work-zone safety simulations, 3) converting real world images into VR system, 4) developing additional walls for the current VR system to accommodate overhead work simulation (e.g., crane operation), and converting current SGI-driven system to PC-driven to reduce system maintenance cost.

G3.4 Driving Safety and Simulation Technology—Tabacchi JG, Grace R, Guzman AM

Motor vehicle crashes are one of the leading causes of work-related deaths and severe injuries in U.S. workers. The statistics show that many workers are at high risk of injury and death from traffic-related accidents. About three workers die from these crashes each day. It is important to realize that many of these accidents occurred due to human error. The potential of improving driving safety is huge particularly when new technologies such as driving simulators and on-board drivers monitoring systems are used for advanced driver training.

The Transportation Research Center of Carnegie Mellon Research Institute, (CMRI) is involved in research issues related to applications of driving simulators. Together with ISIM, a leader in the field of driving simulators, we have designed and developed an advanced driving research facility. A key component of the Center is its driving simulator named "TruckSim." This simulator allows researchers to safely test drivers under conditions that would be hazardous in the real world. During tests, drivers can be subjected to identical situations while their response and actions are recorded by a multitude of sensors mounted throughout the cab. This system has been used to study drowsiness and fatigue in sleep-deprived drivers and has helped us to develop a drowsy-driver-detection system. TruckSim's modular configuration allows for rapid and cost-effective design of human factors experiments. The system is capable of simulating a variety of road vehicles, using interchangeable cabs mounted on an electromechanical motion platform. TruckSim's driving environments and scenarios can be tailored to study the driver's response to hazardous conditions. Driving errors and crashes can be played back using an aerial view to give the driver another perspective of the road situation. The current and future uses of driving simulators are presented in this paper.

G3.5 Fire Dynamics Simulator—McGrattan K, Forney G, Madrzykowski D

Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model of fire-driven fluid flow. The model solves numerically the conservation equations of mass, momentum and energy that govern low-speed, thermally-driven flows with an emphasis on smoke and heat transport from fires. A companion software package called Smokeview is an OpenGL graphics program that allows one to visualize the results of the calculations, including animations of smoke particulate, temperature slices within the three-dimensional domain, and heat fluxes to walls. Users of the package can view the enclosure from any angle from inside or outside. Most users prefer to visualize the evolving fire scenario by way of two dimensional animated slices of temperature or gas concentration. Work is underway to introduce these types of quantities by means of three dimensional surfaces, depicting, for example, the layer of smoke near the ceiling of a burning room.

Future developments include the ability to immerse a target, like a fire fighter, within the space so that the temperature and thermal radiation flux to the body can be assessed. Present applications of the model include testing sprinkler performance in storage facilities and warehouse retail stores, reconstructions of fires in residential buildings, and simulations of large outdoor fires. The software is available to the public via the web site fire.nist.gov, and it has been designed to run either on high-end personal computers or engineering workstations.

Session: G4.0
Title: Selected Workplaces
Category: Injury Surveillance and Intervention Evaluation
Moderator(s): Anne-Marie Feyer

G4.1 Fatal Occupational Injuries in the U.S. Rail Transportation Industry—Fosbroke DE, Moore PH

The rail transportation industry is much safer today than in the days of link-and-pin couplers, brakemen jumping from roof to roof to set hand brakes, and train operations regulated by time tables and train orders. Although significantly improved since the 1890s, work-related fatal injury rates in this industry are currently more than twice the national average.

Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI) data were analyzed to assess the magnitude and distribution of fatal injuries in the rail transportation industry. Denominators for calculating fatality rates were estimated using the Current Population Survey. From 1992-1998, 226 rail transportation workers died of work-related fatal injuries in the United States. The fatal occupational injury rate was 11.2 per 100,000 workers per year. These statistics exclude worker fatalities in local and suburban transportation (e.g., commuter and light rail). Fatally injured workers were employed in 36 different occupations, but, 61% of the victims worked in train operation occupations, including railroad conductors and yardmasters (55 deaths), railroad brake, signal, and switch operators (45 deaths); and locomotive operating occupations (37 deaths). Seventy-five percent of cases involved either a railway event (48.2%), or a pedestrian struck by a vehicle or mobile equipment (12.8%). Eighty-one percent of incidents involved a rail vehicle (68.6%), or a motorized highway vehicle (12.8%). Circumstances associated with fatal injury include being struck by, or caught between rail cars during switching and spotting of rail cars; operating locomotives, or riding on trains involved in derailments and collisions; riding in motor vehicles involved in highway collisions; and being struck by trains during repair, inspection, or maintenance activities. These results indicate that railway workers risk of injury is similar to that of workers in mining and construction where the need for improved safety measures has long been recognized.

