

YOU CAN'T REACH FOR THE STARS IF YOU ARE TRIPPING OVER THE GROUND! (PREVENTING SLIPS, TRIPS, AND FALLS)

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ABSTRACT

Although there are very few mishaps related to ground, vehicle or payload processing at the Kennedy Space Center (KSC), employees have experienced a significant number of injuries due to slips, trips, and falls outside of performing flight processing operations. Slips, trips, and falls are major causes of occupational injuries at KSC, the National Aeronautics and Space Administration (NASA), and in general industry.

To help KSC employees avoid these injuries, and allow them to be fully productive, KSC launched an initiative in 2013 to reduce slips, trips, and falls. This initiative is based on a four-part model focusing on DATA analysis, HAZARD awareness, PREVENTIVE methods, and BALANCE.

1. INTRODUCTION

1.1. Define problem

The Kennedy Space Center (KSC) is the primary launch complex for NASA human space flight. Safety is built into every process and procedure of all vehicle and payload operations as well as ground support operations. This has resulted in very few mishaps related to ground, vehicle or payload processing. However, KSC employees have experienced a significant number of injuries due to slips, trips, and falls (STF) outside of performing flight processing operations. This is the most significant contributor to injuries at KSC, throughout NASA and in general industry in the United States.

Falls account for over eight million hospital emergency room visits each year, representing the leading cause of emergency room visits (21.3%). [1] Slips, trips, and falls cause 15% of all accidental deaths, which is second only to motor vehicles. [2] In addition to the cost and loss of productivity, these injuries can lead to a lifetime of pain.

1.2. Traditional Efforts

Traditional efforts to reduce STF injuries have focused on the work environment. Decades of research and countless dollars have been expended throughout the United States to identify and reduce walking/working surface hazards, including flooring materials, uneven surfaces, surface transitions, and weather-related hazards such as rain and ice.

1.3. Vision, Mission, and Goals

While traditional methods are still being deployed, a new initiative has been developed that includes a focus on the employee in reducing STF injuries.

Vision: No one should suffer the pain or cost of an injury due to a slip, trip, or fall

Mission: To contribute globally to the reduction of injuries due to slips, trips, and falls

Goal: Develop an effective Slips, Trips, and Falls Reduction Initiative that includes innovative solutions within a comprehensive program designed to be replicable across other NASA Centers, general industry, and outside of work.

This initiative looks to strengthen our safety culture through changes in attitudes, actions and an increased sense of personal responsibility.

The STF initiative focuses on four parts:

- Case data analysis
- Hazard awareness
- Preventive and situational awareness
- Balance initiative

2. KENNEDY SPACE CENTER SLIPS, TRIPS, AND FALLS REDUCTION INITIATIVE

2.1. Slips, Trips, and Falls Initiative Model



Figure 1: Slips, Trips, and Falls Initiative 4-Part Model

The KSC Slips, Trips, and Falls Initiative model was developed to address the problem in four inter-related ways. The KSC team decided to continue the traditional efforts to ensure a safe work environment while also adding a new focus on employee's responsibilities.

The first two parts, DATA ANALYSIS and HAZARD AWARENESS, continue to build upon traditional efforts. Data analysis has been expanded to a greater level of detail. Hazards are still mitigated as much as possible, but more emphasis is placed on educating employees to be aware of existing hazards.

The second two parts of the model, PREVENTION and BALANCE, are more innovative. They build on existing information but also give employees methods to reduce their risk of injuries from STF. Updated prevention techniques are being taught to make employees aware of their responsibilities in reducing their likelihood of an STF injury. These techniques focus areas employees can control, such as their actions and decisions. Finally, employees are being offered hands-on training to improve their balance and physical abilities to reduce the likelihood of injury.

2.2. Timeline (How we did this)

In 2013, the KSC Institutional Safety and Mission Assurance (S&MA) organization began focusing on the STF problem by developing a detailed trending analysis of case data which clearly defined the problem. At that time, a partnership was formed between the S&MA organization and the on-site physical rehabilitation group, RehabWorks [3].

S&MA developed the Slips, Trips, and Falls 4-Part Model in 2014. S&MA and RehabWorks also began conducting STF prevention classes and balance classes, with over 1600 employees trained to date.

Two Balance Zones equipped with traditional balance equipment and electronic balance training devices opened in 2015. An initial test group was formed to establish balance baselines, and testing and training protocols.

