these load effects along with an innovative feedback approach to correct for instantaneous position of the platform in both time and frequency domains. **(Non-linear Random Vibration)**.
- Developed schemes for the diffraction of nonlinear random waves by circular cylinders and attendant load effects **(Wave Dynamics)**.
- Developed fundamental understanding and models for the "Ringing" response of TLPs **(Non-linear Random Vibration)**.
- Modeling the dynamics of nonlinear systems with symmetric and asymmetric nonlinearities utilizing Volterra Systems **(Non-linear Random Vibration)**.
- Analysis of nonlinear systems under deterministic and stochastic excitations utilizing attractors in phase space via Poincaŕe mapping to delienate signatures of chaotic and periodic motions **(Non-liear Random Vibration)**.
- Provided a detailed analogy of nonlinear sloshing of fluid filled tanks used as dampers at higher amplitudes in terms of sloshing and slamming utilizing a linear and an impact damper, where the hardening affects are explained by transition of fluid from sloshing mode to periodic impact. **(Non-linear Dynamics)**
- Developed passive semi-active and active strategies for mitigating structural motions through developments in control algorithms, e.g., model predictive control **(Motion Control)**.
- Developed wavelet-based system identification for engineering structures **(System Identification)**.

- Delineated the efficacy of Hilbert and wavelet transforms in signal processing, system behavior analysis, extraction of signal embedded in noise and nonlinear signal analysis **(Time-Frequency Analysis).**
- Development of "Dynamic Load Simulator" with multiple actuators capable of inducing correlated loads; conducted "Hardware-in-the-loop" experiments to physically model nonlinear components and interface them with computational model of the remaining system.
- Developed system identification using transformed singular value decomposition/principle component analysis in time-frequency domain **(Identification of Non-Stationary Data/Damping/Frequency).**

Simulation/Computational Methods/System Identification

Developed efficient simulation schemes for random vector processes: stationary/non-stationary; Gaussian/Non-Gaussian; Conditional/Un-Conditional utilizing spectral and time-series methods in conjunction with a novel scheme named "Stochastic Decomposition."

Examples:

- Developed efficient Monte-Carlo based simulation schemes for the uni-variate, multi-variate and multi-dimensional Gaussian stationary and non-stationary processes **(Simulation).**
- Developed ARMA system modeling and simulation in wind effects **(Simulation).**
- State-Space modeling of combined buffeting and self-excited effects of bridges **(Simulation).**
- Introduced "spectral correction" method that has led to subsequent developments by many others for the simulation of non-Gaussian unconditional, conditional multi-variate and random fields including, e.g., pressure fluctuations on structures, random ocean waves and soil moisture contents**(Non-Gaussian Simulations).**
- Utilized innovative wavelet based scheme and Hilbert transform nested with POD for the simulation of gust front winds and earthquakes **(Gust Fronts and earthquakes)**
- Introduced the Large Eddy Simulation (LES) Scheme for simulating numerically flow around and its load effects on prismatic building **(CFD).**
- Developed High-Order time-frequency domain analysis using wavelets to capture transient nonlinear relationships between two measured processes like turbulence and pressures **(Higher-Order Analysis)**

Uncertainty/Safety and Reliability/Risk Assessment

Developed schemes for the propagation of uncertainty in damping, reliability analysis under winds and pdf of extreme response of nonlinear ocean platforms with applications.

Example:

- Introduced the role of uncertainty in the analysis of wind-induced dynamic response of structures leading to reliability based analysis **(Safety and Reliability Analysis).**
- Introduced reliability based measures for the performance of buildings from human comfort considerations **(Probabilistic Design).**
- Safety and performance analysis of building cladding under extreme wind events **(Wind Speed Damage Correlation).**
- Developed peak factor for non-Gaussian narrow-banded and broad-banded processes.
- Development of load factors for the design of flexible structures in wind in light of uncertainties in system parameters and wind **(Code Based Design).**
- Development of the pdf of extreme response of nonlinear systems, like TLPs in ocean environment based on higher order moments of the response derived from the Volterra series expansion of nonlinear components **(Probabilistic Response Analysis).**

Codes/Standards e-Analysis and –Design Technologies

Developed, improved and implemented current and past versions of ASCE Standard on Wind Loads and developed web-based e- analysis and –design tools for promoting their usage in design practice.

Examples:

- Introduced closed-form expressions for Gust Effect Factor (GEF) in ASCE 7-05 and its predecessors and a new Gust Effect Factor in ASCE 7-05 and an alternate expression for the equivalent static loading which correctly represents the variation of widen loads along the height, which has been in part implemented in AIJ. Developed a 3-D Gust Loading Factor for the along, across and torsional components **(ASCE 7-05)**.
- Developed and introduced an interactive web-based database for aerodynamic wind loads on tall buildings in ASCE 7 05 Commentary (http://aerodata.ce.nd.edu). The framework also evaluates dynamic response of buildings and equivalent static loads for given building dynamic features **(Buildings e-Design)**.
- Introduced a web-based portal for evaluating newly introduced Gust-Front Factor: A new framework for the analysis of wind load effects in gust-fronts (http://gff.ce.nd.edu). This accounts for the contrasting velocity profile and transient dynamics of gust fronts and reduces to current gust GEF for non-gust front winds **(Gust Front Factor)**.
- Developed web-based simulation portal (http://windsim.ce.nd.edu) to faciltate stochastic simulation of wind related processes without the need for user's familiarity with the theoretical background **(Web-Based Simulation).**
- Developed web-base portals for full-scale data monitoring, transfer, processing, mining and on-the-fly processing (http://windycity.ce.nd.edu; http://bdart.ce.nd.edu) **(Web-Based Data Acquisition, Analysis and Management)**
- Developing an Engineering Virtual Organization to reduce the toll of extreme winds on society VORTEX-Winds (www.vortex-winds.org). A cyber-collaboratory of the leading universities, organizations, firms and government agencies dedicated to mitigating the effects of extreme winds on society. VORTEX-Winds coordinates geographically dispersed e-analysis and design modules to enable automated, integrated analysis and design of structures to resist wind) **(Virtual Organizations)**.
- Experimental work on wind loads on TLPs quantified the influence of interference among platform deck strcutures, lift induced moments and discrepencies in the recomendatiosn of the codes and standards in offshore engineering **(Offshore Platforms)**

Recent Research Grants/Projects

- New Frontier of Education and Research in Wind Engineering: A Global Center of Excellence, *Ministry of Education, Culture, Sports, Science and Technology Japan (MEXT) 2008-2013.*
- VORTEX-Winds: A Virtual Organization for Reducing the Toll of Extreme Winds on Society , *National Science Foundation*, USA 2007-2009
- Structural Health Monitoring of Tall Buildings, *Samsung Corporation, Samsung Design and Construction Group, S. Korea.* 2006-2008.
- Performance Evaluation of Tall Buildings under Winds: From Predictive Methods to Laboratory and Full-Scale Measuremnets, *National Science Foundation, USA.2006-2009*
- Performance of Glass/Cladding of High-Rise Buildimngs in Hurricane Katrina and its Impact on the Vertical Evaluation, *National Science Foundation, USA.2005-2006.*

- Study of Load Effects on Structures Induced by Gust-Fronts. *National Science Foundation, USA.2003-2006.*
- Characterization, Modeling and Simulation of Transient Hurricane Loads, *NIST, USA.* 2002-2004
- Full-Scale Study of the Behavior of Tall Buildings Under Winds, *National Science Foundation, USA.* 2000-2004.

Other Major Sponsors in the Past

- Office of Naval Research
- Lockheed Martin
- NASA
- United Nation Development Program
- American Institute of Steel Construction
- Texas Advanced Technologies Program
- Texas Advanced Research Program
- Group of Japanese Universities
- Amber/Booth
- General Electric Corporation
- Cray Corporation
- Ocean Engineering Services
- Halliburton Foundation
- Gulf Research & Development Company
- Chevron Oil Field Research Company
- Brown & Root Corporation
- Conoco Oil
- Shell Development Company
- DnV

PROFESSIONAL COURSES TAUGHT

Computational Methods in Wind Engineering, University of Opole, Poland, March 23rd, 2009.
Motion Mitigation Devices in Structural Engineering, University of Opole, Poland, March 23rd, 2009.
Computational Methods in Wind Engineering, Bridge Engineering Department, Tongji University, Shanghai, PROC, November 21-23, 2007.
Motion Mitigation Devices in Structural Engineering, Bridge Engineering Department, Tongji University, Shanghai, PROC, November 21-23, 2007.
Computational Methods in Wind Engineering, Center of Excellence International Advanced Study Institute, Tokyo, Japan, March 5-9, 2007.
Motion Mitigation Devices in Structural Engineering, Center of Excellence International Advanced Study Institute, Tokyo, Japan, March 5-9, 2007.
Dynamics of Tall Buildings under Winds, Continuing Education Course at the 11th Americas Conference on Wind Engineering, Baton Rouge, Louisiana, May 31, 2005
Aerodynamic Tailoring of Tall buildings, SPACE, Universiti Teknology Malaysia, Advanced School for Professionals and Academicians, Kuala Lumpur, February 23-24, 2005
Wind Effects on Structures: The Next Frontiers, Croucher Foundation Advanced Study Institute, Hong Kong University of Science and Technology, 6-10, December 2004, 8-10, December 2005.
Wind-Excited and Aeroelastic Vibrations of Structures, EU Advanced School, Genoa, Italy, Department of Structural and Geotechnical Engineering, University of Genoa, June 12-16, 2000.
Design of Floating Production Systems, Austin, Texas, sponsored by the University of Texas and Norwegian Institute of Technology, October, 1991.

Wind Resistant Design of High-Rise Buildings, Taipei, sponsored by Building Research Institute, Taiwan, August, 1991.

Design of Steel Bins for the Storage of Bulk Solids at Sydney, Australia, Sydney, Australia, sponsored by University of Sydney, March, 1985.

Wind Loads on Buildings and Structures, Dallas and Houston, sponsored by Texas Tech University, October, 1984.

Wind Effects on Structures Special Reference to Caribbean, Mayaguez, P.R., sponsored by University of Puerto Rico, August, 1982.

Exhibit 3

BRYAN K. RAPPOLT

Mr. Bryan Rappolt is an operational and consulting meteorologist with over 18 years of professional experience. His specialty areas are in Forensic Meteorology, weather prediction, flood warning assessment, and flood preparedness. His expertise stems from participation in flood prediction and flood warning projects in Colorado and Arizona and performing flood warning assessments and the development of flood response plans across the western United States. Mr. Rappolt has worked with numerous law firms and insurance companies on the reconstruction of weather events for claim settlement and litigation and has appeared numerous times as an expert witness in the field of meteorology.

PROFESSIONAL HISTORY

Genesis Weather Solutions, LLC — **President**
Highlands Ranch, Colorado — **April 2005 to Present**

HDR Inc — **Project Manager**
Denver, Colorado — **November 2000 to February 2005**

HMS — **Chief Operational Meteorologist**
Denver, Colorado — **February 1992 to November 2000**

National Weather Service — **Meteorological Intern**
Portland, Maine — **August 1990**

TECHNICAL SPECIALTY AREAS

Mr. Rappolt has performed as Chief Operational Meteorologist, Senior Meteorologist, Project Manager and Forensic Meteorologist for various federal, state, public and private sector clients. Some of these clients include the United States Army Corps of Engineers, United Sates Bureau of Indian Affairs, Colorado Water Conservation Board, Urban Drainage and Flood Control District (Denver CO), Flood Control District of Maricopa County (AZ), Douglas County, CO, Washoe County, NV, Scottsdale, AZ, White and Steel P.C., Foran Glennon Palandech & Ponzi P.C., Holcim Inc., American Family Insurance, State Farm Insurance and Chubb Insurance Company.

Technical specialty areas include the following:

- Weather Event Reconstruction and Expert Testimony
- Doppler Radar Derived Rain/Snow/Wind Reconstructions
- Doppler Radar Derived Hail Swath and Hail Size Reconstructions
- Quantitative Precipitation Forecasts
- Thunderstorm Track Prediction
- Flood Prediction and Warning Notification
- Wind Prediction and Warning Notification
- Climatological Studies
- Flood Warning and Flood Hazard Assessments
- Flood Response Plans
- Rainfall Intensity-Depth-Frequency (IDF) And Depth-Duration-Frequency (DDF) Calculations

TECHNICAL KNOWLEDGE

- National Weather Service WSR-88 Doppler Radar Level II and Level III raster and GIS data sets
- Surface and upper atmospheric data sets
- Cloud to ground lightning data
- Historical precipitation and stream flow data sets
- ESRI's ArcView and ArcMap software
- HTML, JavaScript, Visual Basic languages

PROJECT EXPERIENCE

Forensic Meteorology/Meteorological Consulting

Lasater & Martin, P.C. – Highlands Ranch, CO (2010): Project Manager: Determined the depth, intensity, temporal distribution and return frequency of rainfall that occurred in Colorado Springs, CO. Produced 5-minuite and storm total rainfall depth, areal coverage estimates and a storm mass curve across the entire project area. Utilized Doppler radar Level II datasets, Z-R algorithms, surface and upper atmospheric weather observations and GIS software in the reconstruction process. Produced a report detailing the results and expert findings.

EDUCATION

Bachelor of Science degree, Meteorology. Minor, Technical Mathematics. Plymouth State College, Plymouth N.H. 1991.

Coursework completed toward a Master of Science degree in Hydrology. University of Colorado, Denver, Colorado 1994-1996.

Coursework completed in Visual Basic and advanced Visual Basic. Red Rocks College, Lakewood, Colorado 1998-1999.

CONTINUING EDUCATION

Completed the American Meteorological Society and National Council of Industrial Meteorologist's course entitled **'Forensic Meteorology Principals, Practices and Procedures'** in 2005.

AWARDS

American Council of Engineering Companies (ACEC) of Colorado **Excellence Award 2004** – 'Designing the Perfect Storm' – Meteorologist on project team.

American Council of Engineering Companies (ACEC) of Colorado **Excellence Award 2003** – 'Holcim Wind Predictions' – Chief Operational Meteorologist.

Colorado Association of Stormwater and Floodplain Managers **Merit Award 2001** – 'Otero County Flood Response Plan' - Meteorologist on project team.

Arizona Consulting Engineers **Merit Award 1999** – Wickenburg Arizona Flood Warning Response Plan - Meteorologist on project team.

PUBLISHED PAPERS/PRESENTATIONS

Principal researcher and author of 'Forecast Applications of the Denver Cyclone Convergence Vorticity Zone to Predict Severe Weather and Heavy Precipitation Events'. Paper presented at the 17th annual Severe Storms Conference in St. Louis MO, Oct. 1993. Published by the American Meteorological Society in the 17th Conference on Severe Local Storms preprint volume.

Principal researcher and author of 'Mesoscale Flow Features Influence on Thermal Instability; The Denver Convergence Vorticity Zone'. Paper presented at the Mesoscale Processes Conference 1994. Published by the American Meteorological Society in the Conference on Mesoscale Processes preprint volume.

Principal researcher and author of 'Me(so)ounds Effective modification of atmospheric soundings using elevated mesonet stations'. Paper presented at the Weather Forecasting and Analysis Conference in Dallas, Texas, January 1995. Published by the American Meteorological Society in the Conference on Weather Forecasting and Analysis preprint volume.

Co-researcher and author of 'Operational Applications of the CSP Model to Flash Flood Prediction'. Published by the American Meteorological Society in the 18th Conference on Severe Local Storms preprint volume, 1996.

Researcher and author of 'Severe Weather and Flood Forecasting: A Partnership between the National Weather Service and the Private Sector'. Paper presented at the 1997 NHWC/SAAS conference in St. Louis, MO., October 1997.

Researcher and author of 'Heavy precipitation forecasting in Denver Colorado and Phoenix Arizona - different climates, similar concepts and results. Presented at the Southwest Association of Alert Systems Conference in Lakewood, Colorado October, 2000.

Researcher and author of 'Doppler Radar Rainfall Reconstruction's-Direct Applications for Basin Watershed Modeling and Calibration. Presented at the National Hydrologic Warning Council Conference in Columbus, Ohio May, 2001.

Researcher and author of 'Flood Warning Response Plans – Non Structural Flood Mitigation. Presented at the Association of Floodplain Managers – Flood proofing conference in Tampa, Florida March, 2002.

Researcher and author of 'Flood Warning Response Plans – Non Structural Flood Mitigation. Presented at the National Hydrologic Warning Council Conference in Dallas, TX October, 2003.

Continuing legal education (CLS) presentation 'Forensic Meteorology: Applications for the Legal and Insurance Industry'. Presented at Expert Consulting Service's office in Denver, Colorado December 8, 2009.

Continuing legal education (CLS) presentation 'Meteorology 201: Beyond the Basics'. Presented at Expert Consulting Service's office in Denver, Colorado December 8, 2009.

Genesis Weather Solutions, LLC
10630 Braselton Street
Highlands Ranch, Colorado 80126
303-927-6522
brappolt@genesisweathersolutions.com

Windle Hood Alley Norton Brittain & Jay, LLP – El Paso, TX (2010): Project Manager: Determined weather variables that were observed at a location in Santa Fe, NM that contributed to a slip and fall. Weather variables included precipitation depth and duration, hourly surface temperatures, solar radiation, snowmelt, ice development, and occurrence of freeze re-freeze cycles. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process. Produced a report detailing the results and expert findings.

Spies, Power & Robinson P.C.– Denver, CO (2010): Project Manager: Determined weather variables that were observed at a location in Grand Junction, CO that contributed to a slip and fall. Weather variables included precipitation depth and duration, hourly surface temperatures, solar radiation, snowmelt, ice development, and occurrence of freeze re-freeze cycles. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process. Produced a report detailing the results and expert findings.

McKellar, Tiedeken & Scoggin, LLC - Cheyenne, WY (2010): Project Manager: Determined weather variables that were observed at a location in Casper, WY that contributed to a death. Weather variables included wind velocity and direction associated with a thunderstorm produced wind. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process.

Hillyard, Wahlberg, Kudla & Sloane, LLP – Denver, CO (2009): Project Manager: Determined weather variables that were observed at a location in Calhan, CO that contributed to an automobile accident. Weather variables included wind velocity and wind direction, precipitation depth and duration, hourly surface temperatures, solar radiation, snowmelt, ice development, visibility, and occurrence of freeze re-freeze cycles. Utilized Doppler radar, satellite, surface weather and upper atmospheric weather observations in the reconstruction process to estimate wind velocity, precipitation and visibility. Produced a report detailing the results and expert findings.

Fogel Keating Wagner Polidori Shafner – Denver, CO (2009): Project Manager: Determined weather variables that were observed at a location in Watkins, CO that contributed to an automobile accident. Weather variables included wind velocity and wind direction, precipitation depth and duration, hourly surface temperatures, solar radiation, snowmelt, ice development, visibility, and occurrence of freeze re-freeze cycles. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process to estimate wind velocity and precipitation.

The Hartford Insurance Company - Centennial, CO (2009): Project Manager: Determined the depth, intensity, and temporal distribution of rainfall of a rainfall event that occurred in Colorado Springs, CO. Produced 5-minuite and storm total rainfall depth, areal coverage estimates and a storm mass curve across the entire project area. Utilized Doppler radar Level II datasets, Z-R algorithms, surface and upper atmospheric weather observations and GIS software in the reconstruction process. Produced a report detailing the results and expert findings.

Law Office of Scott Tessmer - Centennial, CO (2009): Project Manager: Determined weather variables that were observed at a location in Glendale, CO that contributed to a slip and fall. Weather variables included precipitation depth and duration, hourly surface temperatures, solar radiation, snowmelt, ice development, and occurrence of freeze re-freeze cycles. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process. Produced a report detailing the results and expert findings.

Wood, Ris & Hames, P.C. - Denver, CO (2009): Project Manager: Determined weather variables that were observed at a location in Longmont, CO that contributed to personal injury. Weather variables included wind velocity and direction and the development of a wind velocity climatology for the Longmont, Colorado area. Determined probability of occurrence of estimated wind velocity values. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process. Produced a report detailing the results and expert findings.

Purvis • Gray, LLP- Boulder, CO (2008): Project Manager: Determined weather variables that were observed at a location in eagle, CO that contributed to a construction accident. Weather variables included precipitation depth and duration, hourly surface temperatures, snowmelt, ice development, and occurrence of freeze re-freeze cycles. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process. Produced a report detailing the results and expert findings.

Lynberg and Watkins – Los Angeles, CA (2008): Project Manager: Determined weather variables that were observed at a location in Washoe County, NV that contributed to an automobile accident. Weather variables included wind velocity and wind direction, precipitation depth and duration, hourly surface temperatures, solar radiation, snowmelt, ice development, visibility, and occurrence of freeze re-freeze cycles. Utilized Doppler radar, surface weather and upper atmospheric weather observations in the reconstruction process to estimate wind velocity and precipitation.

