tify problems and solve them with ergonomics. This is one of the first documented programs to use participatory ergonomics programs to reduce injuries among health care workers.
Method. Three EMAT groups were formed among employees of a large urban hospital. The EMATs represent three different worker groups—orderlies, intensive care nurses, and laboratory technicians. Each group consists of 4-6 members plus technical advisors. Baseline, one year, and two-year follow-up data will be available for this presentation.

Technique #3: Ergonomics Component in a Wellness Program
Purpose. To reduce workers' compensation costs and improve employee comfort.
Method. A team of novice technicians will provide ergonomic services for as many employees in the hospital system as possible in one year. Records of the quantity and type of intervention will be recorded. Workers compensation costs and injury rates will measure success. Four-month data will be available for this presentation.

Results. Discussion of all three techniques will include impact that ergonomic interventions had on workers' compensations costs, injury rates, self reported symptoms, pain and comfort ratings, costs per injury, and productivity.

Conclusion. A comparison of three very different techniques of implementing human factors principles with hospital employees will be evaluated. Technique #1 with professional ergonomists has been proven but can be too costly for some interventions. Technique #2 using participatory teams can work in some settings but does not seem to be successful in areas with direct patient contact. Technique #3 is still under investigation but has promise due to the combination of approaches that will be implemented.

Session 22: Computer Simulation and Modeling

Ergonomics Analysis Using Computer Animation—Sistler F, Waly SM, Husser R

Computer animation was used to perform an ergonomic analysis and re-design of an eight-piece, cut-up saw workstation in a poultry processing plant. The joint angles of the upper extremities and the back were measured for the existing workstation configurations and for the OSHA recommended height. Both situations created undesirable joint angles during some portions of the cut-up operation. The OSHA recommended height was not acceptable because the worker had to bend too far to view the blade as it was cutting the chicken.

A three-camera video digitizing system was used to collect joint angle data to analyze the tested configurations and to validate the accuracy of the animations. Data was collected on three workers, each with several years' experience on a cut-up saw workstation. The shortest, tallest, and an average-size worker were used. Each was measured at the present in-plant configuration (3-4 inches above OSHA recommended height), at the OSHA height, and two inches below the OSHA height. The standard deviation between the joint angles in the animation and the actual worker movements was less than the standard deviation of the joint angles among the chickens cut by the same person with the same saw configuration. There was a natural variation of motion when a person performed the same task multiple times. Since the variation between the animation and the average, actual performance of the task was less than the natural variation when a skilled human performed the same task several times, the model was considered to be operating at an acceptable level of accuracy.

The elbow and shoulder angles were more extreme at the in-plant saw height than at the OSHA-recommended height. When the workstation was changed to the OSHA height, the back bending became more severe. The worker had to bend over more to see the blade at the OSHA height. Animation software was used to create a three-dimensional model of the workstation including the saw, stand, chain conveyor, bag and bag holder, and the conveyor for holding the filled bags. Three-dimensional human models were acquired and modified to match the measurements of the workers.

A workstation design was needed where the saw's guide bar could be lowered to reduce shoulder and elbow movements, and still allow the worker to see the blade as it cut the chicken. This was accomplished by lowering the saw and rotating the guide bar. Rotation angles of 10, 20, and 30 degrees were evaluated. An angle of 20 degrees was found to produce the most ergonomically desirable configuration. The average rotation angles for the elbows, shoulders, and back were all reduced.

Mining Equipment Safety Analysis Using Computer Modeling Research Tools—Ambrose DH

NIOSH, Pittsburgh Research Center recreates and analyzes mine accidents and incidents involving mining equipment using 3D computer graphics modeling research tools. The objective is to examine, evaluate, and determine changes that need to be made to mining equipment or human interaction with the equipment to provide worker safety. Comprehensive accident or incident reports are used to developed an accurate visual 3D computer graphics representation of accidents/incident, including the equipment, environment and worker. Computer simulations are used to analyze the accident/incident to predict equipment problems that have contributed toward the accident/incident. The human interaction with the equipment is also analyzed using simulation software. Software packages DADS and JACK are used for simulation and analysis. This paper discusses several completed examples of the use of 3D computer graphics modeling research tools, specifically with mine hoist and elevator systems and underground coal mine roof bolter machines.

Occupational Traumatic Injury Prevention Using Virtual Reality—Dotson B, Hsiao H, Chiou SS, DiPasquale JJ

In the area of safety research, it would be useful to measure the physical responses of workers in their work environment. The physical response data could then be used to compose recommendations to achieve safer work environments. In many cases this is not possible due to various problems. One such problem is that the measurement systems may not function properly in a work environment. Another concern, is that using the measurement system may add risk of injury to an already dangerous job. At the National Institute for Occupational Safety and Health (NIOSH), researchers are looking at a solution to this problem, where the subject is placed in a computer generated virtual environment. This solution uses state-of-the-art virtual reality devices to give the subject the illusion of being in a work environment. Using virtual environments alleviates the space constraint problems that physical mockup may have, but most important is the reduction of the risk of injury for the subject. NIOSH researchers are using virtual

reality in a study which investigates the physical responses of scaffold workers while walking on elevated planks. The subjects in this study will be immersed in a virtual environment that will provide the illusion of being elevated thirty feet above the ground, but in reality the subject will be walking safely on the floor in the laboratory. This paper describes the current project using virtual reality and ideas for future projects using virtual reality.