3. DATA ANALYSIS

KSC has maintained a long-standing practice of trending the events and exposures leading to the Center's Occupational Safety and Health Administration (OSHA) reportable injuries. Slips, trips, and falls are among the top contributors leading to these occupational injuries. In the fall of 2013, the S&MA Directorate launched an initiative to reduce these injuries. This began with finite analysis of not only OSHA reportable STF injuries, but all injuries that were the result of STFs. These included injuries that required only first aid treatment and minor injuries that resulted in medical evaluation only by KSC on-site health care professionals.

The analysis was expanded to first break down each injury by the category of a slip, a trip, or a fall from other factors. Then each category was analyzed for the mechanism that led to the injury. Additionally, each injury was mapped by location to identify "hot spots" of STF injuries.

This effort led to a greater understanding of the types and causes of STF injuries at KSC. The analysis first showed that STF injuries resulted in the most severe OSHA reportable injuries, and were often responsible for employees missing significant time away from work, or being restricted from performing some of the duties associated with their job. This meant that not only were there direct medical costs associated with these injuries, but that productivity was reduced because a member of the team was not present or was limited in their level of productivity.

As seen in Fig. 2, the analysis shows the most prevalent STF category to date is trips, followed by slips, and finally falls from other factors.

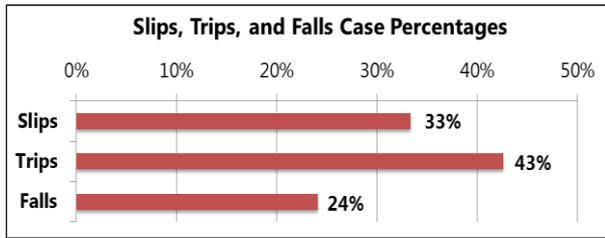


Figure 2: Breakdown of Slips, Trips and Falls at KSC

3.1. Slips

A slip occurs when there is too little friction or traction between your footwear and the floor surface. In most slip events where a worker is walking, the worker’s heel on the front foot slips forward as the individual is transferring weight causing the worker to fall backwards

Fig. 3 shows the mechanisms involved in KSC slip injuries. The most prevalent mechanism was wet surfaces. Many slip injuries occurred where the employee was unable to identify exactly what caused the slip.

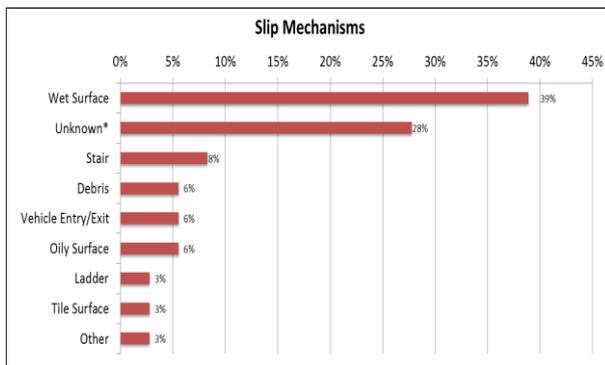


Figure 3: Mechanisms Involved in Slips at KSC

3.2. Trips

A trip occurs when your foot strikes an object resulting in a loss of balance. In a trip, your momentum causes your body to continue forward and commonly results in a forward fall.

Fig. 4 shows the mechanisms involved in KSC trip injuries. The most prevalent mechanism was colliding with miscellaneous objects such as pallets, hoses, or boxes. This was followed by stairs, debris, surface transitions and service carts as cases where the employee was unable to identify exactly what caused them to trip.

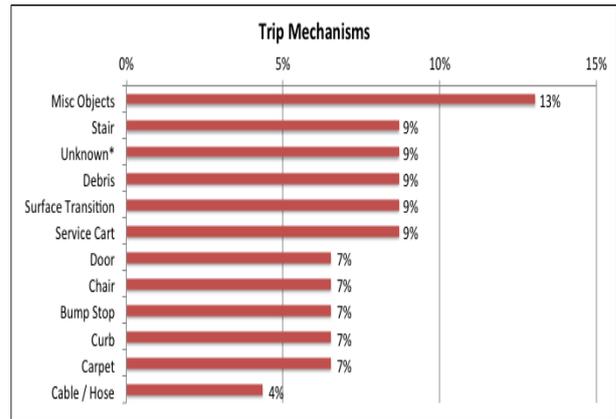


Figure 4: Mechanisms Involved in Trips at KSC

3.3. Falls from Other Factors

Falls can also be the result of personal factors such as balance, medications and health conditions.