Operational Meteorology/Weather Prediction

Urban Drainage & Flood Control District-Flash Flood Prediction Program (1992-2004 & 2007-2010): Chief Operational Meteorologist, Project Manager and Senior Meteorologist: Provided depth, duration basin specific quantitative precipitation forecasts, thunderstorm track predictions, and flood warning and notification to emergency responders within the seven county Denver Metropolitan area.

Exhibit 4

RESUME OF CHARLES M. RECARD

EDUCATION:

Bachelor of Science - Mechanical Engineering
Pennsylvania State University - 1974

University of Wisconsin - Milwaukee - Reliability and Product Safety Engineering - 1986

WORK HISTORY:

Grove Manufacturing Company
06/74 to 10/82 - Structural Design Group
Initial Position: Stress Analyst
Final Position: Senior Project Engineer

10/82 to 01/86 - Product Safety & Reliability Group
Initial Position: Product Safety & Reliability Engineer
Final Position: Project Manager

JLG Industries, Inc.
01/86 to 1/93 - Product Safety & Reliability
Initial Position: Program Director
Final Position: Director - Department Head

Equipment Safety Consultants, Inc.
9/92 to Present - President

WORK EXPERIENCE:

Design -Analyze major structural weldments and detail components for hydraulic cranes, mechanical cranes and aerial work platforms.
-Develop load capacity charts (preliminary and final) for hydraulic cranes.
-Conduct design reviews, safety analysis and functional analysis for hydraulic cranes, mechanical cranes, aerial work platforms, skid steer loaders and forklifts.

Testing -Develop, supervise and analyze results of structural, stability and functional test programs for hydraulic cranes, aerial work platforms, skid steer loaders and forklifts.
-Inspections and evaluations of field units for hydraulic cranes, mechanical cranes, aerial work platforms and fork lifts.

-Testing of proximity warning device on hydraulic crane - Emerson Electric Co.

Standards -Develop verification and certification calculations to prove compliance with various ANSI, PCSA, AISC, British Standards (B.S.) and Canadian Standards (CSA) for hydraulic cranes and aerial work platforms. Participate in various Standards Organizations both domestic and international.

Technical Publications

-Develop, review and approve technical and safety manuals for hydraulic cranes, mechanical cranes, aerial work platforms, skid steer loaders and fork lifts.

Teaching -1986 - Purdue University - Aerial Work Platform Safety Course for United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry.

-1992 - JLG Industries, Inc. - "Train the Trainer - Instruction for Training JLG Equipment Operators".

Risk Management & Litigation

-Accident investigation for hydraulic cranes, mechanical cranes, aerial work platforms and fork lifts.

-Claims supervision for hydraulic cranes, aerial work platforms and fork lifts.

-Participate in negotiations with and make presentations to Lloyds of London Underwriters with regard to annual self-insurance program renewal.

-Corporate representative - Grove Manufacturing Company and JLG Industries, Inc.

-Expert witness - hydraulic cranes, aerial work platforms and fork lifts.

AFFILIATIONS:

Member - American National Standards Institute
A92 Main Committee, A92.5 Sub-Committee, A92.6 Sub-Committee

Member - Canadian Standards Association Technical Board

Member - American Society of Safety Engineers

Member - American Society for Testing and Materials

Member - Society of Automotive Engineer

Member - American National Standards Institute B30 Main Committee, B30.22 Sub-Committee

Member - American Society of Mechanical Engineers

Member - U. S. Technical Advisory Group for International Standards Organization (ISO) Technical Committee 214 - Elevating Work Platforms

CERTIFICATION:

U. S. Department of Labor Instructor In Occupational Safety and Health for the Construction Industry

Exhibit 5

David K. Merrifield, C.S.P.

4515 Stonecrest Terrace
St. Joseph, MO 64506
(816)-364-1540 (office and Fax), (816)-364-4024 (home)
e-mail: dmerrifi@stjoelive.com

Profession

Safety Consultant and Expert Witness

2002 to present

Consulting with manufacturers, owners and users of machinery concentrating on safe design, safe use, warnings, instructions, risk management and defending the product.

Expert witness testimony concerning government and industry standards, warnings, instructions, maintenance and inspections, misuse, hazards and hazard control, duties of parties, fall protection, safety devices, product recalls and service bulletins.

Corporate Director of Product Safety Omniquip-Textron

1998 to 2002

Managing risk and producing safe product and promoting safe use through product safety programs including hazard analysis, proper warnings and instructions, safety and operation training, public education, and public relations relating to safety.

Products include Personnel lifting Devices (Aerial Work Platforms), Telescopic Material Handlers (Rough Terrain Fork Trucks) and Skid Steer Loaders.

Developing standards for safe design and use of product worldwide.

Litigation and liability management, company representation and testimony.

Director of Product Safety Snorkel International Inc

1991 to 1998

Summary duties same as above but at division level.

Education

Degrees

Certificate in Industrial Management—Aurora University
B.A. Business & Economics—Aurora University
M.A. Philosophy and Economics—Northern Illinois University

Continuing education

OSHA 10-Hour General Industry Certification Course
OSHA Materials Handling and Storage for General Industry
University of Wisconsin-Madison Department of Engineering
- Establishing and Implementing the Product Safety Program
- Failure Modes and Effects Analysis
- The Role of Hazard Analysis in Evaluating Product Safety
- The Role of Warnings and Instructions

Equipment Manufacturers Institute's Product Safety Seminar (8 consecutive years attendance)
Defense Research Institute's Products Liability Seminars
American Bar Association Warnings Seminar
American Society of Safety Engineers--Ergonomics Course

4 years directed independent study in preparation for certifications—science, engineering, ergonomics
AWPT (Aerial Work Platform Training Inc.) Operator and Instructor courses
1-1/2 years of Law school—Nashville School of Law

1959-1991

Professional Experience

30 years in industrial management including Manufacturing Engineering, Industrial Engineering, Plant management and Operations management.

Certifications

Certified Safety Professional—Comprehensive Practice

Certified Safety Professional—Ergonomics

IPAF (International Powered Access Federation) Approved Instructor—Aerial Lifts

IPAF Demonstrator—Mast Climbers

Awards

Scaffold Industry Association—1998 Outstanding Council Chairman
Scaffold Industry Association—2000 Coupling Pin Award for outstanding service to the industry

Professional Memberships

Chairman of the Scaffold Industry Associations Aerial Platform Council
American Society of Safety Engineers
System Safety Society
Equipment Manufacturer's Institute eight-year member of Product Safety Committee (no longer active)
Construction Division of the National Safety Council
North American Society of Scaffolding Professionals

Additional Professional Activities

Standards

Chairman of the American National Standards Institute's (ANSI) A92 main committee for Aerial Work Platforms
Past Vice-Chairman of the American National Standards Institute's (ANSI) A92 main committee for Aerial Work Platforms Member of ANSI
Past member of the ANSI A92.3 subcommittee for Manually Propelled Work Platforms
Member of the ANSI A92.2 subcommittee for Vehicle Mounted Work Platforms
Member of the ANSI A92.6 subcommittee Self Propelled Aerial Work Platforms
Member of the ANSI A92.5 subcommittee Self Propelled Aerial Work Platforms
Member of the ANSI interpretations committee for Self Propelled Aerial Work Platforms
Chairman of the ANSI ad hoc committee on fall protection
Chairman of the ANSI ad hoc committee on reorganization of A92.2 subcommittees
Member of U.S. Technical Advisory Group 214 of the International Standards Organization (ISO) for Mobile Elevating Work Platforms
Head of the U.S. delegation to the International Technical Advisory Group 214 of the International Standards Organization (ISO) for Mobile Elevating Work Platforms

Member of ANSI Z535 Main Committee for Warnings
Member of ANSI Z535.4 subcommittee for Product Safety Signs and Labels

Training

Develops both conventional and computer based interactive training materials
Conducts training seminars for operator training and document creation and control

Other

Peer reviewer for NIOSH study of scissor lift tipovers
Member of Aerial Work Platform Training Corporation's Advisory Council
Coordinator of *Lift Applications & Equipment* magazine's Rodeo Review (comparative testing of equipment)
Member of *Lift Applications & Equipment* magazine Editoral Board

Publications and Presentations

Publications and papers

"Safe scissor lift operation," *Lift Equipment* (June 1993)

"Fall protection puzzles," *Lift Equipment* (January 1997)

"An issue of safety," *Snorkel* (1997)

"Aerial Work Platforms: Safety, Liability & the Rental Center," *Professional Safety* (January 1998)

"What Does an Operator Need to Know?" presented before the *International Access Platform Conference* in Maastricht Holland (September 1998)

"Choosing Safety," *Scaffold Industry* (October 2001)

Seminar presentations

National Safety Council
Associated General Contractors of America
American Bar Association
Equipment Manufacturers Institute
Construction Industry Manufacturers Association
Scaffold Industry Association Aerial Platform Council
Defense Research Institute
International Powered Access Federation

Trade Show presentations

National Safety Council
National Joint Apprenticeship and Training Committee for the Electrical Industry
Plant Engineering and Maintenance
Associated Equipment Distributors
Scaffold Industry Association
American Rental Association
American Society of Safety Engineers
Associated General Contractors of America
ConExpo

Exhibit 6

4 April 2011

Notre Dame Lift Accident

Summary of Findings

CPP, Inc. was commissioned to assist in a broad investigation of the Marklift scissor lift that tipped over in the accident of 27 October 2010 and to help ensure that the right people and expertise were involved. CPP's primary involvement was to determine the strength of the wind gust which would cause a tip-over of a lift of the same type and age as the Marklift scissor lift in use at the time of the accident. In addition, CPP was commissioned to determine why two nearby lifts in use at the time of the accident did not suffer a similar result.

Wind speed on campus at the accident site was determined by transfer of wind speeds measured at the airport and from Doppler radar resulting in an estimated gust wind speed of 53 mph at the time of the accident. Following the accident, the failed lift and the site were inspected to determine the extension height of the Marklift; the lift was determined to be at its full extension height of 40 ft at the time of tip-over. Tests were performed on an exemplar of the failed lift and on two nearby lifts that did not tip over, a Skyjack and a JLG, to determine the amount of lift platform lateral movement and rotation under various loads applied at the platform level.

CPP developed a calculation model of wind loads on the lifts based on fundamental principles of Wind Engineering and Fluid Mechanics. These loads were balanced against the resistance to tip-over of the weight of the lift. A wind gust speed of approximately 49-53 mph was just sufficient to cause the Marklift to tip at the 40 ft full extension height ("the tipping-point speed"). This tipping-point speed at the Marklift full 40 ft height is just 0-4 mph below that which is believed to have existed at the time of the accident. Results of this analysis are presented as wind speeds predicted to overturn each lift as shown in the table below.

Wind Speeds Required to Overturn Each Lift

	Tipping-Point Speed mph	Estimated Gust Wind Speed At Accident Site, mph
Marklift at 40 ft	49 – 53	53
Marklift at 35 ft	50 - 54	53
Marklift at 30 ft	55 – 59	53
Marklift at 25 ft	59 – 64	53
Skyjack at 40 ft	70 – 76	53
JLG at 40 ft	75 – 81	53

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The tabulated results show that the Marklift at its 40 ft extension would tip over at the 53 mph that existed at the site. There is a range of speeds from 49 to 53 mph where the Marklift might have tipped over. At 35 ft extension, it is more likely than not that the lift would have tipped over, but the conclusion is not as clear. The Marklift at 30 or 25 ft extension would not have tipped over at the 53 mph speed that existed at the site. Both the Skyjack and JLG lifts would have required wind speeds above 70 mph to tip over at a 40 ft extension, and so they should not have tipped at the time of the accident.

Because the Marklift was at 40 ft extension when it tipped over, the results of this investigation show that the accident would have occurred from wind speed alone without the presence of any structural defects. If structural defects were present in the Marklift that decreased its structural capacity, the lift could have overturned at a lower wind speed than determined herein due to a combination of structural defects and wind loads. Structural deficiency is not addressed in this document.

Marklift at the Accident Site

Figure 1 shows a photograph of the Marklift at the accident site. Marks on the lift pad showing the location of the lift as it fell, and marks on the pavement made by the platform when it hit indicated the lift was fully extended to 40 ft. Measurements of the lift at its post-accident storage location also showed the lift was fully extended.

Wind Speed at the Accident site

At the time of the accident, about 4:55 pm EDT on 27 October 2010, an intense low pressure system was located in Canada north-northwest of South Bend, IN (see Figure 2). At the center of the low pressure system, a barometric pressure of 975 mb was recorded generating strong winds in the surrounding surface environment (circulating counterclockwise relative to the storm center). While the system was sufficiently distant that South Bend did not experience the low pressure (29.61 inches of Mercury = 1002.7 mb; 1013 mb is the average atmospheric pressure under standard conditions), strong wind speeds did extend from the low pressure area. Wind speeds from the southwest increased in magnitude at the accident site as the low pressure system passed by to the north.

Notre Dame personnel reported they checked National Weather Service (NWS) current wind speeds prior to practice. The NWS assesses wind speed and gust roughly 6 minutes before the hour. If special observations are made during the hour when unusual weather events occur, the current conditions are updated a few minutes after the special observations occur. The only special observation associated with wind is a 90 degree shift in wind direction which did not happen on the day of interest. There were no special observations at South Bend on 27 October during the time of interest from 12-5 PM. The wind speed posted on the NWS site is the 2-minute mean in the two minutes before assessment time at 6 minutes to the hour. The posted gust is the highest 5-second gust during the 10 minutes prior to assessment time. Therefore not all recorded NWS wind data were presented that day and the presented data may be as much as one

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hour old, reported only on the hour. The wind speeds and gusts available at hourly post times are shown in the table below. The data in the table were computed by CPP using 1-minute data discussed below.

Wind speed Record – 27 October 2011
NWS Data – South Bend Regional Airport

Data Collection EDT	Wind Speed mph	Gust Speed* mph
11:54 AM	23	34
12:54 PM	23	29
1:54 PM	23	30
2:54 PM	29	38
3:54 PM	22	44
4:54 PM	33	51

* units conversion could cause wind speeds to vary by one mph

Additional wind speed and direction records from the South Bend airport at the time of the accident were retrieved from the National Climatic Data Center in Ashville, NC. These data are not available real time (and thus were not available to Notre Dame personnel or other users on the day of the accident) but can be accessed at a later time. The airport meteorological station is an Automated Surface Observation System (ASOS) where the wind speed and direction are measured at 33 ft (10 m) above ground. This station has “1-minute” data, which means that once every minute the speed and direction (averaged over the last two minutes) are recorded. In addition, the largest 5-second duration gust within the last one minute and its direction are recorded.

Figure 3 shows wind speeds and directions at the airport for the hours leading up to the accident time of 4:55 pm EDT. In the figure, measured 5-second gusts have been converted to 3-second gusts to be compatible with wind load provisions of ASCE 7, the national wind load standard, since elements of that standard are used in this report to calculate wind loads (for example the largest 5-second speed of 53 mph becomes a 3-second speed of 54 mph). In addition, 30-minute running averages (average over 15 minutes before to 15 minutes after each point in time) of both wind speed and direction have been computed and are presented in Figure 3.

Wind speeds at the accident site on campus lagged those at the airport, since the weather system was moving from west to east. The largest gust at the airport occurred at 4:29 pm EDT, while the

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highest winds at the accident site did not occur for some minutes later. In my opinion, the portion of the system with highest gusts did not arrive at the accident site until about 4:55 pm, based on multiple witness accounts and based on the analysis of Bryan Rappolt (discussed below).

CPP performed an analysis to estimate the maximum 3-second wind speed at the accident site. An analytical model of the wind flow near the earth's surface (an atmospheric boundary layer) was used, ESDU 1993a and 1993b (see list of references). The model accounts for the variation in wind speed and gustiness with height and changes in surface roughness upwind of the airport and accident sites. Figure 4 shows that the surface immediately upwind of the accident site is quite smooth, with increased surface roughness farther upwind. The airport and accident sites have similar exposures and so the largest 3-second gust wind speeds at the two sites were similar (54 mph at the airport and 53 mph at the accident site). The mean wind azimuth (the direction from which the wind was blowing) was a southwest wind at 230 degrees (North is 0 degrees, South is 180 degrees, and West is 270 degrees).

There were multiple reports that the wind gust speed responsible for the lift tip-over increased unusually quickly and was large in amplitude. For this reason, and to obtain a second opinion of local wind speed, an analysis of Doppler radar and other data was conducted by Bryan Rappolt of Genesis Weather Solutions. His report indicates a peak 3-second gust at the accident site of 52 - 55 mph at a wind direction of 230 - 235 degrees. These data are consistent with the speed and direction determined by CPP.

The two independent wind speed estimates gave essentially identical wind speeds. We do not normally expect such good agreement, but two estimates that agree closely provide a sound basis to proceed to an analysis of wind effects on the scissor lifts. We are confident that the maximum speed at the accident site occurred at the time of the accident and was at or close to 53 mph.

Scissor Lift Deflection Tests

The ability of a scissor lift to resist wind is influenced by the amount of deflection of the platform under wind load. A horizontal deflection moves the center of gravity of both the platform and scissors reducing the resistance of the lift to overturning. In addition, a tilt from level in the platform increases the overturning wind load. In order to determine the deflection characteristics of the Marklift that tipped and the Skyjack and JLG lifts that did not tip on the day of the accident, physical tests were performed on an exemplar Marklift and the other two lifts that were undamaged. The original Marklift was too damaged to be used for these tests. The other two lifts are a Skyjack (Figure 5b) and a JLG (Figure 5c). Without these deflection tests, our ability to predict the overturning wind speed would have been much less certain. In our experience, not many lift users would be interested in spending the amount of time and dollars required; Notre Dame is to be commended for commissioning these tests.

Figure 5a shows the exemplar Marklift that was purchased by Notre Dame specifically for these tests. It is a 1991 lift, two years younger than the 1989 lift that tipped. The primary difference in

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the two lifts appears to be that the width of the lift is 7 ft while the failed Marklift is 8 ft. Other dimensions appear to be very similar. This difference does not affect our analysis since the width is irrelevant for the deflection test.

The load tests were conducted in an airport hangar in Columbus, OH on 18-20 January 2011. The technical team consisted of the undersigned; Mark Recard of Equipment Safety Consultants, Inc., Needmore PA; Mike Dorohoff of SEA Limited, Columbus, OH; and Brian Tanner, also of SEA Limited. The technical team designed the tests and ensured the data obtained was suitable for calculating deflections of the lifts on the day of the accident.

Each lift was tested to the fullest height permitted given the limitations of the hangar roof. The Marklift and Skyjack were tested to their full 40 ft height by removing or lowering the platform railings; the JLG could only reach a 30 ft platform height because its railings could not be lowered. A series of horizontal forces were applied to the platform of each lift at zero degrees (perpendicular to the long axis of the lift), and at 45 degrees from this direction to simulate southwest winds on the lifts. A photograph of the force application is shown in Figure 5d. The point of application of the force was set so that its line of action would be close to the center of the lift platform – the purpose was to avoid applying an artificial twist about the lift vertical axis.

Assessment of the deflected shape of each lift consisted of two measurements. In the first method, a manual reading of the platform horizontal deflection perpendicular the lift long axis (called the N-S direction) was performed using a plumb bob hung from the platform and a tape measure taped to the floor (Figure 5e). Deflections were recorded to 0.1 inch. Measurements in the long axis direction were also attempted, but the deflections were too small to be reliably recorded by this method. The largest deflection measured was 12 inches for the Marklift under a 200 lbf (pounds force) load at zero degrees (perpendicular to the lift long axis).

The second measurement method for lift deflection was a laser scanning instrument, provided and operated by SEA Limited. In addition, SEA recorded the force applied to the platform based on a load cell output. For each measurement where scanning was employed, scanning was performed from two locations, one on each side of the lift, so that the full 3-dimensional shape of the lift could be determined. In a scan, a laser traversed vertically and horizontally the lift and the area nearby, performing a ranging operation at each point. The two scans were assembled in a post-processing mode into a 3-dimensional point cloud of solid material representing the lift. SEA personnel first outlined the platforms for all scans and inserted these shapes into an AutoCad drawing that CPP could use to measure platform displacement and rotation. In addition, for a no-load case, SEA converted the point cloud into an AutoCad drawing of the entire lift so that CPP would have access to various member dimensions.

The loading process was to first record the lift position under no load. A force of 200 lbf was applied in steps while observing deflections to ensure that deflections would remain at a safe level where there would be no chance of overturning a lift. The deflection was recorded and the load reduced to 150 lbf, 100 lbf, 50 lbf and frequently lower loads that were recorded only by the plumb bob method. Recordings of load were made by at least the manual method, and often by both manual and scanning methods. Scanning was not used for all measurements where the technical team was in agreement that manual measurements were adequate.

