



Down to the Wire:

Freedom Star SRB Recovery

Leadership ViTS Meeting

January 2010

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THE MISHAP

During the Solid Rocket Booster (SRB) recovery for the Space Shuttle mission STS-116, an injury occurred on the retrieval ship MV Freedom Star. On December 12, 2006, the ship was towing a booster into port when the tow wire jumped from its tow chute and struck a nearby crewman. The crewman sustained impact injuries to his abdominal region and minor abrasions to his arms and hands. He was hospitalized for twenty-four days.

Solid Rocket Booster Recovery:

- SRB are recovered by ship after each shuttle launch
- Two SRB retrieval ships: Freedom Star and Liberty Star
- Recovery Process (with diver assistance):
 - Ship arrives at SRB floating upright
 - Parachute and frustum recovered
 - After plugging the exhaust nozzle (beneath the ocean surface), compressed air forces SRB onto side
 - Tow wire connected to SRB
 - Transit back to Port Canaveral with each ship towing one SRB



WHAT HAPPENED?



Tow Chute with (2) pins in place



L to R: 67-Ton shackle replaced 17-Ton shackle

Mission Delays:

- Mechanical problems prior to launch caused the crew to work unplanned repairs and created a compressed timeline to configure ship for SRB recovery
- First Shuttle launch attempt was scrubbed after ship was already in place for recovery
- Adverse weather conditions caused further delays after launch – radar operators transferred to shore by one recovery ship

A First Injury:

- While securing frustum on deck with crane, parachute became entangled
- Frustum jerked unexpectedly and landed on crewman's foot
- Immediate medical evacuation caused additional delays to SRB recovery

The Mishap Occurs:

- As *Freedom Star* approached Port Canaveral, Captain ordered the SRB tow line shortened
- Oversized tow shackle jammed in tow chute and caused tow winch to fail
- After repairing tow winch, Captain ordered crew to pull tow chute pins, to allow the oversized shackle to pass
- During final, right-hand turn, SRB drifted far enough alongside to cause tow wire to jump from tow chute; Crewman injured



PROXIMATE CAUSE

After removing the pins from the tow chute, the crewman lingered nearby, unaware that he had placed himself in a potential path of the wire under load. As the ship made right turns, only the chute resisted the wire's pull toward his side of the deck. Without the pins to keep it in place, the tow wire leaped out of the tow chute and struck the crewman.



ROOT CAUSE / UNDERLYING ISSUES



Lack of Configuration/Physical Controls:

- Crew had regularly improvised, and substituted a larger 67-ton shackle for smaller 17-ton shackle
 - Towing not specifically identified as a hazardous operation, and tow chute pins were not identified as safety barriers, either by labeling or by training
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Hazard Awareness:

- Lack of proper employee hazard awareness training and safety briefing
 - Crew had success in the past, but did not take into account the changing conditions around them
 - Hazard Analysis not initiated as part of configuration change
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Situational Awareness demands on Captain:

- Extremely high workload: coastal navigation, traffic avoidance, medical evacuation, winch repairs, high winds and sea state
 - Schedule pressure: *Freedom Star* had experienced a number of delays and set-backs during mission
 - Fatigue: 16-hour work periods led to sleep deprivation and reduced performance
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Safety and Hazard Analysis:

- Process and configuration changes should trigger reassessment
- Employees should be trained to recognize hazards and encouraged to report them
- We always must consider the wide variety of environments and the large assortment of equipment used for missions

Safety controls:

- Should never be compromised by imposed or perceived deadlines
- “Margin of Safety” should never be lessened needlessly
- Unmitigated hazard identification should be an ongoing process

Human Factors:

- Failure to manage change within high-energy systems may lead to unforeseen consequences
- Individuals that take on multiple monitoring and decision making tasks may lose situational awareness
- Cumulative fatigue will degrade human performance