G4.2 Transportation Incidents - the 500 Pound Gorilla of Occupational Injuries—Luchter S

Introduction: Occupational injuries are a major public health problem in the U. S., with over 6,000 fatalities and more than 1.8 million lost work day injuries a year. In order to focus prevention efforts it is important to know where the injuries are occurring and what type of events are causing them. This study was undertaken to determine the relative significance of transportation related injuries in the occupational setting.

Method: U. S. Bureau of Labor Statistics data on fatal and lost work day injuries in 1997 were analyzed to determine the distribution of these injuries by industry, event and outcome.

Results: Of all occupational fatal injuries reported for private industry in the U. S. in 1997, 40 percent were transportation related, with 83 percent of that total highway or motor vehicle related. These fatalities were the number one or number two cause of fatal occupational injuries in all industry categories and were not restricted to persons whose primary job was transportation. Transportation related non-fatal injuries resulting in lost work days comprised 4 percent of all lost work day occupational injuries. This is a small portion of the total, with overexertion, contact with object and falls comprising 28, 27 and 16 percent respectively.

Conclusions: Transportation related occupational injuries are a small portion of the injuries that result in lost work days, however, they are the number one or number two leading cause of occupational fatalities in all industry classifications. Although transportation related occupational injuries are relatively infrequent, when they do occur they are quite severe, resulting in a major portion of all occupational deaths.

G4.3 Impact of a Design Modification in Modern Firefighting Uniforms on Burn Prevention Outcomes in New York City Firefighters—Prezant DJ, Freeman K, Kelly KJ, Malley KS, Karwa ML, McLaughlin MT, Hirschhorn R, Brown A

Our aim was to determine the impact of 3 different firefighting uniforms (traditional, modern and modified modern) on incidence and severity of thermal burn injuries, the major occupational injury affecting firefighters. Injury data was collected prospectively for the New York City Fire Department (FDNY) wearing FDNY's traditional uniform (protective over-coat) from 5/1/93-8/31/93, FDNY's modern uniform (protective over-coat and over-pant) from 5/1/95-8/31/95 and FDNY's modified modern uniform (short sleeve shirt and short pants rather than long sleeve shirt and long pants worn under firefighter's protective over-clothes) from 5/1/98-8/31/98. Outcome measures were burn incidence and severity. Adverse outcomes were heat exhaustion and cardiac events. During this 12 month study, 29,094 structural fires occurred; the incidence rate for upper extremity burns was 2,341 per 100,000 fires and for lower extremity burns was 2,076 per 100,000 fires. With the change from traditional to modern uniform distribution of burns per fire decreased significantly ($P=0.001$) for upper extremity burns (86%) and lower extremity burns (93%). Days lost to medical leave for upper or lower extremity burns decreased 89%. Burn incidence and severity were not significantly affected by the change to modified modern uniform. The distribution of heat exhaustion or cardiac events per fire was not significantly affected by the change from traditional to modern uniform and heat exhaustion was decreased ($P<0.001$) by the change to modified modern uniform. In conclusion, modern uniforms dramatically reduced burn incidence and severity, while the modified modern uniform significantly reduced heat exhaustion without significantly affecting thermal protection.

G4.4 The Impact of Protective Hoods and Their Water Content on Firefighter Burn Injuries: Laboratory Tests and Field Results—Prezant DJ, Barker RL, Stull JO, King SJ, Rotanz RA, Malley KS, Bender M, Guerth C, Kelly KJ

The New York City Fire Department (FDNY) is the largest fire department in the United States. In 1996, FDNY introduced the thermal protective hood as part of its modern fire protective uniform. The purpose of this study is to determine (1) the effectiveness of hoods in reducing head burns and (2) whether hood water content (dry, damp or saturated) affects the level of thermal protection. Laboratory (radiant heat performance, thermal protective performance, and fully dressed manikin) and FDNY field tests were utilized. Laboratory tests evaluated 4 different conditions (no hood, dry hood, damp hood, and saturated hood) exposed to 4 different heat fluxes (0.1, 0.25, 0.5 and 2.0 cal/cm2/sec) equivalent to approximate air temperatures of 200, 400, 600 and 2,250^{o} F (3). Field tests compared FDNY head burns during 3 winters wearing the hood to 3 winters not wearing the hood. Compared to not wearing a hood, wearing a hood dramatically reduced head burns. This was true for all laboratory tests, at all heat flux exposures and all hood water content conditions. At 0.1 cal/cm2/sec, dry hoods were superior to wet hoods. At all other heat flux exposures, thermal protection was either not significantly different between water content conditions or improved as water content increased. FDNY field results confirmed these laboratory results. During the time periods studied, there were a total of 611 head burns

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ABSTRACTS

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