Key elements and observations of the deflection tests are illustrated in Figures 5f – 5k.

Limits on hangar roof height required removal of the railings on the Marklift to reach 40 ft extension; the Skyjack with folded railings (that could not be completely removed) could not reach 40 ft at 45 degrees; the JLG with railings fixed upright could not reach 40 ft at either 0 or 45 degrees.

The laser scanner can be seen in the lower left of Figure 5f and spheres used to register scans from two directions can be seen on traffic cones.

The deflection of the Marklift platform at 0 degrees and 200 lbf (Figure 5f) was about 12 inches; the cantilever shape of the lift (vertical scissors at the base, increasing curvature with height in the scissors, rotation of the platform about a horizontal axis) can be seen. This cantilever shape was observed for all lifts but at different magnitudes of deflection.

Both Marklift and Skyjack lifts have stabilizing outrigger feet which were deployed for these tests similar to how they were deployed at Notre Dame on the day of the accident; the JLG does not have feet, but has a significantly higher weight for stability.

A tape seen hanging from the platform was used to measure platform height, a string suspending the plumb bob is present near the tape but is not easily visible in these photographs.

Results of the deflection tests are shown in Figure 6. Each part of the figure shows the applied force in pounds (lbf) on the horizontal axis and deflection in inches in the north-south direction on the vertical axis. Plumb bob measurements are shown as solid diamonds while scan data are shown as open squares. Parts a) and b) are for the Marklift at 0 and 45 degrees, part c) is for the Skyjack, and part d) is for the JLG. Plumb bob and scan results match very well except for the Marklift at a height of 40 ft in part a) at 0 degrees. For this case, the Marklift had a deflection of several inches with almost no applied load. It is likely that the no-load scan deflection was about 3 inches different from the no-load plumb bob measurement. Since the 0 degree case is not of interest for the accident analysis, and because we are mostly interested in the slope of the deflection curve, this result is of no consequence for our analysis. The good match between plumb bob and scan data for the remaining data provides a solid basis for the analysis of the next section.

The scan data were used to determine the platform angle for each load case. To analyze this data, we used the observation during deflection tests that the lift deflected as a cantilever. For our analysis, a cantilever is a structural member fixed at one end and loaded at the other end with a force. The data was matched to the deflection of the lift as predicted by equations representing a cantilever loaded with a concentrated force at the top. The equations also provided a calculation of the platform angle since the platform remained perpendicular to the scissors. In this way, the platform angle change under load could be predicted by the slope of the cantilever tip. Analysis

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of cantilever equations showed that the platform angle should be related to the deflection at the platform by

$$\alpha = \tan^{-1}\left(\frac{1.5 * Deflection}{Platform\ Height}\right)$$

In this equation, α is the platform angle. Figure 6e shows a comparison of the measured platform angle and the angle predicted by the above equation. The cantilever appears to model the data well. The largest measured platform angles for each lift are shown in the figure, showing the Marklift has a significantly larger deflection and angle than the other two lifts. This model is used in the next section.

Analysis Procedure

One purpose for this analysis is to determine why the Marklift tipped over and why the other lifts did not. In addition, it is of interest to understand if the Marklift would have remained standing if it had been at an extension lower than 40 ft.

The method used for this analysis is a relatively standard one in Wind Engineering for forensic investigation. The likely gust wind speed and direction at the site was first determined as was done in an earlier section of this report. This transfer included the variation of wind speed with height and included gustiness in the wind appropriate to the ground roughness upwind of the accident site (open ground, buildings, trees, etc.). The gust wind speed was then separated into its North-South and East-West components for application to the scissor lift structures. The tipping mechanism examined was the wind-induced drag force on the scissor lift elements. The wind was applied to various elements of the lift to obtain forces on these individual objects. The wind speed at which the lift tips is determined by balancing the wind-applied forces against the weight of the lift. This balancing of forces is formally accomplished by calculating and summing "moments" of all forces (each moment is found by multiplying a force by its distance (moment arm) from the point at the ground level where the lift rotates if it tips over).

The elements in the scissor lift were separated into three sections: platform (including base, rails, toolbox, person and camera), lifting section members (including large scissor members, horizontal support bars, and hydraulic lifters), and base section (tires, engine, scissor base tracks, and control panel). The purpose was to permit the wind forces to be based on wind speeds that are variable with height and to permit the appropriate moment arm (for moment calculation) for each area to be determined. For each of these sections, the affected area was calculated based on projection of the area to the southerly component of the wind (i.e. the wind component in the direction in which the lift tipped). If the wind had been only from the south, some elements would have been shielded by upwind elements. Because the wind was from the southwest, all members were essentially unshielded and no shielding factors were included in the analysis.

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Using the affected area of each scissor lift section, the applied wind force (drag) on each section was calculated, using the wind gust speed profile with height in the ASCE 7 wind load provisions for an open country environment (a 0.105 power law exponent for variation of gust velocity as height varies from 33 ft). The wind force for each section was then used in conjunction with deflection test results to determine a wind-induced moment for each section of interest.

The platform section required somewhat more in-depth analysis due to the dynamic wind force on the underside of the platform as the lift began to deflect. The combination of vertical and horizontal forces on the platform acting as a flat plate in the wind were calculated using the deflection and platform angles from the deflection tests discussed in the previous section. These deflection data were put into a form so that deflection in the N-S direction could be plotted as a function of the N-S component of the applied load. Here, N-S refers to the direction perpendicular to the lift long axis (N-S is the direction of tip for the Marklift). These data are shown in Figure 7 where a deflection model based on these data has been added as a dashed line. The model is based on the 45 degree data, since there is a somewhat different deflection pattern for the 0 degree data. We believe the difference between deflections at 0 degrees and 45 degrees is that at 45 degrees the joints in the scissor lock up faster with load and thus reach the point earlier where structural stiffness in the scissor members limit the N-S deflection/play rather than deflections within the joints.

Lift deflections in the N-S direction as a function of load in the same direction as shown in Figure 7 are summarized below. The important part of the fitted curve is the extension to higher loads.

Marklift at 40 ft height – Defl (in) = 2.9 + 0.030 * Load (lbf)
Marklift at 35 ft height – Defl (in) = 2.1 + 0.0325 * Load (lbf) [interpolated from 40 & 30 ft]
Marklift at 30 ft height – Defl (in) = 1.3 + 0.035 * Load (lbf)
Skyjack at 35 ft height – Defl (in) = 3.6 + 0.021 * Load (lbf)
JLG at 30 ft height – Defl (in) = 1.6 + 0.013 * Load (lbf)

Loads on the platforms caused by scissor lift deflection and platform rotation were determined using data in Peterka et al. (1989).

The restoring moment (equipment weight force due to gravity) was calculated using weights for each lift. Total weights were determined from publicly available data from the manufacturers. A breakdown of weights for the base, scissor, and platform were needed, since our analysis accounted for the decrease in resistance due to horizontal deflection of the scissor and platform. Assistance from Mark Recard permitted the breakdown in weights between base, scissor and platform. The weights used in this analysis are:

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Weight Distribution	Base lbf / %	Scissor lbf / %	Platform lbf / %	Total lbf / %
Marklift	3390	2920	1390	7700
	44	38	18	100
Skyjack	5770*	3500*	1600*	10870
	53	32	15	100
JLG	9000	4500	1800	15,300
	59	29	12	100

* Estimated from other data in this table

The analysis computations are contained in a handwritten derivation of formulas and in a spreadsheet that has more detailed comments on the procedure than can be presented herein. The results of the analysis are presented as wind speeds that are predicted to overturn each lift. These results are summarized in the table in the Summary section at the beginning of this report.

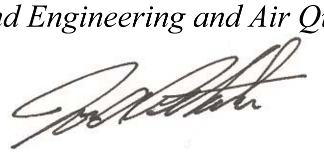
References

ESDU (1993a) Strong winds in the atmospheric boundary layer, Part 1: mean hourly wind speeds, ESDU Report 82026, ESDU International.

ESDU (1993b) Strong winds in the atmospheric boundary layer, Part 2: discrete gust speeds, ESDU Report 83045, ESDU International.

Peterka, J.A., Tan, Z., Cermak, J.E., and Bienkiewicz, B. (1989), Mean and Peak Wind Loads on Heliostats, Journal of Solar Engineering, Vol. 111, pp 158-164.

Sincerely,
CPP, Inc.
Wind Engineering and Air Quality Consultants



Jon A. Peterka, PhD, PE
Principal

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Figures 1a and 1b. Marklift scissor lift at accident site.

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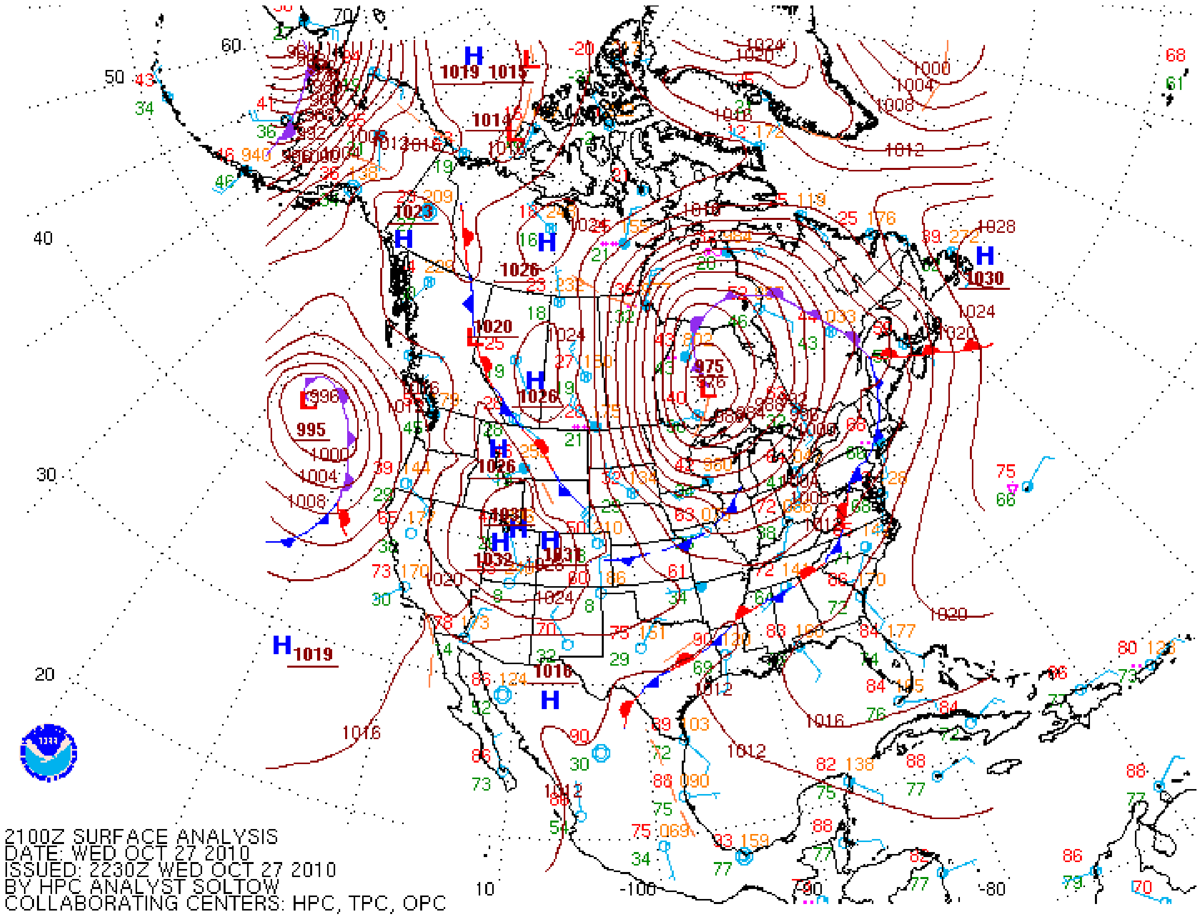

Figure 2. Weather surface analysis map for the time of the accident showing an intense low pressure in Canada north-northwest of South Bend.

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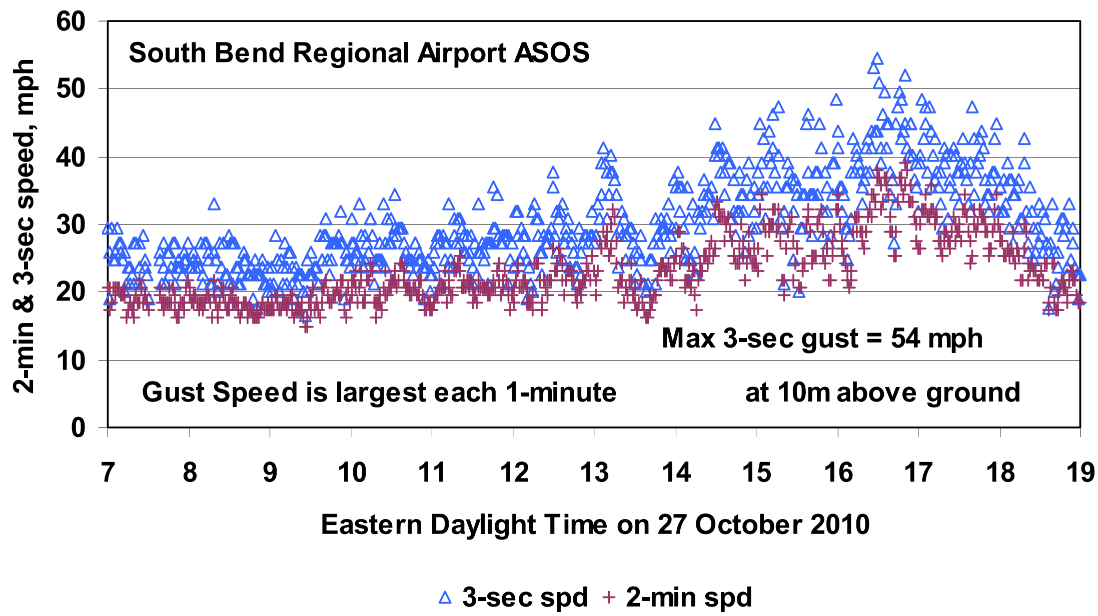

Figure 3a. Two-minute mean wind speeds and 3-second gust speeds from South Bend Regional Airport.

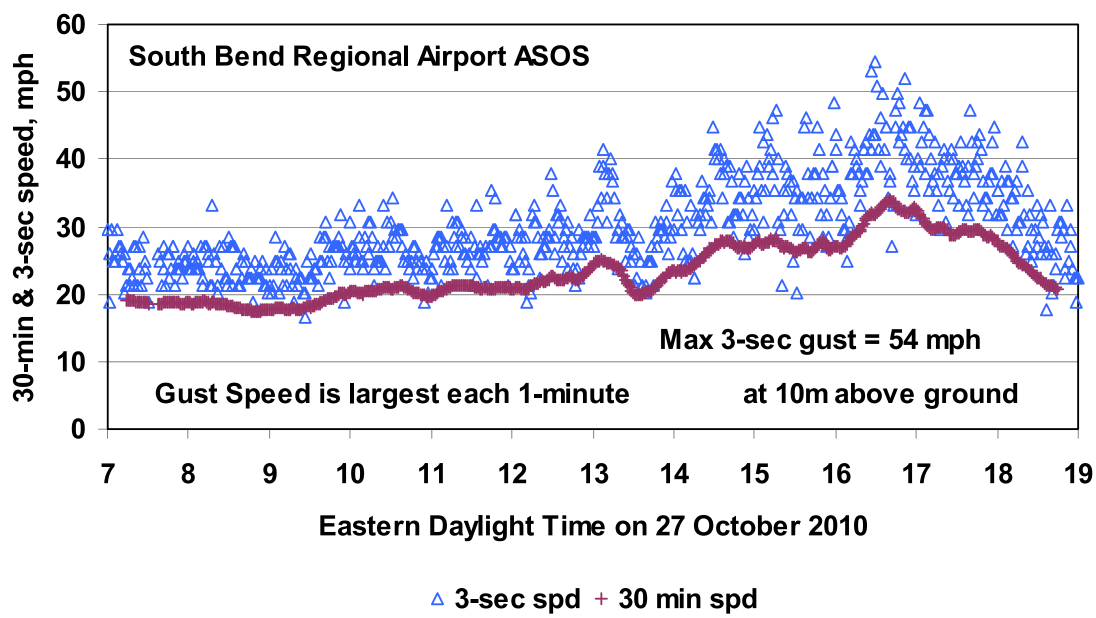

Figure 3b. Thirty-minute mean wind speeds and 3-second gust speeds from South Bend Regional Airport.

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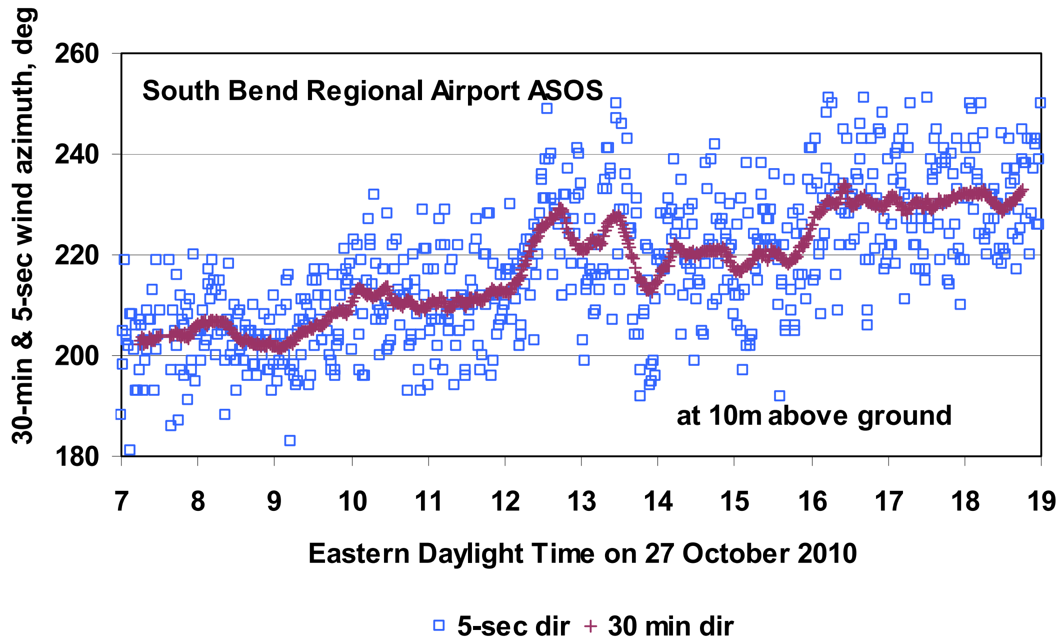

Figure 3c. Thirty-minute mean wind azimuth and 5-second azimuths from South Bend Regional Airport.

Figure 4. Photograph looking upwind from the accident site (Southwest) to the direction from which the wind gust occurred that tipped over the Marklift.

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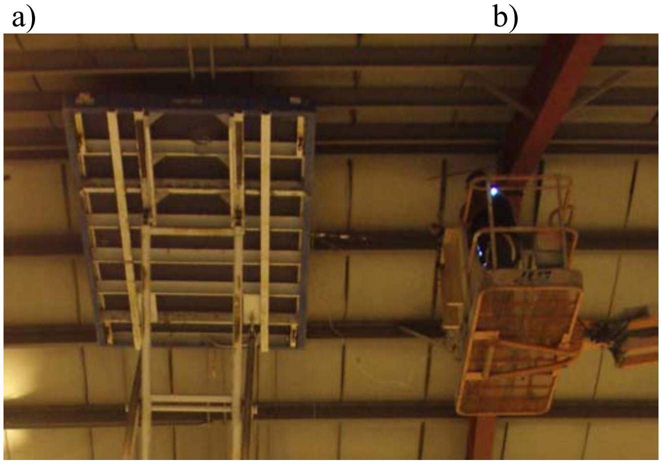
a)

b)

c)



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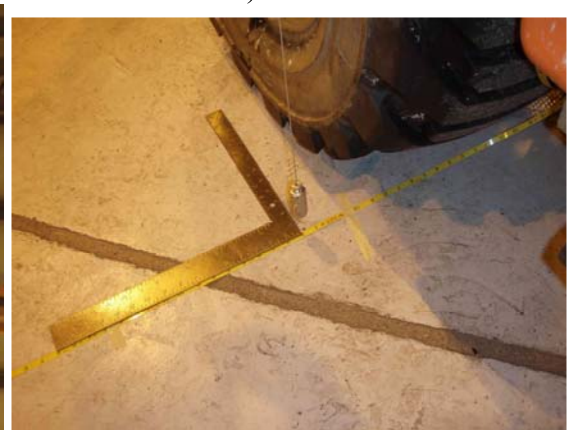

e)

Figure 5. a) Marklift exemplar at 40 ft, b) Skyjack website photo, c) JLG website photo, d) pull cable attached to Marklift at 40 ft, e) plumb bob measurement of deflection.