Fig. 5 shows the mechanisms involved in KSC falls from other factors. The most prevalent mechanism was an employee’s leg or ankle giving way. This was followed by unsafe acts and other personal factors.

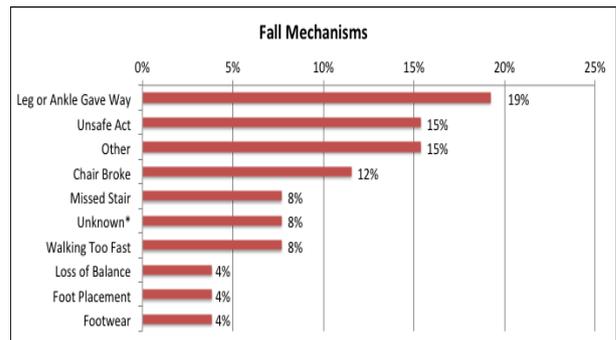


Figure 5: Mechanisms Causing Falls at KSC

4. HAZARD AWARENESS

Employees encounter various hazards when walking in the workplace. KSC is vigilant in ensuring employees have a safe work environment. This includes mitigating slips, trips and falls, but some infrastructure elements and work environments contain innate hazards that can lead to a slip, trip, or fall. This part of the model emphasized educating employees about these hazards and raising awareness to help them avoid these injuries. The first step is to identify the various hazards that can lead to slip, trip or fall injuries.

4.1. Slip Hazards

Slips can be caused by weather events that result in ice, snow or water collecting on a surface, but they can also be the result of surface contamination or inadequate floor coverings, materials or preparation.

Contaminated surfaces are broken down into two major categories: wet floor contamination and dry floor contamination. Examples of wet floor contamination are ice, water, mud, grease, oil, food, and soap. Examples of dry floor contamination are dusts, powders, granules, and small objects such as metal nuts and bolts. Examples of inadequate floor coverings, materials and floor preparation are loose or unsecured mats, sloped walking surfaces, ramps and gangplanks without anti-skid material. Even poor lighting can lead to a slip if the individual cannot see a surface transition.

4.2. Trip Hazards

Trip hazards include changes in elevation such as seams or irregularities in sidewalks, door thresholds, uncovered hoses, cables or extension cords, clutter or obstacles in walkways and work areas, open cabinet or desk drawers, and construction materials not stored or staged properly. Curbs and stairs cause many tripping injuries. Trips are also caused by unmarked steps or ramps, rumpled or rolled up carpets, and ramps.

4.3. Falls from Other Factors

In addition to the slip and trip hazards we are all exposed to every day, there are additional personal factors that can make an individual more prone to a fall. These include balance, medications or combinations of medications, vision, and musculoskeletal conditions. You are also at a higher risk to fall if you have a fall history or have a health condition such as diabetes, osteoporosis, or foot, ankle or leg injuries. Obesity, arthritis, and stress can also affect your balance.

5. PREVENTION METHODS

This portion of the initiative focuses on the personal responsibility of the employee. In addition to sharing injury data in the training sessions, an attempt is made to make this more personal while also emphasizing teamwork and looking out for each other at work.

5.1. Training

Once employees understand the difference between a slip, trip, and fall, they are taught some specific things they can do to prevent each of these types of injuries. This includes common-sense preventive methods, plus newer topics, such as distractions from cell phones. This is important because distracted walking cases in the U.S. have quadrupled in the past seven years [4]. People may be hesitant to report their use of a cell phone after an injury, so these cases may be underreported.

It may seem like common sense to wear proper shoes for the environment, but many STFs are caused by improper footwear. To reinforce the concept, employees

are taught more details, such as how shoe surface area and traction can increase the chance of slipping or falling. Some shoes may look sturdy but have smooth leather soles and lack tread. Other shoes, like high heels, don't provide an adequate contact patch between the foot and the ground, especially at the heel.

Walking techniques are discussed such as stride, foot position, keeping hands free for balance, walking in designated areas, visibility, and carrying loads.

Keeping work areas clear, common obstacles in work areas, lighting, and wet surfaces are discussed to encourage employees to change their environments to reduce the likelihood of STFs.

Being aware of the walking areas is also emphasized, including slowing down and paying attention. One catch phrase is, "WWW - Watch Where You're Walking."

Since overall health can make a difference, lifestyle decisions such as, getting adequate rest, exercising, and keeping stress under control are also discussed.

Everyone acts unsafely at times, but the training emphasizes that these are controllable decisions that can affect risk of injury. Some examples include, standing on chairs or tables with wheels, or on items like furniture that are not intended for standing/climbing.

