

ARES CORPORATION



Lessons Learned and the Importance of a Safety Culture

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Introduction

- ◆ **The space community must ensure that a learning culture is encouraged for the support of continuous improvement in safety**
 - **Lessons learned from other parallel, high reliability industries can augment space mission excellence**
 - **Imbedded in the mindset is that risk management and hazard analysis is not enough to protect a mission**
 - **Each supplier, and agency represents an individual link that support outcome and mission success**



Lessons learned in space programs



Figure 2: Wires where the fire was suspected to have started.



Figure 1: Grissom, White and Chafee.

- Apollo 1 – crew lost in fire
- Challenger – crew lost
- Lewis Satellite – payload lost
- Columbia – crew lost
- Tyura-Tam – personnel and facility lost

Critical Launch and Mission Reviews for Space Missions

- ◆ **There is a lack of repeated failures – we permanently fix the last problem following a failure**
- ◆ **We are highly unlikely to experience a failure mechanism twice**
- ◆ **We know that we will experience another failure – but WHERE and WHEN and WHY?**

Parallel industries with HIGH RELIABILITY and REGULATORY OVERSIGHT – Lessons learned

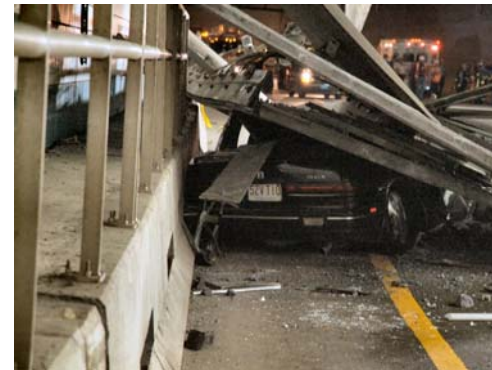
- ◆ Nuclear Energy
- ◆ Submarines
- ◆ Transportation
- ◆ Petroleum Processing



Control rod lodged in ceiling of SL-1 reactor building.



Figure 13. Destroyed trailers west of the blowdown drum (red arrow in upper left of the figure)



Ceiling Collapse in Boston, MA, USA



The propellants self-ignited and exploded the rocket's first stage engine, engulfing dozens in an inferno of toxic fumes.

Nuclear Energy Industry – Case Studies

- ◆ **Highly regulated industry**
- ◆ **Documented oversight, audits, and safety policies**

- ◆ **Chernobyl – lack of emergency response, poor containment plans, risks were not anticipated, thousands of square miles impacted**
- ◆ **Three Mile Island – emergency response plans were rehearsed, redundant safety systems contained event and minimized exposure**

What has this got to do with Space Missions?

Lessons Learned from Nuclear Accidents

- ◆ Specific emergency response plans must be documented
- ◆ Emergency plans should be updated for changes
- ◆ Rehearsal of response imbeds the response plan in the mindset of the workforce

Through rehearsal, review, training, and planning it is possible to control an event and prevent an uncontrolled series of events from becoming a catastrophic failure.

Submarine Industry – Case Studies

- ◆ **Highly regulated industry**
- ◆ **Completely self-contained and life supporting. Very similar to manned space flight**
- ◆ **In 40 years - 2 failures**

- ◆ **USS Scorpion – lack of adequate overhaul budget complicated by compressed schedules, ignored report of issues and continued mission – average overhaul requires approx. 24 months, scorpion was compressed to 6 months**
- ◆ **USS Thresher – operation exceeded design test limits, inadequate ability to respond to emergency**

What has this got to do with Space Missions?

Lessons Learned from Submarine Accidents

- ◆ **Cost cutting and reduced schedule cannot be done in a whole sale method (e.g. a 10 percent reduction across all labor categories) must be tailored**
- ◆ **Cost or schedule savings must be carefully evaluated and risk/hazard analysis updated and reviewed**
- ◆ **The entire supply chain must ensure that limited budgets and schedules are subjected to the same level of review as any design, process, or other factors are evaluated for impact.**
- ◆ **Operational anomalies must be investigated for root cause and corrected to prevent failures**

Transportation Industry – Case Studies

- ◆ **Another highly regulated industry**
- ◆ **Big Dig – Design review decision to trade out one anchor system for a different anchor system led to epoxy failure in a ceiling anchor system failure – ceiling panels fell, killing a vehicle passenger impacted**
- ◆ **Minneapolis Bridge collapses – environmental and load conditions changed and were not re-evaluated, corrosion and traffic weights, exceeding original design requirements that ultimately resulted in bolts and infrastructure failure.**

What has this got to do with Space Missions?

Lessons Learned from Transportation Board Accidents

- ◆ **Design review at initial planning are critical to long term excellence**
- ◆ **Risks must be re-evaluated when**
 - **operating conditions change**
 - **Environmental conditions change**
- ◆ **Material substitution following design review require that thorough risk analysis be undertaken**

Space missions rely on legacy, and long term infrastructure to support mission success.

Petroleum Industry – Case Studies

- ◆ **Highly regulated industry**
- ◆ **Documented oversight, audits, and safety policies**

- ◆ **Texas City, TX, 2005 – Explosion at BP plant kills and injures over 118 people, costs \$2 billion in claims and lost production**
 - **Required audits not performed**
 - **Over-worked personnel**
 - **Safety upgrades slow to be implemented**
 - **Culture of safety not encouraged**

What has this got to do with Space Missions?

Lessons Learned from Refinery Accidents

- ◆ Audits should not be skipped due to budget cuts
- ◆ Immediate implementation of new safety requirements – must be tracked and actively managed
- ◆ Adequate personnel, training, and oversight
- ◆ People must be encouraged to speak up without retribution

Intention to reduce training, resources, budgets, or maintenance must be balanced against risk and hazards.

Safety Culture is Continuously Improved by Lessons Learned

- ◆ **The basis for establishing a safety culture starts with top management commitment.**
- ◆ **All functions must be aware and generate effective review processes to ensure risk is evaluated throughout the entire lifecycle**
- ◆ **The change process must be tightly controlled to ensure effective evaluation and timely response to risk, or other factors that are unacceptable going forward.**
- ◆ **Risk management must identify trends or lessons learned that can be used to reduce risk.**

Safety Culture is Continuously Improved by Lessons Learned

The purpose of a learning organization is to base performance in best practices, continuous improvement and utilization of lessons learned. This institutionalization must be effective in creating a supply chain that relies on strong partners, links, and processes that move in a single minded direction for mission success.