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f)

g)

Figure 5. f) and g) Marklift under 200 lbf load at zero degrees.

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h) i)

Figure 5. h) and i) Skyjack under 200 lbf load at 45 degrees.

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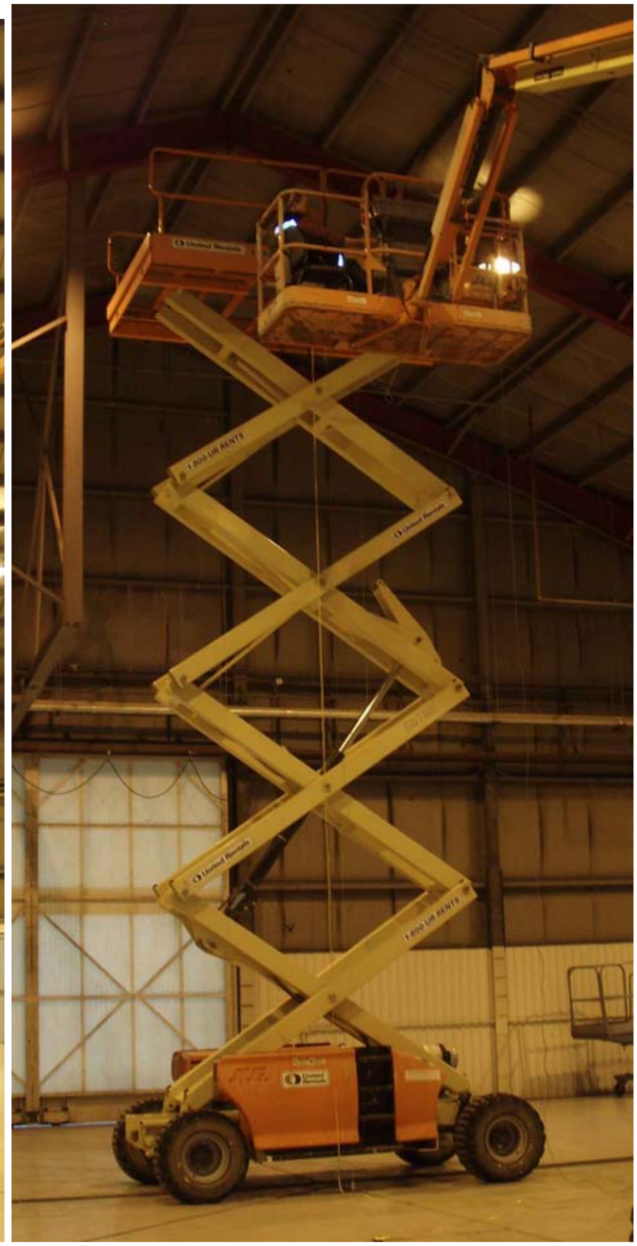
j)



k)

Figure 5. j) and k) JLG under 200 lbf load at zero degrees.

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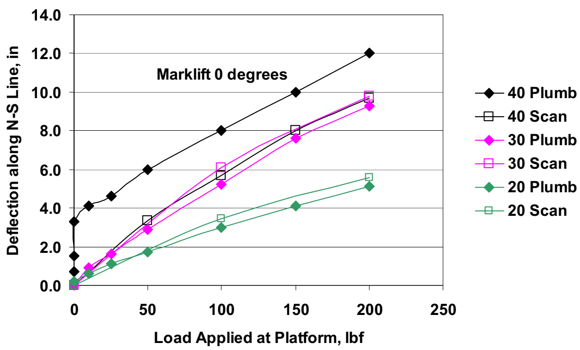

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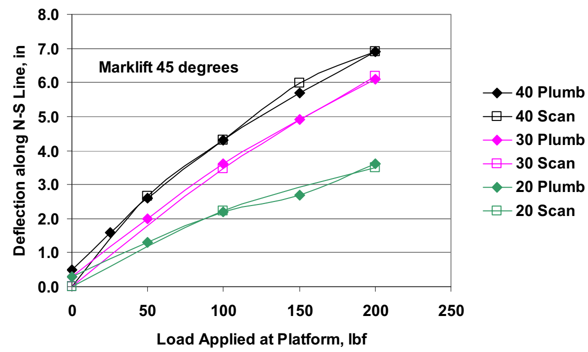

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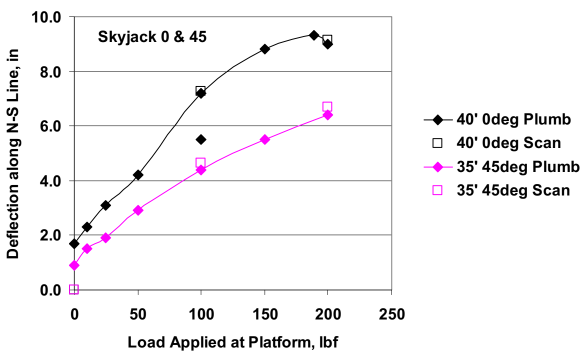

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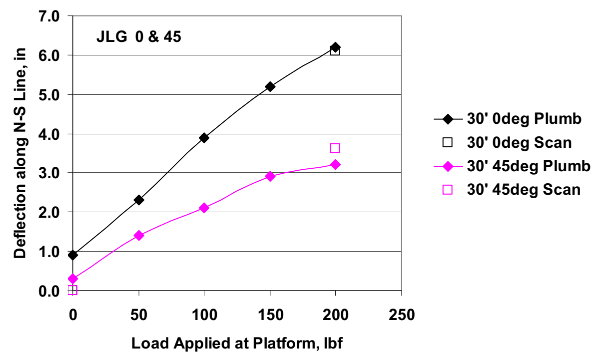

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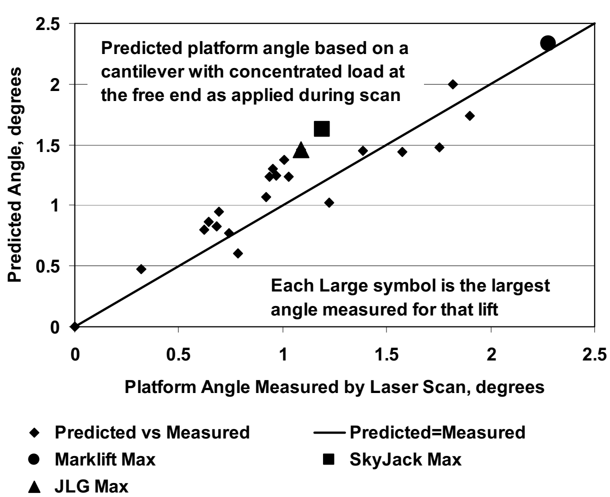

e)

Figure 6. a) to d) Results from the deflection tests;
e) platform angle results compared to a cantilever model.

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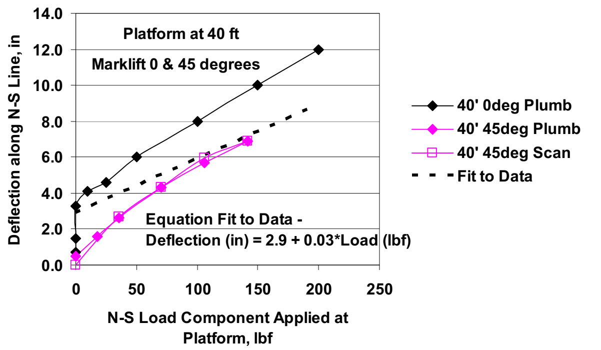
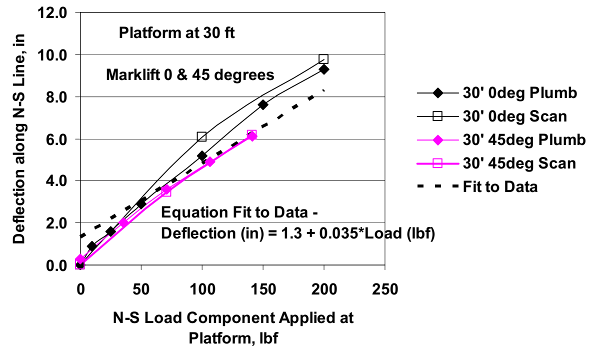


a)



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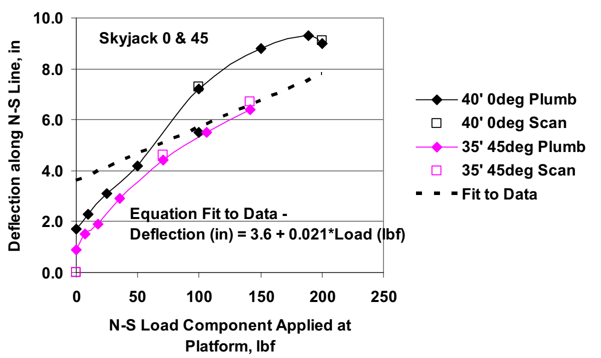

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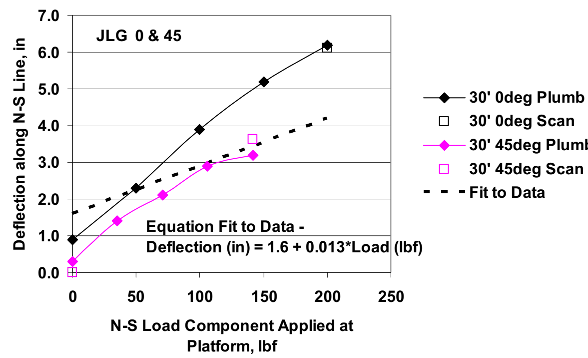

d)

Figure 7. Deflection models for the three lifts.

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Exhibit 7

Notre Dame Scissor Lift Accident

Evaluation of Scissor Lift Pre-Accident Condition

The purpose of this report is to provide an analysis and evaluation of the pre-accident operational and maintenance condition of the scissor lift involved in a tipover accident on the Notre Dame University campus on October 27, 2010.

The reference Industry Standard which will be used as a benchmark for this evaluation is ANSI/SIA A92.6-2006 American National Standard for Self-Propelled Elevating Work Platforms ("ANSI").

Background

The scissor lift involved in this accident is a Marklift Model MT 40G, serial number 68918561 ("The Lift"). The Lift was designed and manufactured by Mark Industries, Brea, California. Mark Industries is no longer in business manufacturing scissor lifts. The Lift was manufactured in June 1989 and has been in service since it was originally sold. Extended use of a scissor lift such as The Lift over a long period of time may cause more flexibility in the lift structure and may result in less lateral stability than a newer lift.

The Lift is characterized in the Aerial Platform Industry as a "Rough Terrain Scissor Lift". The Lift (Figure 1) consists of a large work platform supported by four (4) pairs of scissor arms which are attached to a drivable chassis. The Lift may be driven in the elevated condition up to an extended height of thirty (30) feet. Above the thirty (30) foot elevation The Lift is designed so that it is supported by four (4) hydraulic outriggers which are manually extended and pinned in the horizontal direction and hydraulically extended in the vertical direction from controls at the platform operating station. The purpose of the four (4) outriggers is to increase the stability of The Lift when it is operated above thirty (30) feet.

The Lift is designed and equipped with various safety devices and systems including:

1) Load ratings based on certain structural and stability safety factors which are verified by testing.
2) Holding valves on all platform lift cylinders designed to prevent lowering of the platform in case of hydraulic system failure.
3) A slope measuring system designed to detect an out-of-level condition which may occur while The Lift is being driven. This system incorporates an automatic lowering feature which lowers the platform when the chassis reaches a pre-determined out-of-level condition, although the lowering system is not triggered as a result of wind loading.
4) The outrigger hydraulic cylinders are protected by a holding valve similar to that used in the platform lift cylinders. The holding valve prevents retraction of the outrigger cylinder in the event of a hydraulic system failure.
5) A platform height interlock system which measures the raised height of the platform and pressure in the outrigger cylinders. When the height of the raised platform reaches thirty (30) feet The Lift drive function is disabled and the platform lift function is disabled until such time as the outrigger cylinders are extended vertically. Only when the outriggers are vertically extended and pressure is detected in the cylinders due to the supported weight of the lift, is the platform lift function enabled to allow The Lift to be raised above thirty (30) feet.

Section 3 of ANSI defines the owner of The Lift as an "entity who has possession of an aerial platform by virtue of proof of purchase". In this case the owner of The Lift is Notre Dame University. As the owner of The Lift, under Section 6.7 of ANSI, Notre Dame has the responsibility to "ensure that an annual inspection is performed on the aerial platform no later than thirteen (13) months from the date of the prior annual inspection. The inspection shall be performed by a person(s) qualified as a mechanic on the specific make and model of the aerial platform or one having similar design characteristics. The inspection shall be in accordance with items specified by the manufacturer (remanufacturer) for an annual inspection. The owner shall not place the aerial platform into service until all malfunctions and problems have been corrected." Notre Dame had previously chosen United Rentals to perform annual inspections on The Lift beginning in 2001, according to service records. Based on my knowledge and experience with United Rentals, they are qualified to perform this service.

The specific requirements for annual inspections are not defined by ANSI, but rather by the manufacturer of the specific product. However, the requirements for the inspection for each type of aerial lift equipment such as "rough-terrain scissor lift" for The Lift are generally similar. A Marklift annual inspection form was not available for The Lift, but a review of the United Rentals service records indicates that they did have various "check list" type forms which they used in conjunction with the annual inspection. These forms indicate the type of inspection and the items which are typically inspected on an annual basis.

Review of The Lift's service records indicate that it was last given an annual inspection on August 3, 2009. On the day of this accident, The Lift was overdue for annual inspection by 54 days.

The service records for the lift also indicate that the hourmeter which measures engine run time and thus operating time for The Lift was broken and registered the same reading of 2,164 hours since August 2001. Although the hourmeter is not essential to the functioning of The Lift, it is essential to assist in the proper maintenance and inspections for The Lift in that it provides an indication of The Lift usage and extent of wear of the components. The hourmeter should have been repaired as part of the annual inspection.

Further review of the service documents indicates that the time spent by United Rentals for conducting an annual inspection was typically 2-2.5 hours. Based on the extensive requirements of an annual inspection and my experience in conducting and supervising annual inspections on this type of scissor lift, 2-2.5 hours is not enough time to conduct a proper annual inspection for a scissor lift of this age. A more appropriate time would be 4-6 hours (not including repair time).

Height of Lift at Time of Accident

At the time of this accident The Lift was being used with its platform in the extended or elevated condition. The Lift work platform was extended such that the floor of the platform was at a level of forty (40) feet above the ground. This is the fully-elevated condition.

The bases for this conclusion are:

1) A security camera located on a building on the far side of the football practice fields recorded an image of The Lift just prior and during the tip over. I examined that video and determined that the work platform of The Lift was even with the top of the football goal post which was determined to be forty (40) feet.

2) The Lift was measured post-accident while positioned horizontally on a flatbed trailer at the South Bend Airport. The measured distance from the floor of the platform to the bottom of the outrigger

pad was forty (40) feet. Other measurements of the Lift taken at the accident site, post-accident, indicate that the length of The Lift is thirty-eight and one half (38.5) feet. This distance is lower because of the reference points used (other than the platform floor and bottom of the outrigger pad) and the fact that The Lift's arms were curved when they were lying horizontally at the accident site.

3) The height of The Lift as measured on the trailer is the same height as The Lift would have been just prior to tip over. The height of The Lift (either longer or shorter) would not have changed as a result of the tip over. The Lift is designed with integral hydraulic holding valves in the lift cylinders which would prevent the cylinders from moving except in case of a breach of the cylinders themselves. There was no evidence that such a breach occurred. Thus because the lift cylinders did not move, the scissor arms did not extend or retract as a result of the accident.

<u>Pre-Accident Condition of The Unit</u>

I visually inspected The Lift on two occasions, November 23, 2010 and January 7, 2011. The Lift at the time of inspection was resting on a trailer, on its right side in an extended condition. This is the condition that it was in immediately after the accident (in terms of directionality, The Lift tipped over to the North and landed on its right side (Figure 1)). The Lift had sustained structural damage to the scissor assembly as a result of the tipover accident.

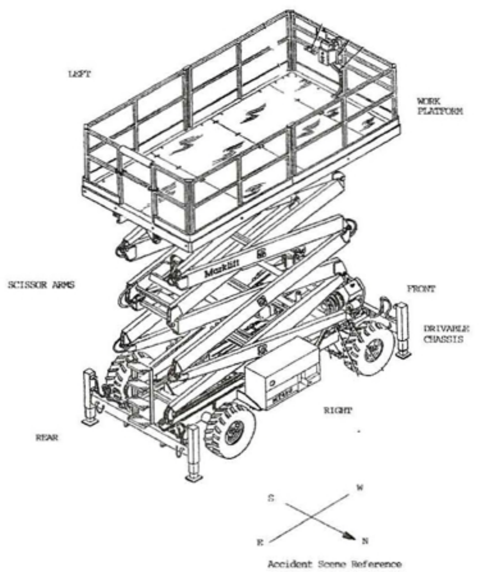


Fig 1 – Overall Lift Drawing

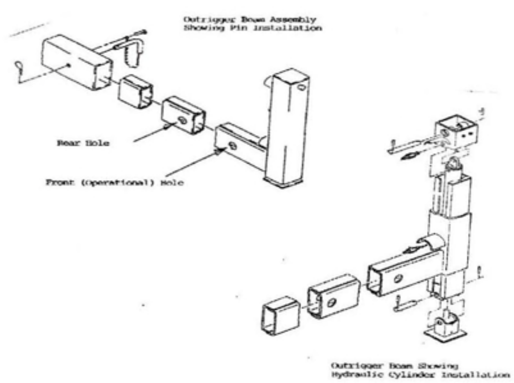


Fig 2 – Outrigger Drawing

Further inspection of The Lift revealed two areas of damage that pre-existed the accident. They were, damage to the platform railing assembly and corroded and unpinned outrigger assemblies. Additionally, I determined that the center pivot shaft of the top inner scissor arm assembly was fractured and that a portion of the shaft was found lying on the ground near The Lift after the accident.

Damage to the Platform Railing Assembly

The platform railing assembly is made up of seven (7) individual railing sections which are joined together at the bottom of the rail by insertion into pockets on the outside perimeter of the platform and at the top of the railing by integral pin assemblies.

The integral pin assemblies are designed to join the railing assemblies at the four (4) corners of the work platform at the top of the rails. Two of the pin assemblies were broken. Visual inspection of the fracture surfaces indicate that based on the extent of corrosion and wear, the pins were not fractured as a result of the accident and had been broken for a period of time such that the fracture should have been detected during the August 2009 annual inspection.

Although this damage in no way caused or contributed to the tipover accident, this damage would have prevented The Lift from certification for annual inspection.

Corroded and Unpinned Outrigger Assemblies

As previously discussed the Lift is equipped with four (4) outrigger assemblies which are operated from the platform control station and consist of a vertical hydraulic jack and a horizontal beam which is manually extended and pinned in position. The Lift also is designed with an interlock system which prevents the platform from being elevated beyond the thirty (30) foot level unless the four (4) outrigger jacks are extended to the ground. The purpose of the outriggers is to increase the stability level of The Lift from that of operating on the tires alone.

The outrigger beam weldment (Figure 2) is designed with two holes in the beam into which the pin may be inserted, one hole close to the vertical jack and one hole at the aft end of the beam. The Marklift operator's manual is silent as to which hole should be used during "on outrigger" operation. However, based on a review of the parts manual drawings (which shows the lift in an elevated position with the outriggers pinned in the hole closest to the vertical jack), an evaluation of the loading and structural properties of the outrigger beam, and my experience with other scissor lifts of this type; it is my opinion that the pin hole closest to the vertical jack is to be used for pinning the outrigger beam during operation.