5.2. Make it Personal

The fact that STFs are the main source of injury at KSC, NASA, and in general industry is not enough to motivate most people to make changes. It is necessary to bring the message to a more personal level. None of the people who were injured at KSC expected to go home injured or go to the hospital that day. These injuries can have a far-reaching impact on each of us, our families, and our employers. It is important to discuss this in the training and spread the message through promotional materials.

A related catch-phrase is used, "Beat the Statistics, Don't Become One!"

5.3. It is Up to All of Us

The STF Initiative emphasizes that preventing accidents and injuries in the workplace starts with each one of us, individually. We need to be willing to make decisions and take actions that not only keep us safe, as an individual, but to keep our co-workers from getting injured.

One of the ways to help keep our co-workers safe is to report safety concerns, particularly those that may pose an STF hazard. At KSC, the various methods of reporting emergencies and safety concerns is widely

publicized. It can be found at the top of the main KSC web page, and it is communicated in such occasions as the beginning of most training classes, and during new employee orientations. At NASA, being knowledgeable and willing to report problems is an important part of a strong safety culture.

All personnel need to work cooperatively to identify, report and correct unsafe conditions and behaviors. Ideally, if we see someone walking at risk, performing an unsafe act, or appearing to not see a hazard, we would step up and help them by speaking up. One action may help avoid an injury.

In the STF training, attendees are asked to make a commitment to themselves to develop an awareness of the potential walking hazards in their work and home lives and share what they learn with their coworkers and family.

The message can be summarized in this catch-phrases; “Remember at the End of the Day...Safety Is Up To You!”

6. BALANCE

The final part of the initiative provides a programmatic approach to reduce the risk of injuries due to STFs by focusing on three key areas: Education, hands-on training, and research.

Employees can take action by participating in the balance activities offered at KSC to understand personal risk factors, improve awareness, and train to improve balance.

When the S&MA organization and KSC RehabWorks teamed to tackle the problem of STFs, they didn’t find a program that fit the needs of the KSC population, which has approximately 8000 employees with an average age of about 50 years. A great deal of research exists in the area of sports concussion management and geriatric fall rehabilitation. However there was very little research or programs found for the middle-aged population in an occupational setting.

6.1. Education

Healthcare professionals, including both athletic trainers, and health and wellness professionals, teach onsite classes to provide employees with self-assessment tools and awareness of personal risk factors that contribute to STFs. Presentations are also made available online.

An important piece of the initial training is to give employees an understanding of how their bodies stay in

balance. Whether we are on Earth or in space, our bodies use information to maintain balance from three complex sensory input systems. Simply stated, these systems include vision, proprioception (unconsciously perceiving body position from sensory mechanisms throughout the body) and vestibular (sensory mechanisms in the inner ear which track the position of the head). All of the sensory input information is integrated in the brain to produce a motor response output. Through balance training, the speed of this response can mean the difference between falling and recovering when a trip hazard is encountered.

To help employees learn more about their own balance needs, the balance team developed a short Fall Risk Questionnaire and a longer Health History Form that relates to issues that may affect balance.

The Fall Risk Questionnaire is a rapid assessment of five risk factors that increase the chance of an STF injury (Fig. 6). If any apply to an employee, then they are directed how to take action. The five areas include: Age, medication, vision, recent injuries or surgeries, and systemic conditions.

Figure 6: Fall Risk Questionnaire

A more detailed Health History Form builds upon the Fall Risk Questionnaire to fully assess a person’s risk of an STF injury.

- Musculoskeletal: weak muscles, arthritis/joint pain, low back, hip, or lower leg injury/surgery

- Systemic: High and low blood pressure/orthostatic hypotension, irregular heartbeat/arrhythmia, diabetic neuropathy (numbness) of the feet, pregnancy, obesity
- Visual: change in prescriptions, bifocals/trifocals, glaucoma, vestibular, inner ear damage, ear/nose/throat infection, Meniere's disease
- Medication side effects and interactions
- Neurological: Stroke, Parkinson's, Multiple Sclerosis, ALS

Through a Balance Initiative Speaker Series, subject matter experts were invited from KSC and within the local community to talk about issues that affect balance. They included an ophthalmologist, neurologist, pharmacist, gerontologist, and athletic trainer.

Promotion for the Balance Initiative is accomplished through KSC safety and health events, emails, newsletters, and an internal NASA website. The website includes videos showing balance drills, educational videos, and a video by Astronaut Cady Coleman discussing the importance of balance training [5].