Computer Simulation of ROPS Testing in ASAE S519—Harris JR, Mucino V, Etherton JR, Snyder KA, Means KH

The American Society of Agricultural Engineers (ASAE) is one professional society which has developed a standard for certification testing of rollover protective structures (ROPS) on agricultural tractors. Certification of a ROPS can be performed following static procedures in the current standard, ASAE S519. This research simulates rollovers about the rear axle and compares ROPS stress levels with stress levels found during simulated ASAE S519 static testing.

The ROPS modeled in this simulation is representative of one that might be found on small tractors (~50 hp PTO) operated on a hillside. Modeling has been performed using finite element techniques. Variables describing the ROPS construction, such as part dimensions and materials, have been parameterized to allow rapid simulation of a variety of ROPS prototypes. Additional variables include the ground slope and the tractor's initial rotational velocity. For the current research, slope angles of 10, 30, and 60 degrees were examined. Initial rotational velocities included 1, 3, and 4 rad/sec. A slope angle of 60 degrees matches the slope recommended in ASAE S519 rear field upset tests. An initial rotational velocity of 4 rad/sec, when converted to a pure translation, is in excess of the speed recommended for the ASAE S519 rear field upset test.

Initial analyses began the rear rollover model at 90 degrees to the ground plane since ROPS-ground contact occurs in the final 90 degrees of rollover. Furthermore, this initial position served to conserve computer time and storage space. For these simulations, it was observed that ground-impact induced stress levels recorded during rear rollovers were on average 19.4% lower than stress levels recorded during simulated static ASAE S519 testing. However, these simulations failed to identify slope angle as a major contributor to ROPS stress. The rear rollover model was modified to initiate the rollover at the point of no return, when the tractor center of gravity is vertically above the rear axle. Starting the simulation at this point will model the energy transfer during the overturn, from potential to kinetic, more accurately than the previous simulation. Preliminary examination of these data suggests the new simulation identifies a more pronounced slope angle effect on ROPS stress.

Future work will include development of models for side rollovers based upon knowledge gained in rear rollover simulation work.

Session 23: Agricultural Injuries

The Ohio Agricultural Safety Promotion System (ASPS), 1994-1997—Eicher LC, Bean TL, McCaslin NL, Nieto R, Owens M, Nolan J, Rodriguez J, Wessel P

Many farms in the United States continue to be family-run operations. However, over the last fifty years, there has been an increase in the number of corporate agricultural operations that rely on non-family labor. Since the farm crisis of the late 1970's and early 1980's, this trend has accelerated with an increasing number of family farms either "down-sizing" to become part-time farming operations or "up-sizing" to become family corporations. There has also been a trend for operations that have remained primarily family-run businesses to become increasingly reliant on non-family labor to remain competitive and to meet production demands. Furthermore, more and more states now require that agricultural employers carry workers' compensation coverage on their employees.

These circumstances afford an ideal opportunity to reduce the agricultural death and injury rate by working with agricultural organizations (The Ohio Farm Bureau, The Ohio Pork Producers Council, and the Ohio Division of the National Organization of Independent Business) who have workers' compensation programs. A random selection of farms was conducted from a population of 1,700 employers. The Ohio State University provided safety information and training materials for employers to provide short, frequent safety training for their employees. Half of these individuals are in the treatment group, half in the control group. A representative sample (90) of employers in both the treatment and control groups were selected for on-farm inspections of worker protection equipment, shielding, etc. A pre- and post-safety awareness test was also developed and administered to both the treatment and control groups. In addition, accident history prior to the one-year testing period was collected to document pre-treatment accident rate. This approach will validate the use of employer training programs in the agricultural industry for improving cognitive, attitudinal, and behavioral characteristics of employers and employees in farming operations.

Livestock-Related Injuries Associated with Cattle Handling in Oklahoma—Huhnke RL, Hubert DJ, Harp SL

A 1993 study by the USDA's National Agricultural Statistics Service showed 26% of the work-related injuries that occurred on U.S. farms were sustained while working and handling livestock. A 1994 NIOSH farm injury study conducted in Oklahoma revealed that greater than 75% of all lost-time injuries were from handling beef, sheep, and swine. An important consideration in this investigation of livestock-related injuries is whether (and if so, how) handling equipment and working facilities contributed to the sustained injuries. The purpose of this study was to assess the hazards associated with animal handling in a cow-calf operation. This research was funded by the Southwest Center for Agricultural Health, Injury Prevention, and Education at the University of Texas Health Center at Tyler.

Over 6000 Oklahoma cow-calf operators were identified through a random sample from the population of more than 60,000 operators. Individuals identified were mailed injury survey cards inquiring whether they or an individual associated with their operation were injured while working cattle during 1996. In addition, producers were asked whether they would be willing to participate in a voluntary personal interview. Based on the information obtained from the initial mailing, researchers identified willing participants and potential candidates for interviews. Selected individuals were then interviewed by either a county agriculture extension agent or one of the researchers. All in-person interviews were completed within about a two-month period ending May 15, 1997.