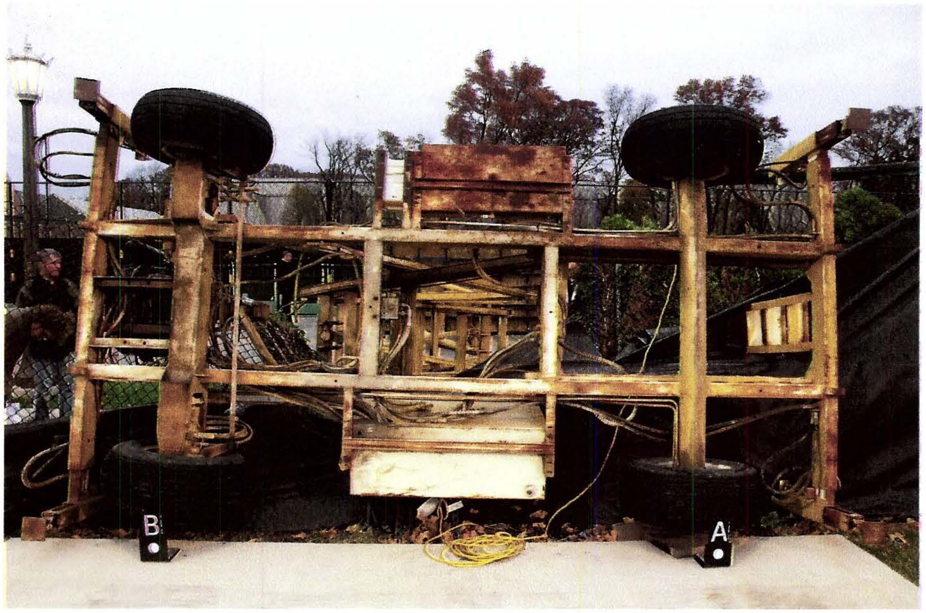


Photo 1 - Lift in Tipped Condition Showing Outrigger Position

It is my opinion that the outriggers of The Lift were appropriately extended both horizontally and vertically and that the position of the outriggers did not cause or contribute to this accident. The bases for this opinion are as follows:

1. Post-accident photographs indicate the horizontal and vertical positions of the outriggers (Photo 1).

2. The platform height interlock system requires the outrigger cylinders to be extended downward until they are pressurized in order for The Lift to be raised to its post-accident height.

3. The position of witness marks on the concrete pad after the accident. These marks indicate firm contact between the pad and the outriggers.

4. The outrigger cylinders have a holding valve system that would prevent retraction of the cylinders in case of hydraulic failure. There was no evidence of a hydraulic failure in the outrigger system.

Post-accident inspection of The Lift revealed that the four (4) pins which are normally attached to the outrigger beams by means of a chain lanyard and are designed to secure the beams into position were missing. Further inspection revealed that the outrigger beam sockets were corroded to the extent that the beams were "frozen" into position in the horizontal direction to a point where they were extended 1-5 inches beyond the normal pinned position. It should be noted that either as a result of the tipover accident or post-accident transportation of The Lift the corrosion "lock" on the right rear outrigger beam was broken and the outrigger beam became completely extended and free from the frame (Photo 2).

Photo 2 - Right / Left Rear Outriggers

Photo 3 - Right Front Outrigger

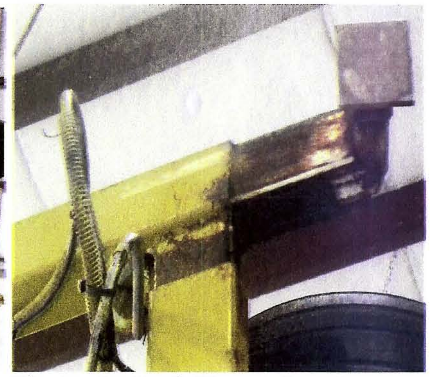


Photo 4 - Left Front Outrigger

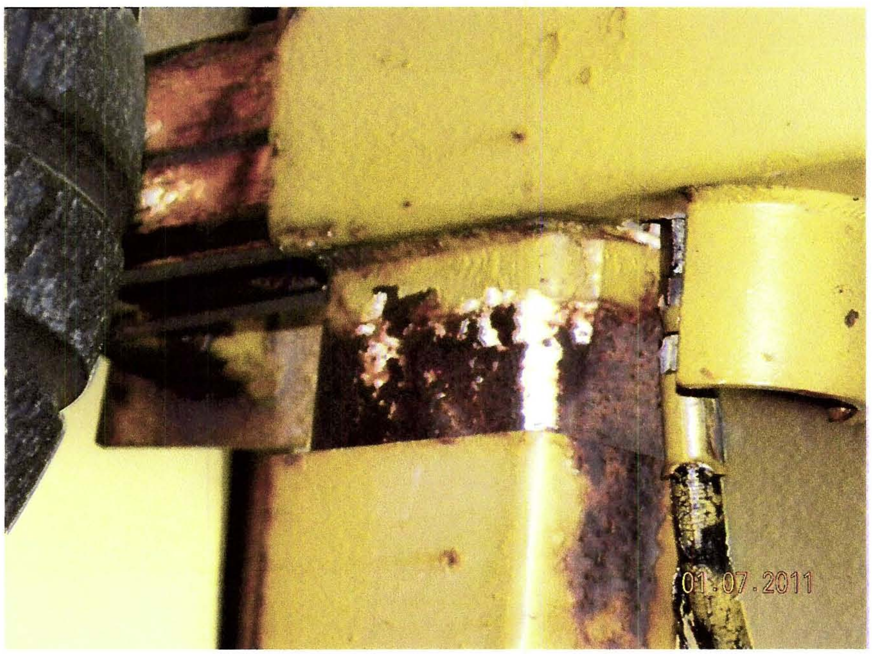


Photo 5 - Outrigger Beam Showing Extension – Painted and Unpainted (Corroded)

Analysis and inspection of The Lift indicates that although the outriggers were not pinned at the time of this accident, they were secured, as a result of corrosion between the metal surfaces, into a position which did not decrease the lateral stability of The Lift. As the above photograph shows the normal pinned position of the outrigger beam is indicated by the yellow painted surface. Post-accident the beams were shown to be in a position where they were extended beyond the normal (painted) position (Photos 3, 4 & 5). Because the beams were extended beyond the normal pinned position the stability footprint of The Lift was increased and thus its resistance to tippover was increased due to the somewhat larger base. The outrigger beams were not extended to the point where their structural strength was compromised.

With regard to the pre-accident condition of The Lift, the corroded condition of the outrigger beams indicates that the pins had been missing for a significant period of time. The corrosion of the beams and missing pins should have prevented The Lift from being certified by annual inspection in 2009.

Damage to the Center Pivot Shaft of the Top Inner Scissor Arm Assembly

The work platform of The Lift is supported by four (4) sets of scissor arms which are designated top, top center, bottom center and bottom. These sets are joined together by steel pins at each end and a steel shaft in the center.

Post-accident inspection of The Lift determined that the center pivot shaft of the top inner scissor arm assembly, on the left side of the lift had completely fractured, thus separating the inner and outer scissor arms (Photos 6 & 7).

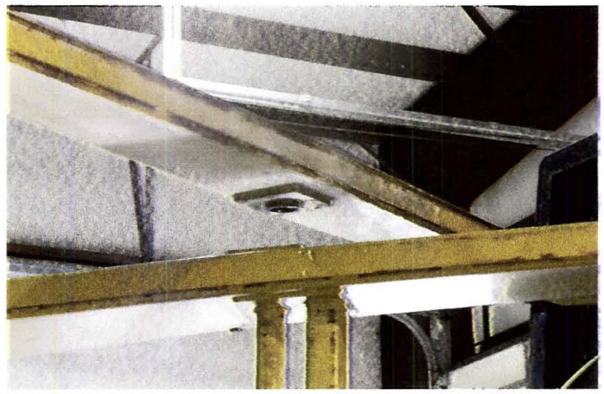


Photo 6 & 7 - Damage to Scissor Arms and Pivot Shaft

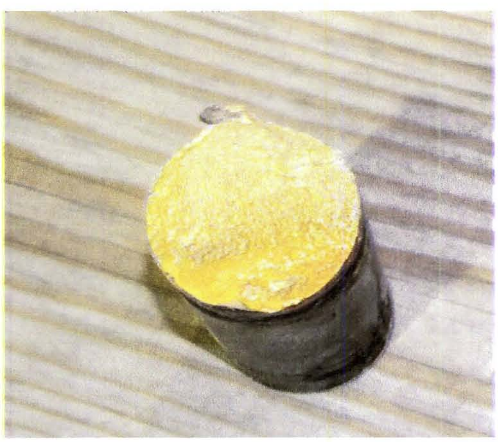


Photo 8 – Pivot Shaft Fracture Surface

Because a fractured pivot shaft in the scissor assembly can contribute to instability of the entire scissor lift, it was necessary to determine whether fracture occurred before the accident or as a result of the accident. A visual inspection of the fracture surface of the pivot shaft indicated that a metallurgical examination of the surface would be beneficial in quantifying the type and age of the shaft fracture. Qualified metallurgists at SEA Limited conducted such an examination and determined that the fracture was a brittle fracture as a result of a single-overload event likely caused by an impact loading.

This type of loading is consistent with the forces generated in the shaft as a result of the lift striking the ground. The type of loading which caused the shaft to fail is not consistent with the loading which would occur in the shaft during normal operation or normal operation with the application of high lateral or wind loadings.

In summary, prior to the tipover accident there existed deficiencies in the platform railing assemblies and the four (4) hydraulic outrigger assemblies which would have prevented certification of The Lift for annual machine inspection in 2009. The failure of the center pivot shaft of the top inner scissor arm assembly occurred as a result of The Lift striking the ground. The failure was not a factor in the causation of this accident.

Respectfully Submitted

Charles M. Recard
President
Equipment Safety Consultants, Inc.

Exhibit 8

Merrifield Safety Consulting

Notre Dame Incident Report

Summary Bio

I am an independent safety consultant. My company's name is Merrifield Safety Consulting, LLC. For the first 32 years of my career I worked in manufacturing, first as a machinist, then as manufacturing engineer and finally in plant management. From 1989 to 1991 I managed a manufacturing operation which made scissor lifts similar to the one in this case. From 1991 to 2002, I was the Director of Product Safety for a major manufacturer of construction machinery including scissor lifts similar to the one in this case. My duties included oversight of all aspects of the safe design, manufacture and use of the product including, among other things, conformance with appropriate standards, developing instructions for use and developing and delivery of training.

I serve on the ANSI (American National Standards Institute) committees that write standards for the kinds of lifts involved in this accident. I am the chairperson of the ANSI committee which develops the standards for scissor lifts as well as other personnel lifts. In addition, I serve on the ANSI committee that writes standards for safety signs and labels. I also serve on the U.S. Technical Advisory Group for ISO (International Standards Organization); the international organization that produces standards for aerial devices.

I am a Certified Safety Professional (certified by the Board of Safety Professionals) in both Comprehensive Practice and Ergonomics. I am an approved Aerial Lift instructor under IPAF (International Powered Access Federation)

1. Summary opinion

In my analysis of this case I have assumed wind as the cause of the accident although there may be other contributing causes. Although it was most unfortunate that the lift was elevated when the wind gust came along, in my opinion there was nothing in particular wrong with the actions of the supervisor on the field or the operators. Both the supervisor and the operators received some training (familiarization) on the functions of the lift and general operation. They also had an understanding of the hazard of wind and how to deal with it. Neither the supervisor nor the operators received, either through the Notre Dame training course or otherwise, the formal and complete training required by the ANSI standard. That training would not have improved their understanding of how to deal with the wind hazard nor changed their operation of the lifts that day. Both the supervisor and the operators were aware of the wind that day and were prepared to lower the lifts if the wind reached their subjective threshold. Unfortunately, a gust exceeded that threshold and the lift toppled. Going forward, the wind hazard can be addressed to a greater extent (beyond common industry practice) by augmented training and by adding monitoring devices. Since subjectivity can never be totally eliminated from the equation and unexpected wind gusts are always possible, augmented training should emphasize a conservative approach.

I have listed a number of areas where the supervisor and/or operators and/or Notre Dame did not strictly comply with the ANSI standard but there is no indication that this non-compliance had anything to do with the accident.

2. ANSI standards

a. **General**
   i. The American National Standards Institute standard for scissor lifts was first published in 1979 and has undergone constant review and refinement since.
   ii. The current revision became effective in 2007.
   iii. The stated purpose of this standard is:
      1. to prevent personal injuries
      2. to provide criteria for design, manufacture, inspection, maintenance, training and operation
      3. to establish and promote an understanding of responsibilities by designers, manufacturers, dealers, owners, users and operators
   iv. This standard is the accepted industry standard of good practice
   v. OSHA recognizes the ANSI standard as authoritative and recognizes adherence to the standard as the same as adherence to OSHA

b. **Standards as they relate to wind**
   i. The ANSI standard says that the user and operator will check the area for wind and weather conditions before elevating the platform. It does not quantify a cutoff wind speed.

3. Facts of the accident

a. I am assuming the cause of the accident was wind although there may have been other factors
b. The ANSI standard does not specify a wind speed but does require that wind and weather conditions be checked before elevating the platform
c. The manual for the equipment involved does not specify maximum wind speed.
d. The supervisor and operators were generally aware of the dangers of high winds.
e. The supervisor had a protocol (albeit unwritten) for dealing with wind
   i. Consulting weather information
   ii. Instructing the operators to lower partially or all the way if they became uncomfortable
   iii. Calling the operators down if the wind exceeded his adjudged maximum

f. On the day of the accident, neither the supervisor nor the operators reached any of the above decision points.

4. Discussion and Conclusion

a. The appropriate standards and practice

The supervision on the field followed a reasonable protocol relating to wind on the date of the accident. The industry standard and practice for dealing with the wind hazard has been to follow the ANSI standard and make a subjective judgment. The supervisor in this case followed this practice. The supervisor monitored the wind and the forecasts. Based upon the wind data referenced by the supervisor throughout the day, he made a judgment that the lift could be safely operated in the reported conditions. It was appropriate for him to follow this practice. This is still the accepted practice in the U.S.

Although the outcome was disastrous, I can not fault the *process* the supervisor employed.

b. The appropriate decision making

The ANSI standard makes the user, in this case embodied in the supervisor, responsible to direct the operator in the proper use of the lift and to monitor his or her performance and supervise the work.

It is the responsibility of the operator to make decisions in the use of the lift as it may affect his safety or the safety of others.

It appears that the judgment of when to bring the lifts down along with the authority to do so was in the hands of the supervisor. The supervisor gave the operators the authority to lower the lift either all the way or part way if they became uncomfortable.

Again, although the outcome was disastrous, I can not fault the decision-making protocol

c. The appropriate training

The Notre Dame training includes wind and weather conditions as a topic but does not lay inordinate stress on wind nor does it attempt to quantify a maximum speed. This approach is entirely consistent with the standard and practice in the industry.

Although neither the supervisor nor the operators attended Notre Dame training, the supervisor was well aware of the hazards of wind and I have no reason to believe that the Notre Dame training would have changed his behavior or that of the operators.

d. **Label issues**

   i. There is a warning in the safety section of the Skyjack manual about operating in windy conditions, but the warning is not specific to wind speed.

   ii. Reference is made later on in the manual (not in the safety section) to the serial number nameplate for maximum wind speed. However, no maximum wind speed was on that plate.

   iii. There is, however, a label on the Skyjack machine's toe board, but it is not a warning label per ANSI. The ANSI Z535 symbol scheme provides criteria that all warning labels must have in order to "...identify and warn against specific hazards..." The ANSI standards are intended to insure that users understand hazards and to encourage users to comply with warnings and instructions.

      1. The label on the toe board is ***not a warning*** according to ANSI Z535.4 as it lacks the essential elements of a warning:
         a. A signal word denoting the seriousness of encountering the hazard
         b. Formatting and colors
         c. A statement of the hazard
         d. How to avoid the hazard
         e. Consequences of not avoiding the hazard
      2. It is not clear that a user would have recognized the symbol on the label as an indication of wind speed.
      3. There is a different symbol for wind speed in the manual. That symbol comes from ISO 7000 and likewise is not a warning.
      4. Neither symbol (the one in the manual or the one on the machine) is incorporated in the ISO standard for safe use of aerial work platforms, so even in an ISO country there is nothing in the aerial platform standard connecting either symbol with the safe use of aerial platforms.

   iv. It is not immediately apparent from the Skyjack manual that 28 MPH is the proper maximum wind speed for that machine. It requires matching up the warning in the manual, the explanation of the label elsewhere in the manual and the informational label on the machine, and then discerning how the words in the manual relate to the symbol and the numbers below it. Even if the 28 MPH conclusion were reached, there is no reason for a user to draw the further conclusion that 28 MPH would be appropriate for other machines like the Marklift. After all, the Skyjack manual says "rating will change over varying units."

   v. I would not expect the Skyjack machine, manual and placards, taken in their entirety to change the behavior of Notre Dame vis-à-vis the Marklift

Despite the above, going forward, improvements should be made to prevent such an occurrence from ever happening again. Several items can be made more robust as outlined below.

Going Forward

Many of the following points were in effect the day of the accident. They should be reemphasized and firmly embedded in the operating policies and procedures

1. Organization-policy
    a. Requirement that operators are trained (Current Policy)
    b. Assurance that operators are trained
    c. Assurance that operators are authorized
    d. No operation without proof of training card
2. Decision-making on the field
    a. Reaffirm that the supervisor of the videographers has absolute authority to bring his people down when weather threatens (Current Policy)
    b. A supervisor or manager should monitor all weather information and other possible safety hazards to the exclusion of non safety-and-health duties while employees are elevated
    c. The individual operators should have overriding authority to come down when they see fit (Current Policy)
3. Training management
    a. Owner, User, Operator responsibilities
        i. Train first line supervision
            1. Conventional training including all the ANSI requirements
            2. Added emphasis on wind hazards
            3. Training on how to use wind monitoring equipment
        ii. Train the level of management above the first line supervision in responsibilities of parties
        iii. Leave the AWPT (Aerial Work Platform Training inc.) or IPAF (International Powered Access Federation) training program in the hands of risk management in order to perpetuate training
        iv. Emphasize access control—no untrained or unauthorized operators allowed to operate lifts
4. Training operators and trainers
    a. AWPT trainer to train trainers and core operators
    b. In house trainers (Current Policy) to augment outside AWPT training
    c. Training program audited by AWPT
    d. Add emphasis to the wind hazard in training materials
5. Authorization to operate and security means
    a. Either a ND or AWPT card required to operate
    b. Access control--Alternatives
        i. Large visible badge worn by operator
            1. Periodic snap inspections by Risk Management or Safety Committee
            2. Write-ups and disciplinary action for operators, supervisors, managers who do not comply

ii. Some central agency (like Risk Management or Maintenance)
1. Owns all the lifts and only issues them shift by shift to authorized operators
2. Remove control box at end of shift and reissue only to card holding operator

6. Maximum allowable wind speed
   a. Install anemometer on the field-(consult with wind expert on details)
   b. Forecasts and alerts—weather station computer on field
      i. Instant access to weather on internet
   c. Follow ISO 28 mph rule
      i. As referenced previously the applicable ANSI standard does not have a specific limit for wind speed. However, the international community has developed a set of standards for lifts known as the ISO (International Standards Organization). This standard includes a wind speed of 28 MPH in the stability calculations. Recently, manufacturers have begun rating their machines for a specific wind speed in line with the international standard (International Standards Organization). This rating is 28 MPH or 6 on the Beaufort scale. This rating, however, does not eliminate subjectivity because it is still the common practice to guess at the wind speed (it would be highly unusual to find someone who actually measured wind with an anemometer).

7. Machine Selection
   a. Rent or own only machines that comply with 28 mph ISO requirement
   b. Use no machines designed for inside operation outside (Current Policy)

David Merrifield

Exhibit 9

Meteorological Analysis and Weather Variable Estimation October 26th, and October 27th, 2010 at and in the proximity to the LaBar Practice Complex located at Notre Dame University in South Bend, Indiana.

March 1st, 2011

Performed by:
Genesis Weather Solutions, LLC
Highlands Ranch, Colorado
303-927-6522
www.genesisweathersolutions.com

Re: Notre Dame Weather Reconstruction

Genesis Weather Solutions (GWS) has been retained to perform a meteorological analysis and estimation of weather variables at and in the proximity to the LaBar Practice Complex located at Notre Dame University in South Bend, Indiana. From this point forward in the report this location will be known as the Location Of Accident (LOA). The meteorological analysis and weather variable estimation was performed for the dates October 26th, 2010 and October 27th, 2010.

1.0 Data and Information

GWS relied on the following information in the weather analysis and estimation:

1. United States Department of Commerce surface weather observations (ASOS), taken at South Bend Regional Airport (KSBN) located in South Bend, Indiana.

2. United States Department of Commerce One Minute Observation (OMO) data taken at South Bend Regional Airport (KSBN - ASOS) located in South Bend, Indiana

3. United States Department of Commerce radiosonde upper atmospheric weather observations recorded above Central, Illinois, (KILX) and Detroit, Michigan (KDTX).

4. National Oceanic and Atmospheric Administration vertical wind profiler data recoded above Wolcott, Indiana (WLCI3).

5. National Weather Service KIWX (North Webster, Indiana) Level II Super Resolution Doppler radar Base data.

6. National Weather Service KLOT (Chicago, Illinois) Level II Super Resolution Doppler radar Base data.

7. National Weather Service KGRR (Grand Rapids, Michigan) Level II Super Resolution Doppler radar Base data.

8. Federal Aviation Administration TMDW (Chicago, Illinois) Terminal Doppler radar Base data.

Figure 1 depicts the LOA (blue arrow) located on the campus of Notre Dame University in South Bend, Indiana.