Figure 7: Balance Team with Astronaut Cady Coleman

As a quick reference, a laminated card was developed to fit in the badge holders of KSC employees (see Fig. 8).

Informal on-line surveys were developed to learn about employees' interest in participating in the Balance Initiative and to gather feedback from those who participated.



Figure 8: Two-sided Balance Badge

6.2. Training

Balance Zones (BZ) are being established across KSC where employees can train through a combination of conventional drills, electronic gaming devices, and core stabilization exercises. Participants follow a progressive protocol designed to incorporate and improve the various components of balance.

BZ facilitators provide individualized, hands-on training sessions in the BZs. The facilitators include healthcare professionals and trained employee volunteers. Employees are required to use the "Buddy System" to ensure no one is alone in the unlikely event an injury would occur.



Figure 9: Balance Zone Training Session

6.3. Research

The KSC workforce represents an untapped data set of the 40 – 70 year old demographic for researchers of the musculoskeletal, visual, vestibular, and somatosensory systems' effect on balance related to STF injuries. In an effort to capture both the magnitude of the balance challenges to the KSC workforce, as well as the

effectiveness of the balance training, a Biodex SD Balance System, a product of Biodex Medical Systems, is being used to assess and train volunteer KSC employees (see Fig. 10).



Figure 10: Biodex Balance System

Initially, a pilot study was conducted with 36 NASA Safety employees who completed pre and post testing of the Fall Risk Screening (FRS), which can identify a balance problem in under 2 minutes, and the Modified Clinical Test of Sensory Integration of Balance (m-CTSIB) Test, which helps determine which sensory system (visual, somatosensory, or vestibular) the patient relies on to maintain balance (see Fig. 11).

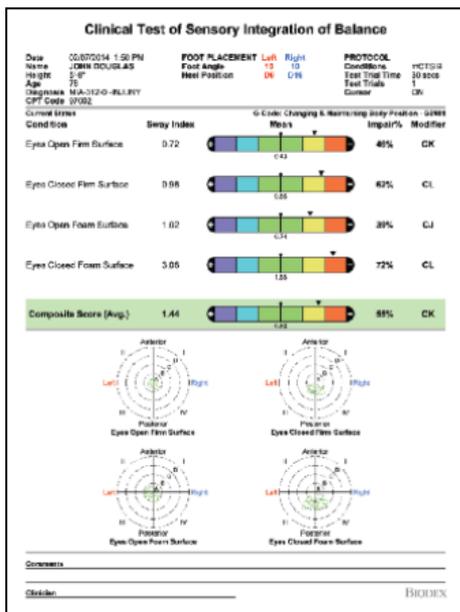


Figure 11: Clinical Test of Sensory Integration of Balance report

Additional research is being conducted by KSC RehabWorks entitled, “Establishment of Normative Data for the Biodex Fall Risk Balance Test in Adults Aged 40-70 Years of Age,” which will help fill the gap in normative data with regard to STF injuries in the middle aged worker. Upon completion of the study, the

data will provide a baseline for future training and testing of the KSC workforce using the existing BZ facilities and equipment.

7. AWARENESS AND OUTREACH

To make the program successful, a paradigm shift must occur which is generally a slow and consistent process. To allow this to become part of employees’ normal way of life, the team has chosen to reinforce the messages at many levels. These include training classes, a web site, videos, posters, employee newsletters, emails, and safety tips. The program began development in 2013 but was officially rolled out in March of 2015. However, it will be necessary to continually reemphasize the message in different ways over time.

8. PARTNERS

One of the most important parts of being successful in this new initiative is developing strong partnerships with people in organizations all around KSC and at the NASA Agency level. These include: KSC Wellness Program and Fitness Center, KSC Aerospace Medicine and Occupational Health, Indiana University Purdue University Indianapolis (IUPUI), KSC Web Development, KSC Graphics, KSC Facility Management, KSC Public Affairs, NASA Safety Center, and KSC employees who volunteered for balance testing and training.

Over time, the support for the initiative has become very strong from senior management, at KSC and NASA Headquarters.

9. SUMMARY

The STF Initiative has evolved since 2013 and will be ongoing for years to come. It has gained support from leadership and employees. To make this program sustainable, employees are being empowered to take personal responsibility for preventing STF injuries at work and at home. Over time, KSC’s Safety Culture has been shifting from an expectation that the employer will remove all hazards, to a culture where employees will take action to reduce their risks of injuries. This is being done through changes in attitudes, actions, and an increased sense of personal responsibility.

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