The weather variable analysis and estimation was performed using the information listed above and includes the following variables. Wind directions are in degrees, 0 to 359, from true north, based on a 2-minute average, approximately 30 feet above the ground. The wind direction represents the direction that the wind is blowing from. Wind gust velocity is in miles per hour, based on a 3-second average, at approximately 30 feet above the ground. Note: Wind gust velocity observed by surface weather stations are 5-second wind gusts. All wind gust velocity observations utilized in the analysis have been converted to 3-second wind gusts by multiplying the 5-second wind gust by 1.02 (Durst, 1960).

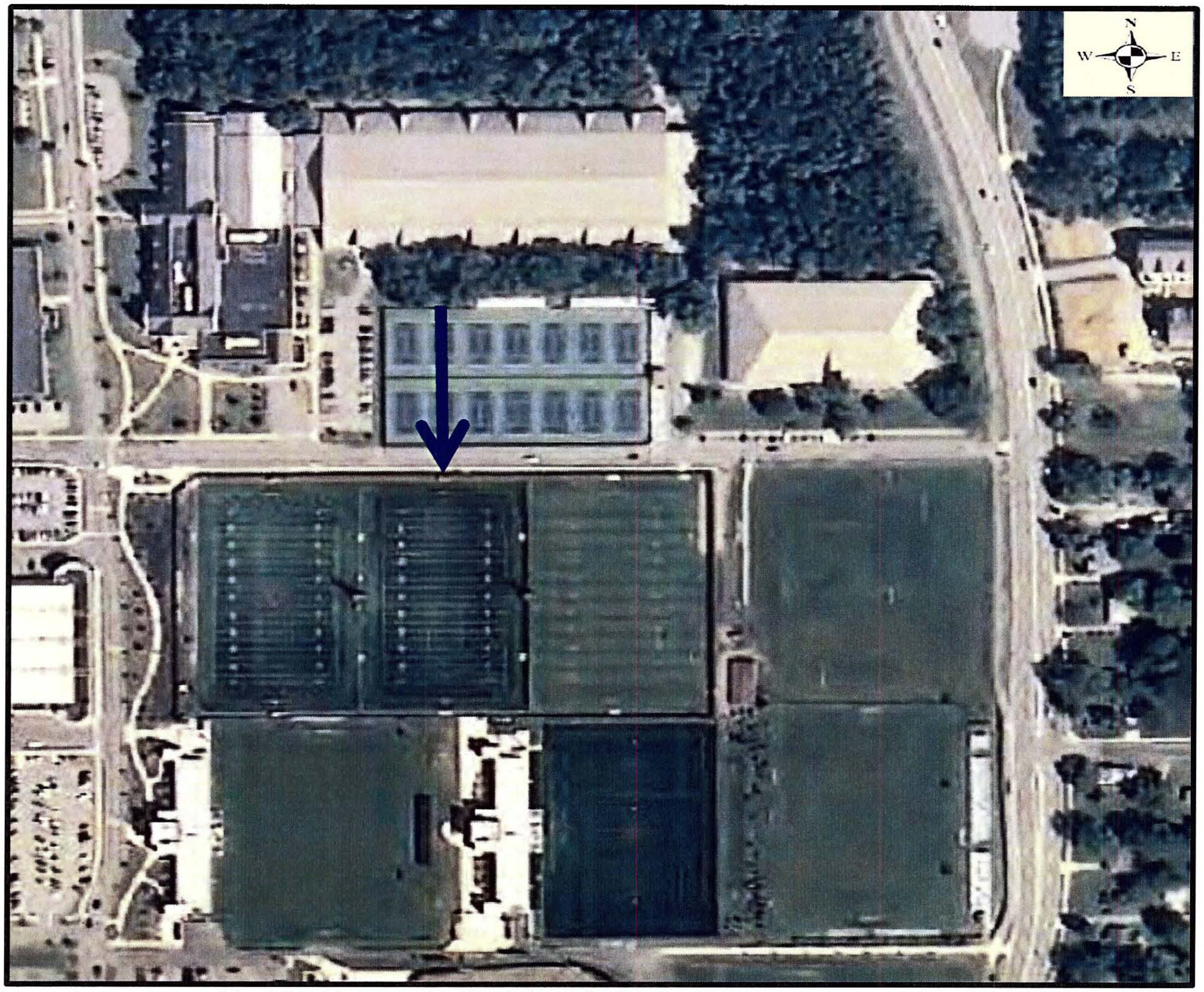


Figure 1: Areal view of the LOA (blue arrow) in South Bend, Indiana.

Table 1 contains the weather observation sites used in the weather analysis and weather variable estimation. Information contained in the table includes the observation sites ID, name, the type of observation site, the distance and the direction of the site relative to the LOA and the elevation of the observing site.

ID	Name	Type	Distance From LOA (Miles)	Direction From LOA	Elevation (Feet MSL)
LOA	LaBar Practice Complex	N/A	N/A	N/A	739
IN022	MP 77 - South Bend	RWIS	2.31	West/Northwest	698
KSBN	South Bend Regional Airport	ASOS	4.72	West	773
KIWX	North Webster, Indiana WSR-88D	Doppler Radar	36.10	Southeast	960
TMDW	Chicago-Midway, Illinois TDWR	Doppler Radar	74.27	West	620
WLCI3	Wolcott, Indiana VWP	Vertical Wind Profiler	74.82	Southwest	692
KLOT	Chicago, Illinois WSR-88D	Doppler Radar	96.32	West	663
KGRR	Grand Rapids, Michigan WSR-88D	Doppler Radar	89.58	Northeast	778

Table 1: Surface weather observations and Doppler radar used in the weather analysis and weather variable estimation.

Figure 2 depicts the locations of the weather observing sites and the LOA

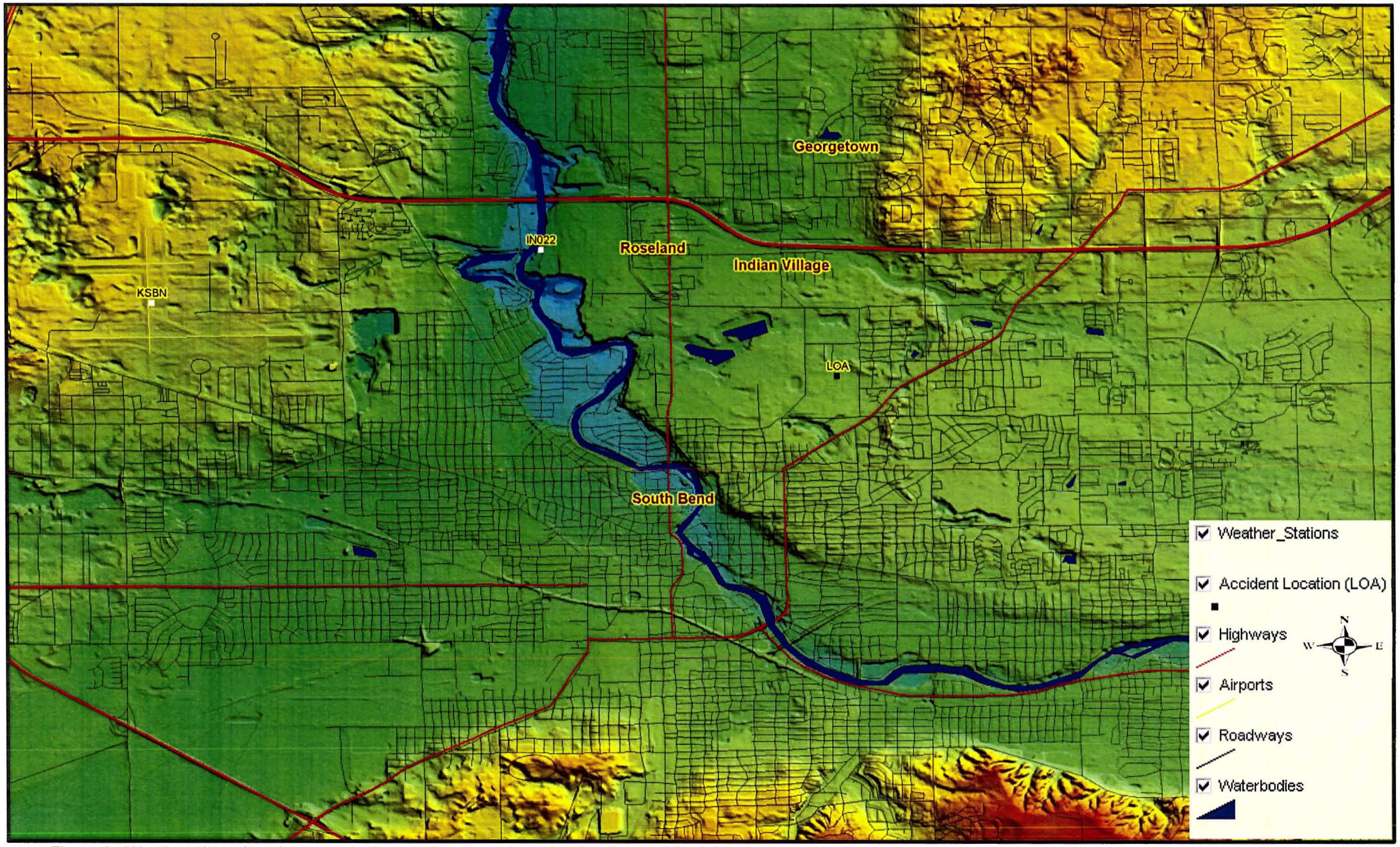


Figure 2: Weather observing sites used in the weather analysis and estimation and the LOA.

2.0 Wind Gust Velocity Return Frequency Analysis

A wind velocity frequency analysis was performed using the South Bend, Indiana regional airport (KSBN) Automated Surface Observing System (ASOS) wind gust velocity observations. The primary function of the ASOS is to provide minute-by-minute meteorological observations and produce Aviation Routine Weather Report (METAR) and Aviation Selected Special Weather (SPECI) reports. ASOS provides the surface weather observations at many airports across the United States. An anemometer measures wind velocity and wind vane measures wind direction. Figure 3 is an example ASOS.

The KSBN ASOS was commissioned in July 1996. Prior to 1996 wind velocity was observed by an Automated Meteorological Observing System (AMOS) and a Remote Automated Meteorological Observing System (RAMOS). The anemometer and wind vane on the KSBN ASOS is located 10 meters (32.8 feet) above the ground.

The anemometer and wind vane starting threshold for response to wind direction and wind speed is 2 knots (2.3 mph). Winds measured at 2 knots or less are reported as calm. Five-second wind direction and wind velocity averages are computed from the 1-second measurements. The 5-second averages are rounded to the nearest degree and nearest knot. Five second wind gust velocity observations were converted to 3-second wind gust velocity observations using the methodology discussed in Section 1.0.

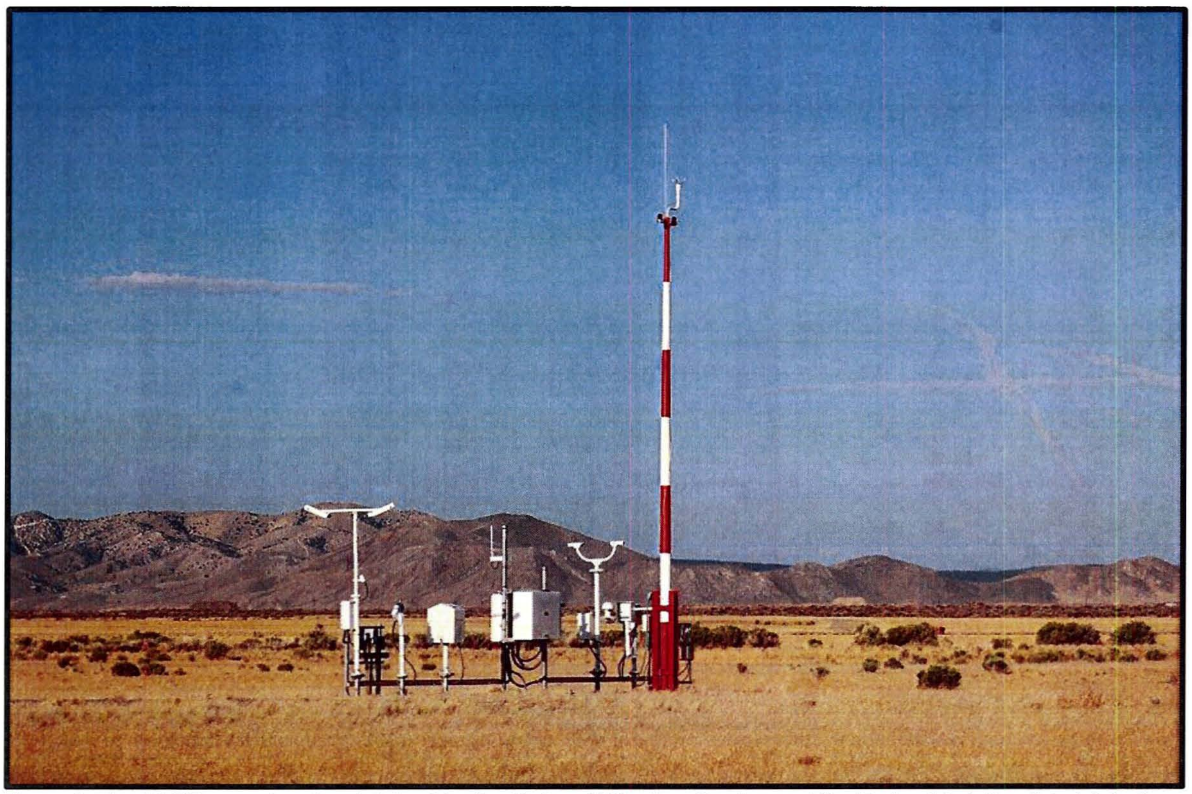


Figure 3: An ASOS owned and maintained by the National Weather Service and the Federal Aviation Administration.

The entire period of record of wind gust velocity observations were evaluated from the official National Climatic data Center (NCDC) TD-3280 database. Maximum wind gust velocity for a 37-year period, (1973-2010), was identified, extracted and quality controlled.

Maximum wind gust velocity observations were determined for each year (1973-2010) and became the Annual Maximum Time Series (AMTS). If it was determined that the maximum wind gust velocity observation was produced by a thunderstorm it was removed. Only non-thunderstorm produced wind gust velocities made up the AMTS. Thunderstorm produced wind gust velocities were determined by reviewing the METAR observation at the time of, and in the proximity to the time of, the reported maximum wind gust velocity. Doppler radar base reflectivity data was viewed for some of the years between 1994 through 2010 to identify if thunderstorm cells were in the proximity to KSBN when the maximum wind gust velocity was observed.

The 3-second AMTS was subjected to frequency analysis methods in order to provide non-thunderstorm produced 3-second wind gust estimates for frequencies of 1 year through 1000 years based on a generalized extreme value (GEV), Gumbel, and Log-Pearson III distributions. The GEV distribution was selected over the Gumbel and LPE3 frequency distributions, due to a better overall fit to the data.

The wind gust velocity return frequency analysis produced results of average reoccurrence interval in years and annual exceedance probability (AEP) in percent. For example a 2-year return frequency means that there is a 50% probability of occurrence on an annual basis; a 5-year return frequency means that there is a 20% probability of occurrence on an annual basis; a 10-year return frequency means that there is a 10% probability of occurrence on an annual basis; a 25-year return frequency means that there is a 4% probability of occurrence on an annual basis; a 50-year return frequency means that there is a 2% probability of occurrence on an annual basis; and a 100-year return frequency means that there is a 1% probability of occurrence on an annual basis.

Table 2 contains the results of the wind gust velocity return frequency analysis for non-thunderstorm produced wind gusts. The table shows that a 3-second wind gust velocity of 55 mph has a reoccurrence interval of approximately 3 years and has an annual exceedance probability (probability of occurrence on an annual basis) of 33%.

South Bend (KSBN) Non-Thunderstorm Produced 3-second Wind Gust Velocity (mph)		
Years	Annual Exceedance Probability % (AEP)	GEV (mph)
1.01	99.0099	41.2
1.1	90.9091	45.6
1.25	80.0000	48.0
1.5	66.6667	50.1
2	50.0000	52.5
3	33.3333	55.0
5	20.0000	57.4
10	10.0000	60.2
25	4.0000	63.1
50	2.0000	64.9
100	1.0000	66.5
200	0.5000	67.9
500	0.2000	69.4
1000	0.1000	70.4

Table 2: Results of the KSBN non-thunderstorm produced 3-second wind gust velocity reoccurrence interval frequency analysis.

The all-time maximum observed non-thunderstorm produced 3-second wind gust velocity over the time period of 1973 through 2010 is 65 mph which occurred two times, once on May 15th, 1976 and the other on April 6th, 1979. The second all-time maximum observed 3-second wind gust velocity over the time period of 1973 through 2010 is 61 mph which occurred on April 30th, 1984.

3.0 October 26th, 2010 Weather Synopsis

One of the strongest storms in the history of the central United States affected the Midwest on October 26th, 2010. As the storm reached peak intensity during the late afternoon on October 26th over Minnesota, the lowest surface barometric pressure readings ever recorded in the central United States occurred. A reading of 955.2 mb or 28.21 inches of mercury was recorded at Bigfork, MN. A surface barometric pressure of 955.2 mb is comparable to the surface barometric pressure found in Category 3 hurricanes.

This large surface low pressure system was located over northern Minnesota at Noon on October 26th, 2010. An associated cold front moved through the LOA at approximately 1100 AM EDT. A line of rain showers and thunderstorms moving from southwest to northeast ahead of the cold front moved through the LOA between 850 AM EDT and 1055 AM EDT. The rain showers and thunderstorms produced 0.74 hundredths of an inch of rain at the South Bend Airport.

Severe weather in the form of strong winds greater than 58 mph and tornadoes were observed across a large portion of Indiana. The maximum observed wind across Indiana was in Hancock County where a wind gust velocity of 81 mph was observed. The winds were produced by a thunderstorm.

The maximum temperature was approximately 70 degrees and the minimum temperature was approximately 54 degrees. The maximum temperature occurred during the early morning hours. The maximum 3-second wind gust velocity at South Bend Airport was 53 mph, which was from the south/southwest at 1033 AM EDT. The winds were produced by a thunderstorm.

The following is a narrative of the weather from the National Weather Service located in Northern Indiana:

> *A record-breaking low pressure system over Minnesota pushed a strong cold front through the lower Midwest on October 26, 2010. The associated cold front aided in the development in a line of strong thunderstorms known as a squall line that stretched from northern Wisconsin through Illinois into Missouri during the early morning hours of the 26th. This line of thunderstorms pushed through the Northern Indiana office's county warning area during the morning and early afternoon hours.*
>
> *The squall line produced widespread wind damage across the Midwest with wind gusts of 50 to 60 mph with some locations recording gusts up to 75 mph! In addition to the strong winds, some of the storms produced tornadoes in Wisconsin, Illinois, Indiana, and Ohio. The image below (Figure 4) shows the storm reports as relayed to the Storm Prediction Center from the day.*

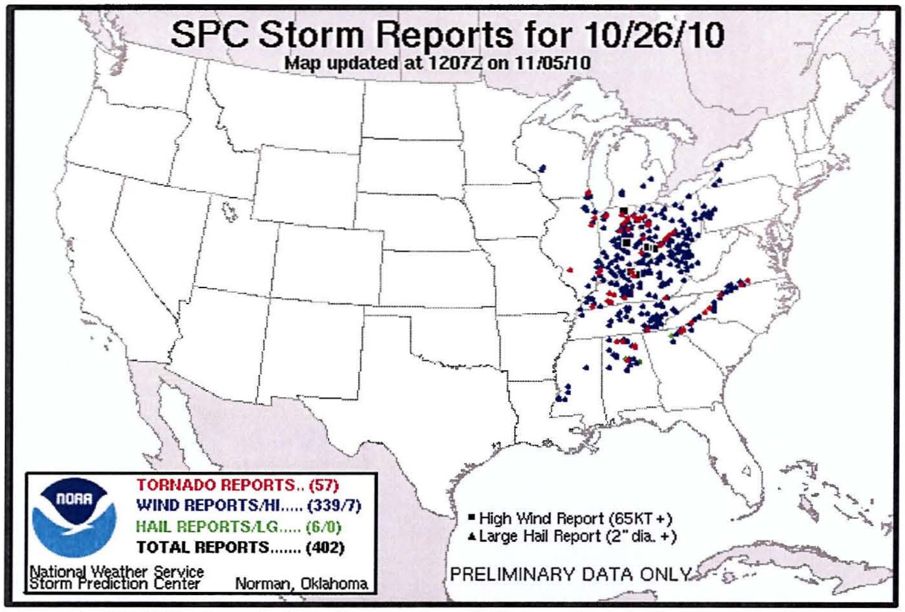


Figure 4: NWS Northern Indiana has confirmed 13 tornadoes in their county warning area (CWA) in northern Indiana and northwestern Ohio.

The National Weather Service Forecast Office (NWSFO) located in Syracuse, Indiana has weather prediction, weather advisory and weather warning responsibilities for northern Indiana including the South Bend area. During the early morning hours of October 25th, 2010 the NWSFO issued a High Wind Warning for northern Indiana that was valid from 800 AM EDT October 25th, 2010 until 800 PM October 26th, 2010.

A High Wind Warning is issued when sustained winds of 40 mph or greater are expected for at least 1 hour or wind gusts of 58 MPH or greater are expected within the warning area.

4.0 October 27th, 2010 Weather Synopsis

A surface low pressure system, of decreased intensity than that experienced on October 26th, 2010, was centered over south central Ontario, Canada at Noon on October 27th, 2010. Strong winds associated with the storm system were observed across Illinois, Michigan and Indiana. The strong winds were produced by the difference in surface pressure between the surface low centered over south central Ontario, Canada and high pressure cells located over the western United States.

The maximum temperature was approximately 65 degrees and the minimum temperature was approximately 45 degrees. The maximum 3-second wind gust velocity at South Bend Airport was 54 mph, which was from the southwest at 429 PM EDT.

At approximately 400 AM EDT on October 27th, 2010 the NWSFO issued a High Wind Warning valid from 800 AM EDT to 900 PM EDT October 27th, 2010 for northern Indiana. At 244 PM EDT on October 27th, 2010 the NWSFO canceled the High Wind Warning for northern Indiana and replaced the warning with a Wind Advisory, valid until 900 PM October 27th, 2010.

A Wind Advisory is issued when sustained winds of 30-39 MPH are expected for at least 1 hour or for frequent wind gusts between 46 and 57 miles an hour.

Figure 5 is a graph depicting the 3-second wind gust velocity observed by the KSBN ASOS from 900 AM EDT through 600 PM EDT on October 27th, 2010.

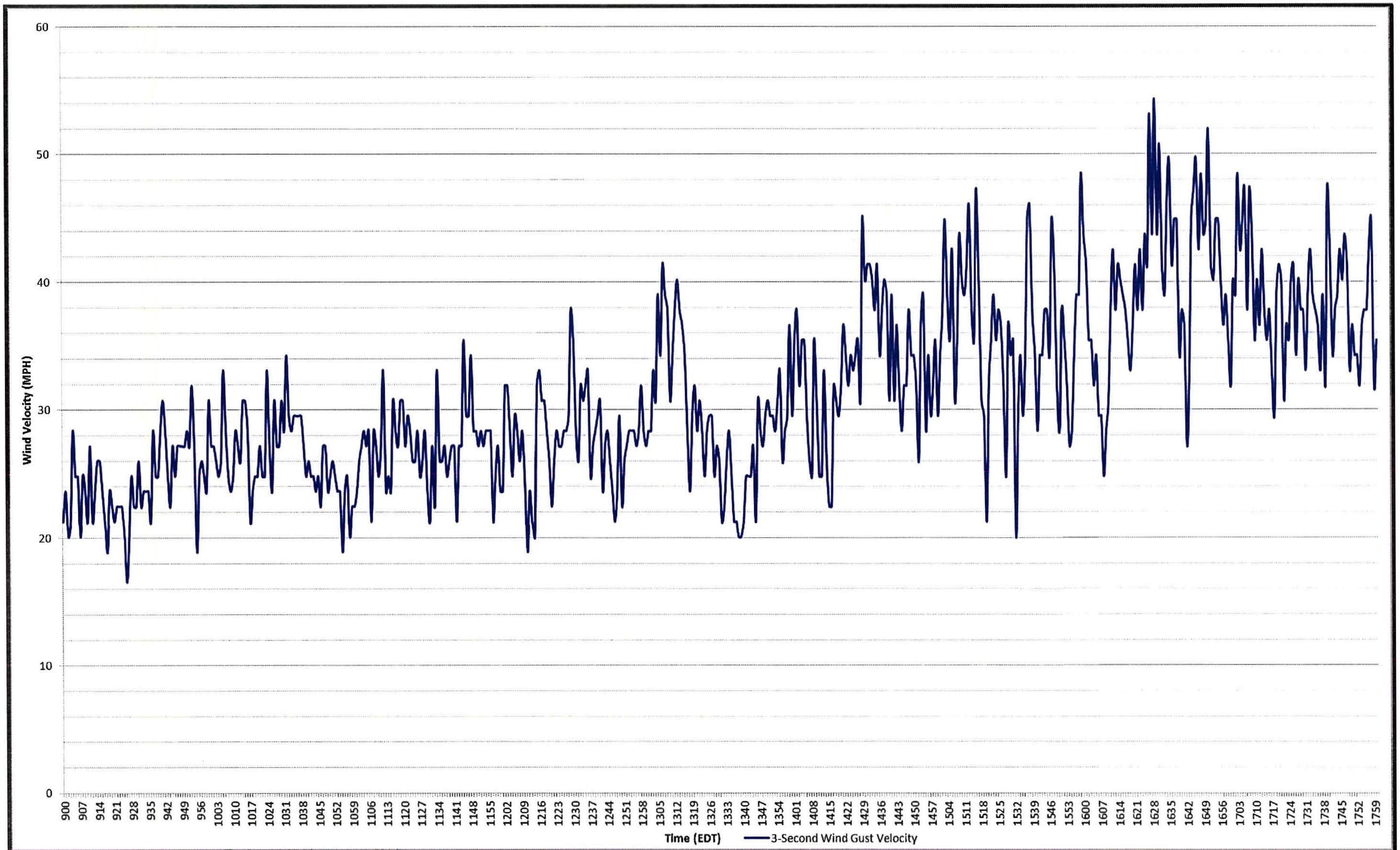


Figure 5: 3-second wind gust velocity observed by the KSBN ASOS from 900 AM EDT through 600 PM EDT October 27th, 2010. Time step 1-minute.

5.0 Wind Velocity and Wind Direction Estimates

An ASOS surface weather station, RWIS surface weather station, National Weather Service and Federal Aviation Administration Doppler radar Base Velocity data, a vertical wind profiler and radiosonde data were all utilized in the estimation of wind velocity at and in the proximity to the LOA.

ASOS and RWIS measures wind velocity, both sustained wind velocity and wind gust velocity, with an anemometer. Wind direction is measured with a wind vane.

Doppler radar Radial Velocity is a product measured by the radar. Radial Velocity is the average radial velocity of the targets observed by the radar beam at a given location. Radial velocity is the component of the target's motion that is along the direction of the radar beam. Doppler radar measures wind velocity by measuring the radial component of the wind either toward the radar (negative values) or away from the radar (positive values). Negative values are represented by cool colors (green) while positive values are represented by warm colors (red). Radar velocity measurements are taken at multiple elevations above the ground each time the radar completes a 360 degree scan. The scan time ranges from 4 minutes to 10 minutes depending on the scan mode the radar is operating in.

A vertical wind profiler uses sound waves (SODAR) to detect the wind velocity and direction at multiple elevations above the ground. Vertical wind measurements are taken every 6 minutes.

Radiosondes measure vertical wind velocity and direction at multiple elevations above the ground. A balloon attached to the radiosonde provides the buoyancy to measure wind velocity and direction from the ground up to around 60,000 feet above the ground. Radiosondes are launched twice a day a fixed locations across the United States.

The wind observed at and in the proximity to the LOA on October 27th, 2010 was produced by a low pressure system centered in south central Ontario, Canada. The central sea level barometric pressure of this system at 500 PM EDT was approximately 975 mb or 28.79 inches of mercury. The see level barometric pressure at and in the proximity to the LOA at 500 PM EDT was approximately 1003 mb or 29.61 inches of mercury. Wind blows from higher pressure to lower pressure, but is deflected toward the right of the low pressure center due to external forces.

Radiosonde data derived from upstream (central, Illinois) and downstream (Detroit, Michigan) stations and vertical wind profiler data derived from an upstream station (WLCI3) was used to estimate the wind velocity above the ground in northern Indiana. Table 3 depicts the estimated wind velocity at multiple elevations above the ground in northern Indiana at 500 PM EDT October 27th, 2010.

Date	Time (EDT)	Pressure Level (mb)	Approximate Elevation Above the Ground (feet)	Wind Velocity Estimate (mph)
October 27, 2010	**500 PM**	925	1,160	48-52
October 27, 2010	**500 PM**	850	3,460	54-58
October 27, 2010	**500 PM**	700	8,560	82-86
October 27, 2010	**500 PM**	500	16,910	102-106
October 27, 2010	**500 PM**	300	28,960	162-166

Table 3: Estimated wind velocity over northern Indiana at 500 PM EDT on October 27, 2010.

The maximum temperature of 65 degrees was first observed by KSBN at 301 PM EDT. The temperature fluctuated between 64 degrees and 65 degrees between 301 PM EDT and 350 PM EDT. A constant temperature of 65 degrees was observed from 350 PM EDT until 505 PM EDT. Over this same time period the surface dew point (direct measurement of water vapor in the air) decreased from 30 degrees to 24 degrees.

The warming and drying of the lower atmosphere on this day can be attributed to mixing of the lower atmosphere. The mixing process causes air located above the ground to descend to the ground and warm due to compressional heating. In addition, winds above the ground are transported to the ground due to the mixing process.

The lower atmosphere was well mixed by the late afternoon. The depth of the mixing layer was approximately 9,590 feet, from the ground to approximately 10,330 feet above sea level. The winds above the ground were transported to the ground but experienced some reduction in velocity due to frictional effects.

Doppler Base Velocity data observed by the 4 radars found in Table 1 was reviewed for the afternoon and early evening of October 27th, 2010. At 458 EDT the KIWX Doppler radar's lowest beam (elevation angle 0.54 degrees) detected a target (an object that reflects a portion of the radar beams energy back to the radar) approximately 5 miles to the east/northeast of the LOA. The target was located approximately 2,455 feet above the ground in a rural area, with farmland. It is possible that the target the radar observed was blowing dust or dirt.

The velocity of the target determined by the radar was 70.4 mph. The 70.4 mph wind velocity is an instantaneous observation by the radar beam and is more representative of a sustained wind velocity observation than a wind gust velocity. To convert a sustained wind velocity to a 3-second gust velocity the sustained wind velocity is multiplied by 1.22 (Durst, 1960 and ASCE 7-02). See equation 1:

Equation 1: Sustained Wind Velocity * 3-Second Gust Factor (1.22) = 3 second Wind Gust Velocity

(1) $70.4 * 1.22 = 85.9$ mph

Equation 2 is used calculate the wind velocity a certain height with a known wind velocity at a known height.

Equation 2: $V_z = V_g\,[Z/Z_g]^{1/\alpha}$

Where V_z is the wind velocity at a given height in feet, V_g is the wind velocity at a known height, Z is the height of the wind velocity being calculated in feet, Z_g is the gradient height found in Table 4 and α is a constant found in Table 4.

(2) $V_z = 85.9\,[32.8/900]^{0.1053} = 60.6$ mph

Equation 2 yields a 3-second wind gust velocity of 60.6 mph. This is the estimated 3-second wind gust velocity at approximately 32.8 feet above the ground, and below the height where the radar estimated a wind gust velocity of 85.9 mph.

There were no other base velocity observations from any of the 4 radars at and in the proximity to the LOA during the late afternoon and early evening of October 27th, 2010.

Due to a lack of radar velocity observations and surface weather stations at and in the proximity to the LOA it is not known if a wind velocity of a similar magnitude to what was calculated in equation 2 was observed at the LOA during the late afternoon and early evening of October 27th, 2010.

Terrain	Exposure	Z_g	α
Water	D	700 ft	11.5
Open	C	900 ft	9.5
Suburban	B	1200 ft	7.0
Urban	A	1500 ft	5.0

Table 10: Numeric values for gradient heights (Z_g) and the alpha exponents for different terrain exposure categories.

A surface weather station (Road Weather Information System or RWIS) owned and maintained by the Indiana Department of Transportation (IN022) located approximately 2.3 miles to the west/northwest of the LOA observed a temperature of 66 degrees, a dew point temperature of 25 degrees and a 3-second wind gust velocity of 44 mph at 516 PM EDT October 27th, 2010.

The observation prior to the 516 PM EDT observation was taken at 316 PM EDT – 2 hours between observations. At 316 PM EDT IN022 observed a temperature of 65 degrees, a dew point temperature of 31 degrees and a 3-second wind gust velocity of 40 mph.

At 329 PM EDT KSBN observed a temperature of 65 degrees and a dew point temperature of 31 degrees. The 3-second wind gust velocity at this same time was 37 mph.

Comparing the 3-second wind gust velocity observations for station KSBN and IN022 shows that there is a strong correlation between wind gust velocity observations when the stations were observing the same temperature dew point combinations (65 and 31 degrees respectively). Note: The anemometer on RWIS stations are typically lower in height then ASOS stations and this may account for the lower 3-second wind gust velocity observed by IN022 (37 mph) versus KSBN (40 mph).

The maximum 3-second wind gust velocity of 54 mph was observed by KSBN at 429 PM EDT. At this same time the temperature was 65 degrees with a dew point of 25 degrees. At 516 PM IN022 observed the same temperature dew point combination.

Based on the temperature, dew point, and wind gust velocity comparisons between KSBN and IN022 it is likely that the maximum 3-second wind gust velocity was observed at and in the proximity to IN022 sometime between 430 PM EDT and 516 PM EDT October 27th, 2010 when it is estimated that the maximum temperature (66 degrees and the minimum dew point temperature of 25 degrees) was observed. The maximum 3-second wind gust velocity within this time period at and in the proximity to IN022 is estimated to be the same or possibly even higher than the peak 3-second wind gust velocity observed at KSBN due to the fact that the maximum temperature observed by IN022 was 1 degree higher than KSBN (66 degrees versus 65 degrees).

IN022 is located approximately 2.3 miles from the LOA and has a similar elevation as the LOA. Therefore the weather variables observed by IN022 can be considered representative of the weather variables at the LOA. Based on this the estimated maximum 3-second wind gust velocity at and in the proximity to the LOA between 430 PM EDT and 516 PM EDT on October 27th, 2010 is within the range of 52-55 mph.

It is likely that the 3-second maximum wind gust velocity occurred at the LOA when the scissor lift located on the north end of the LaBar Practice Complex fell over. At the same time witnesses at that same location reported a significant increase in wind velocity which caused loose objects on the ground to be displaced from their locations. Therefore the estimated time of the maximum 3-second wind gust velocity in the range of 52-55 mph was approximately 455 PM EDT on October 27th, 2010.

Although it is possible that a 3-second wind gust velocity similar to the 3-second wind gust velocity of 60.6 mph, estimated by the KIWX radar approximately 5 miles to the east northeast of the LOA, occurred at the LOA there is a lack of information (surface wind velocity observations and radar velocity observations) in the proximity to the LOA to provide confirmation.

The estimated maximum wind gust velocity at and in the proximity to the LOA is a 3-second gust velocity at a height of approximately 33 feet. The direction of the estimated 3-second maximum wind gust velocity is in the range of 230 to 235 degrees (south/southwest).

If additional information becomes available, we reserve the right to amend our opinions and conclusions.

The above meteorological analysis and weather variable estimation performed, is my opinion, based on a reasonable degree of scientific certainty derived from the information listed in this report.

If you have any questions, please do not hesitate to contact me.

Sincerely,

Bryan Rappolt
President and Consulting Meteorologist
Genesis Weather Solutions, LLC

REFERENCES

Durst, C. S., "Wind Speed Over Short Periods of Time," Meteorological Magazine, 89, 181-187, 1960.

Nodolski, V.L, "ASOS users Guide", 1998.

Parzybok, T., "Wind Reoccurrence Interval Calculations", Technical Memorandum, 2011.

SEI/ASCE 7-02, "Minimum Design Loads For Buildings and Other Structures," ASCE/SEI, 298, 2003.

Exhibit 10

Examination of Broken Pin from Scissor Lift

Location: Notre Dame University
Date of Loss: October 27, 2010

SEA Project No. 154188

7349 Worthington-Galena Road
Columbus, Ohio 43085
614.888.4160 • 800.782.6851
Fax 614.885.8014
www.SEAlimited.com

On February 15, 2011, SEA, Ltd. was asked to examine a broken pin from a scissor lift that toppled over on October 27, 2010, and render, if possible, professional opinions regarding the cause of failure of the pin. As requested, this report summarizes the examination and findings.

The steel pin provided to SEA is approximately 2" in diameter and 5 1/2" long (**Figure 1**). One end appears to be saw cut and is stamped with the number 8 (**Figure 2**). There is a depression drilled near this end and scrape marks or gouges lead from the depression to the end of the pin (left side of Figure 1). This depression appears to have been a receptacle for a retention screw, and the scrape marks are consistent with the pin being forced from the joint despite the presence of the retention screw.

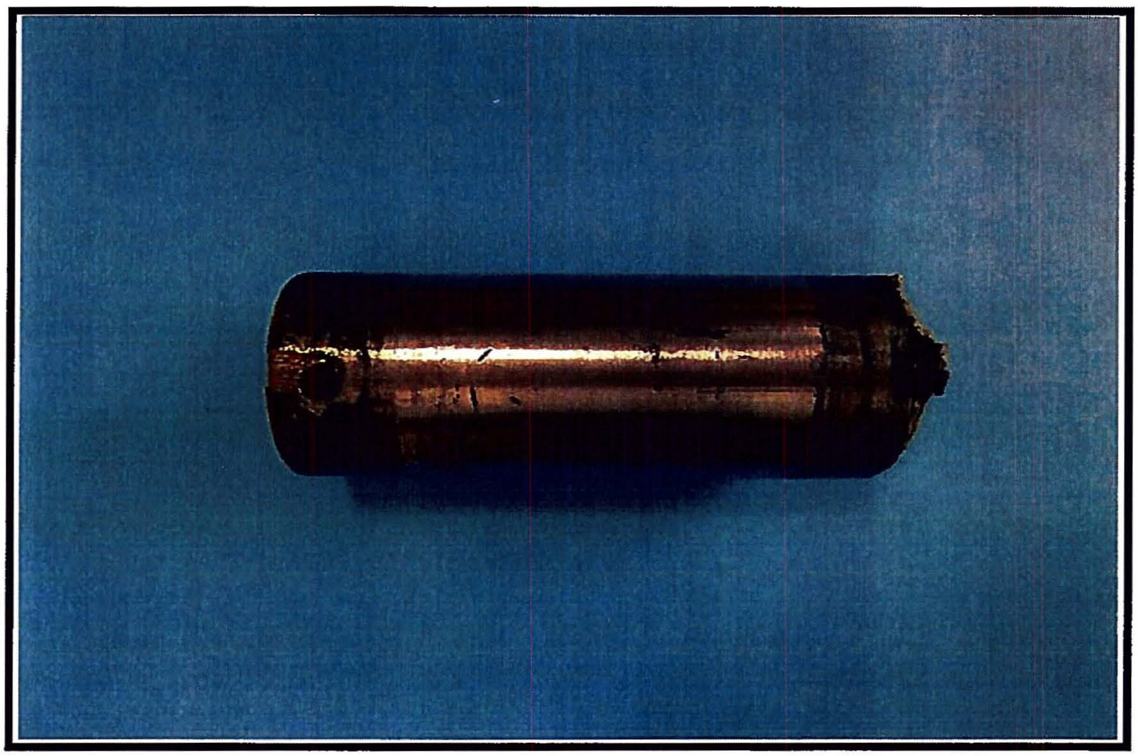


FIGURE 1: Overview of pin.

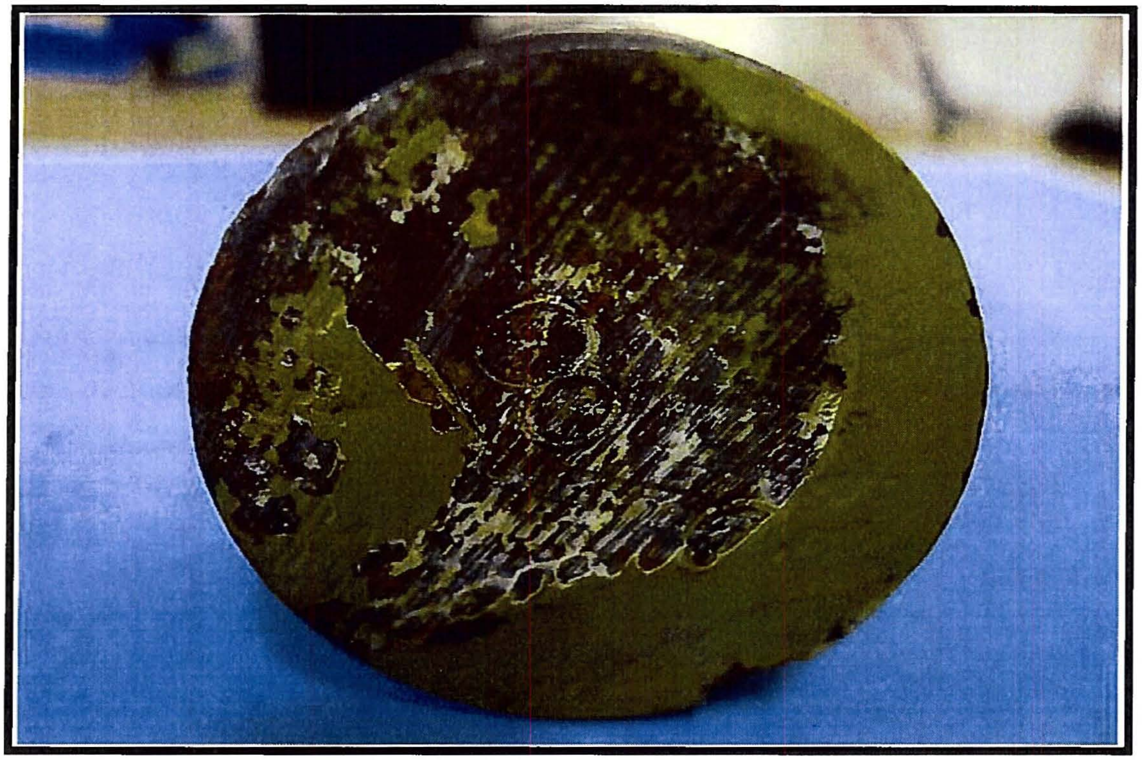


FIGURE 2: Cut end of steel pin.

The other end of the bar is fractured (**Figure 3**). Near the fracture there is a section of weld metal bonded to the bar (arrow on left side of Figure 3). Only one end of the bar was sent to SEA for evaluation; pictures of the other end were sent, but it was not examined as it is still in place in the scissor lift (**Figure 4**). Comparison of the photographs of the end of the bar still in the lift and the portion sent to SEA indicates that the fractures appear to be mating fractures (there does not appear to be a missing third fragment).

There is rust on much of the fracture surface of the bar, and the rust is a light orange in color (Figure 3). Similar light orange rust is present in the grooves adjacent to the retention depression. The light color of the rust indicates that it occurred recently and is consistent with a fracture in October 2010 followed by storage in a protected environment. Older rust is darker in color.

Examination of the fracture surface of the pin reveals that the fracture was brittle and, at least in the portions of the fracture surface not obscured by rust, propagated intergranularly (between rather than through the grains which make up the steel pin). The fracture origin is located on one side of the pin near the weld metal deposit. There is no indication of cracking prior to the final failure of the pin. Had the pin been cracked previously due to fatigue, the portion of the fracture due to fatigue would be much flatter and more uniform, and likely would have exhibited darker pre-existing rust.

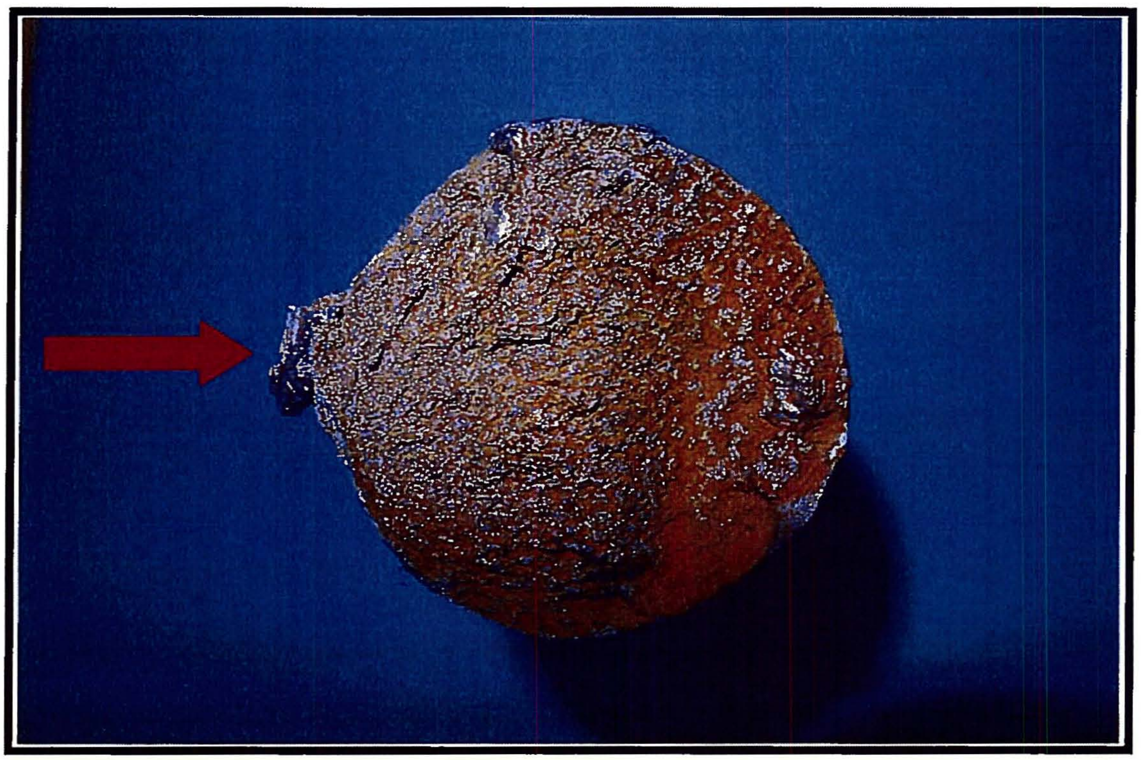


FIGURE 3: End view of fracture showing weld metal (arrow).

FIGURE 4: Picture of pin half still in place on scissor lift.

Additionally, had the lift been used after the pin was cracked, the pin would have been subjected to cyclic loading (the stresses are increased and relaxed as the lift is extended and retracted or sways in the wind), and regions of the pin fracture surface would likely be flattened or damaged.

The lack of pre-existing cracking indicates that the fracture occurred as a result of a single-overload event. Furthermore, the brittle nature of the fracture indicates that the cause of the failure was likely an impact load. Pictures of the lift after it fell over indicate that portions of the "scissor" assembly of the scissor lift are bent (**Figure 5**). Falling over with the lift extended would produce large impact stresses in the scissor assembly, consistent with a bent scissor assembly and a broken pin. The pin most likely broke due to impact of the platform and scissor assembly with the ground.

FIGURE 5: Photograph of lift after incident.

Report Prepared By:

Nicholas E. Biery, Ph.D.
Technical Consultant

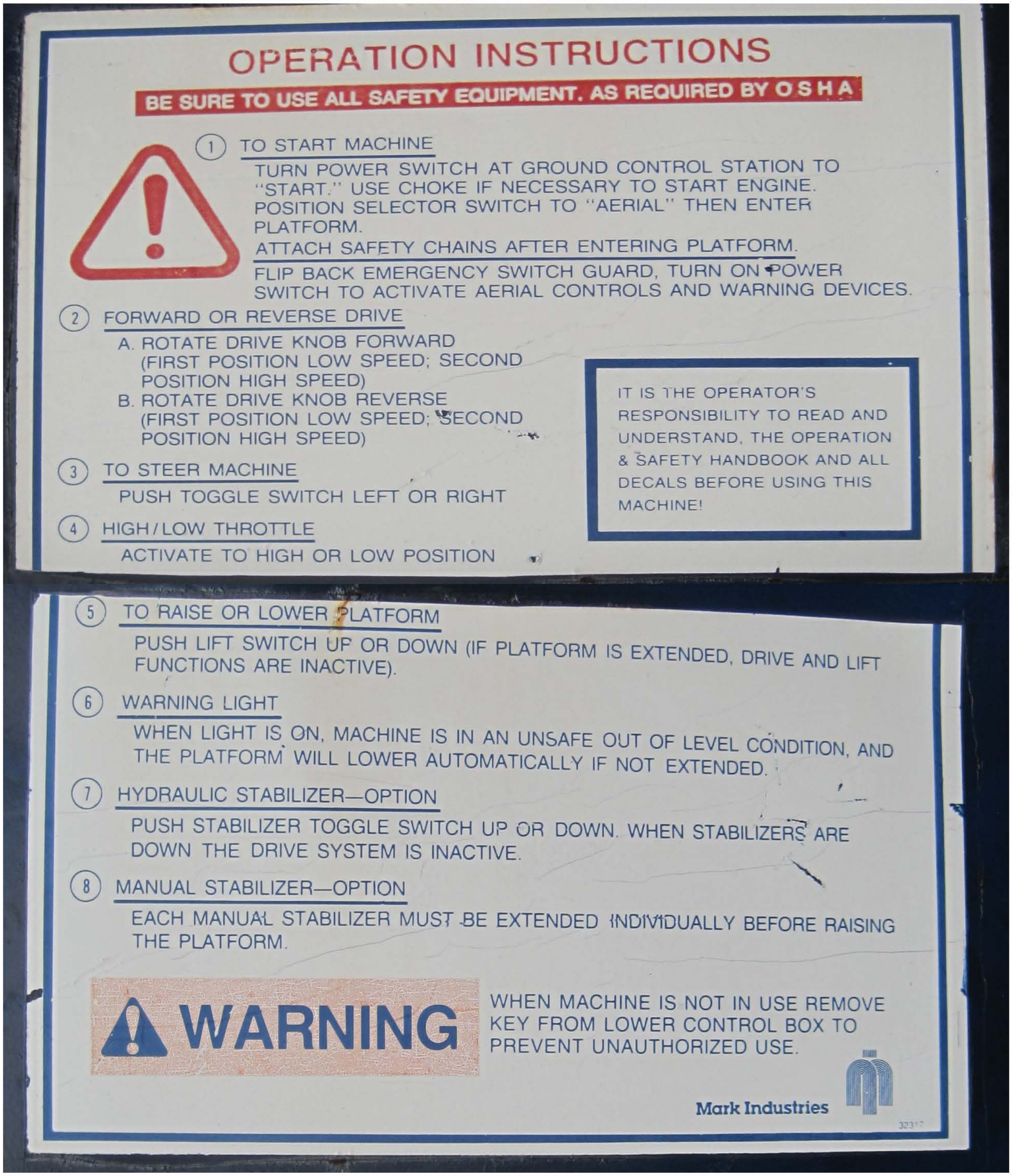
Report Reviewed By:

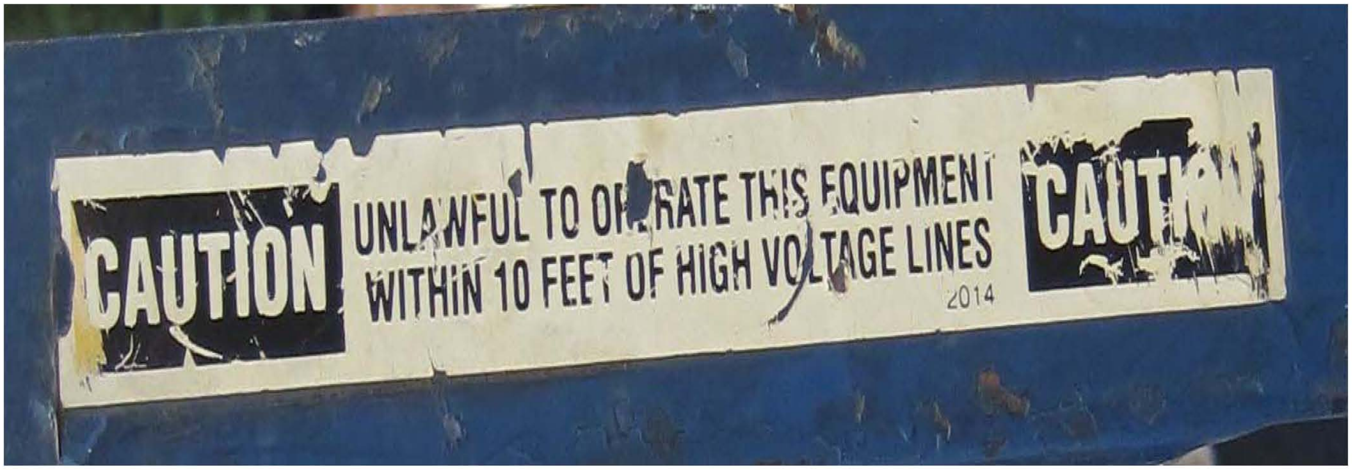
Robert S. Carbonara, Ph.D.
Senior Analyst

NEB:an
Enclosure

Exhibit 11

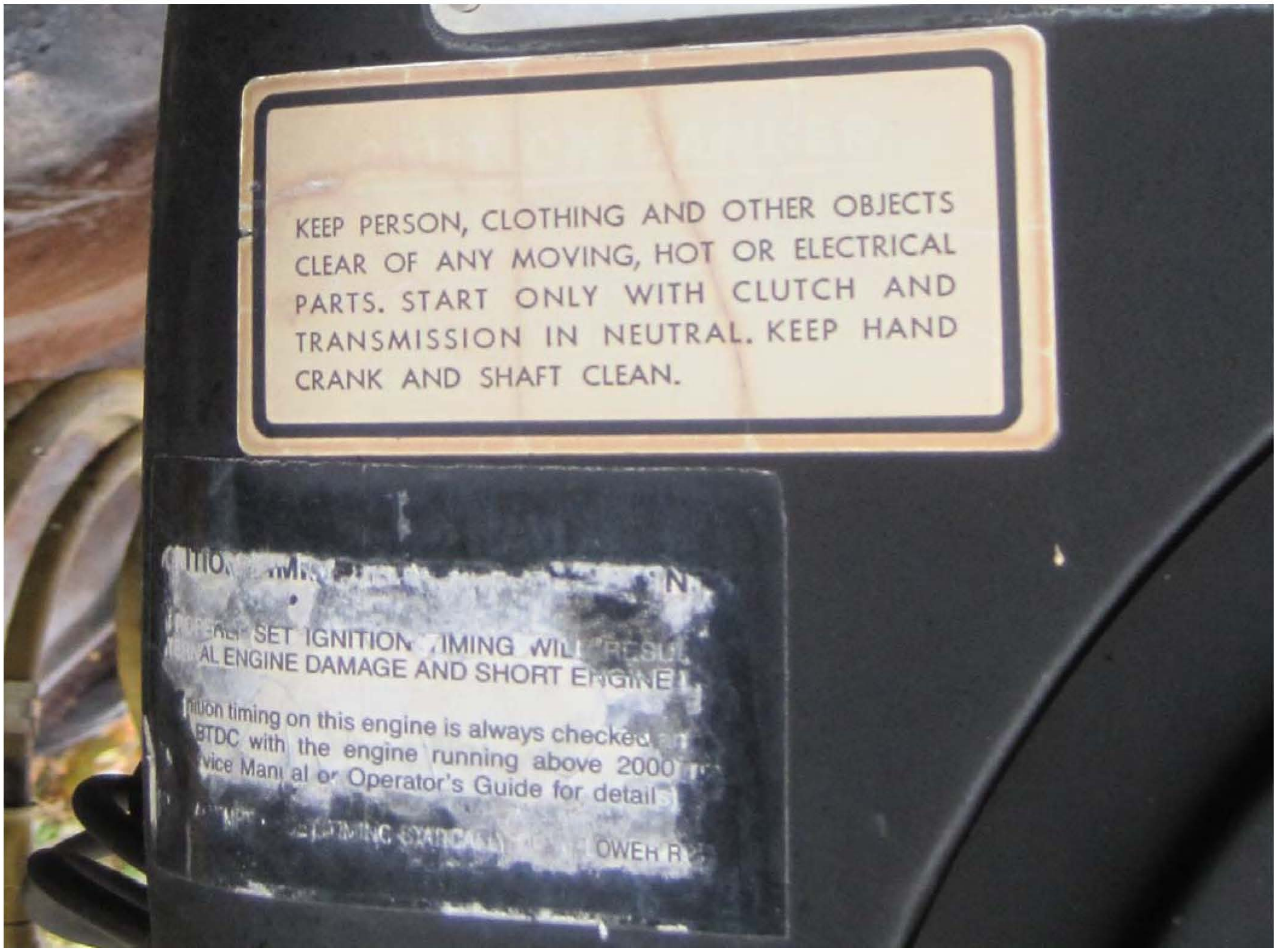
Warning Labels on Marklift MT40G

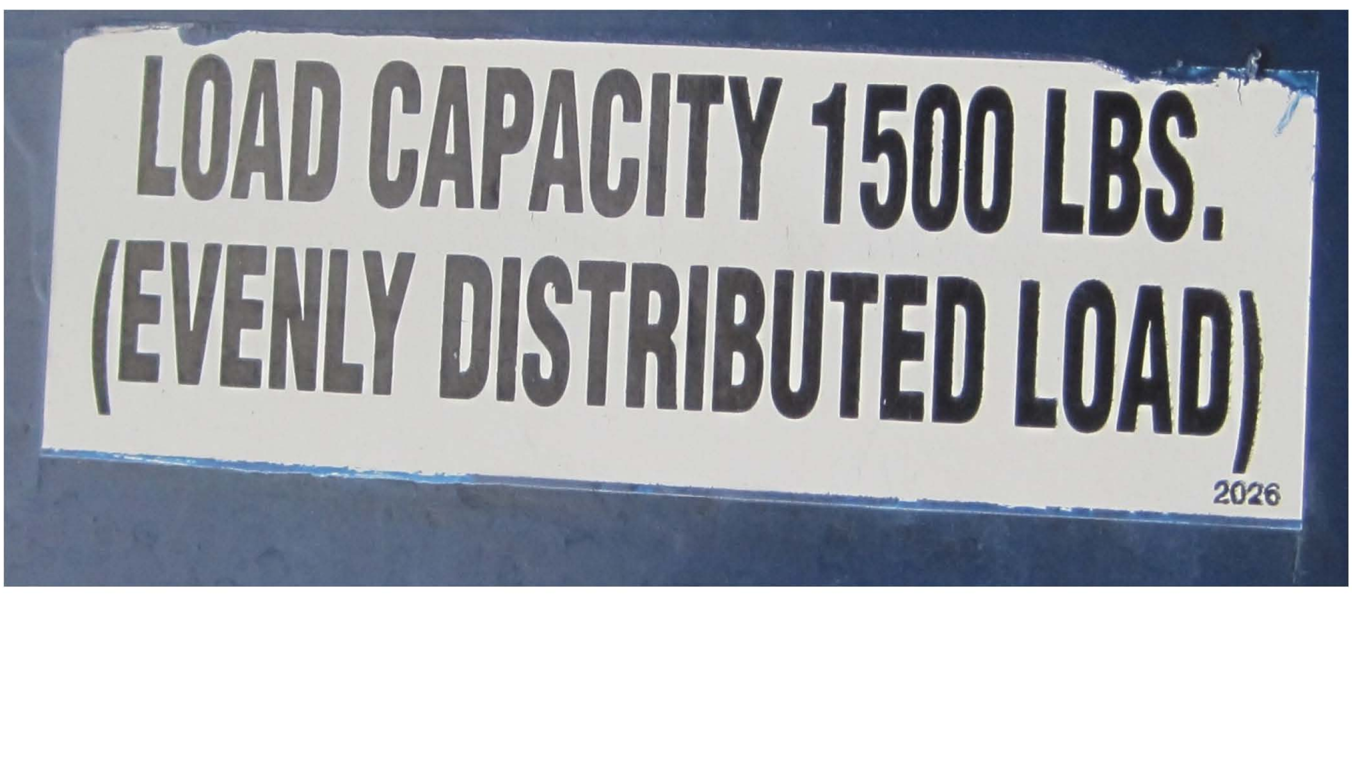



CAUTION
UNLAWFUL TO OPERATE THIS EQUIPMENT
WITHIN 10 FEET OF HIGH VOLTAGE LINES
2014


DO NOT LIFT
FROM THIS END
2041


GUARD RAILS ARE FOR YOUR SAFETY
DO NOT REMOVE
OPERATING THIS MACHINE WITHOUT GUARD RAILS
COULD RESULT IN DEATH OR SERIOUS INJURY
CAUTION
31109


KEEP PERSON, CLOTHING AND OTHER OBJECTS CLEAR OF ANY MOVING, HOT OR ELECTRICAL PARTS. START ONLY WITH CLUTCH AND TRANSMISSION IN NEUTRAL. KEEP HAND CRANK AND SHAFT CLEAN.
SET IGNITION
ENGINE DAMAGE AND SHORT
timing on this engine is always
with the engine running above
Operator's Guide for


LOAD CAPACITY 1500 LBS.
(EVENLY DISTRIBUTED LOAD)
2026