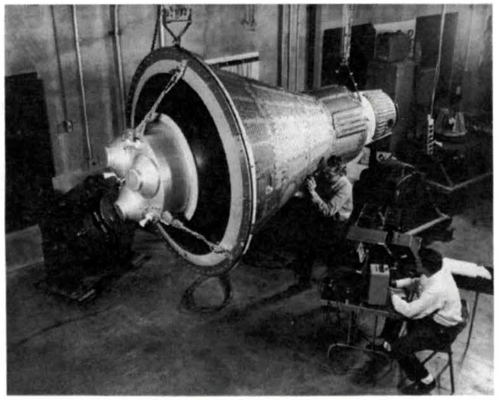
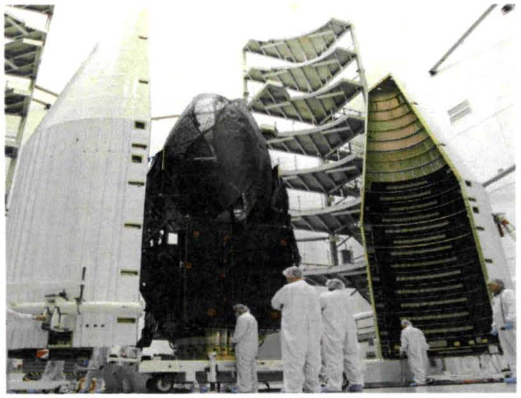
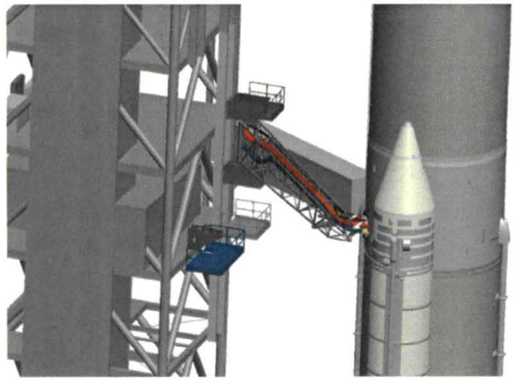
Lessons Learned for Improving Spacecraft Ground Operations







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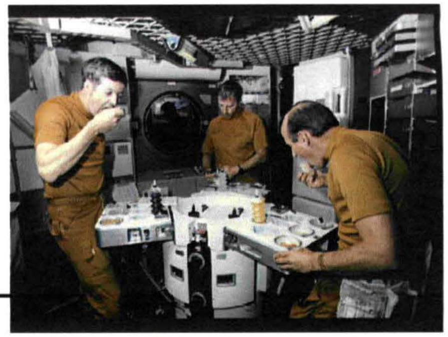
Lessons Learned is

- knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. Both should be considered excellent sources of lessons learned.

Problem Introduction



Throughout NASA's history (Mercury Program, Gemini Program, Apollo Program, Skylab Program, Space Shuttle Program, International Space Station Program, Constellation Program, SLS and Orion Programs) many lessons have been learned.

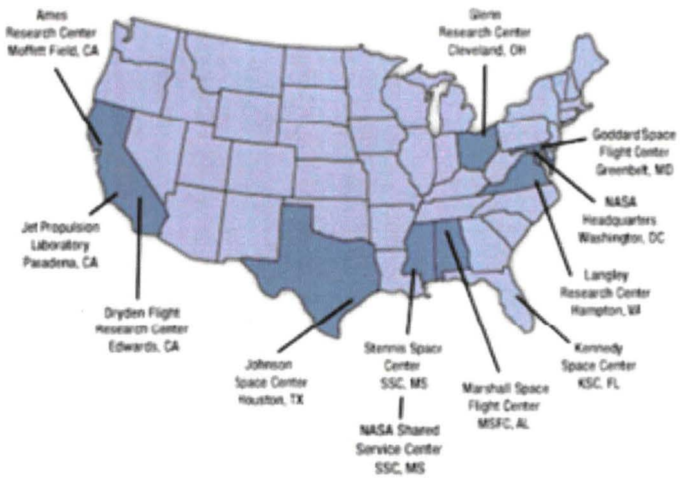
- These lessons deal with very complex and unique systems.
- This knowledge needs to be carried over into new programs.
- The lessons learned may not be needed for several years to come.

Solution

- NASA policy requires each Program or Project to develop a plan for how they will address Lessons Learned.
- Projects have the flexibility to determine how best to promote and implement lessons learned.
- A large project might budget for a lessons learned position to coordinate elicitation, documentation and archival of the project lessons.

The LLIS process

- The lessons learned process crosses all NASA Centers and includes the contactor community.
- The Office of The Chief Engineer at NASA Headquarters in Washington D.C., is the overall process owner, and field locations manage the local implementation.

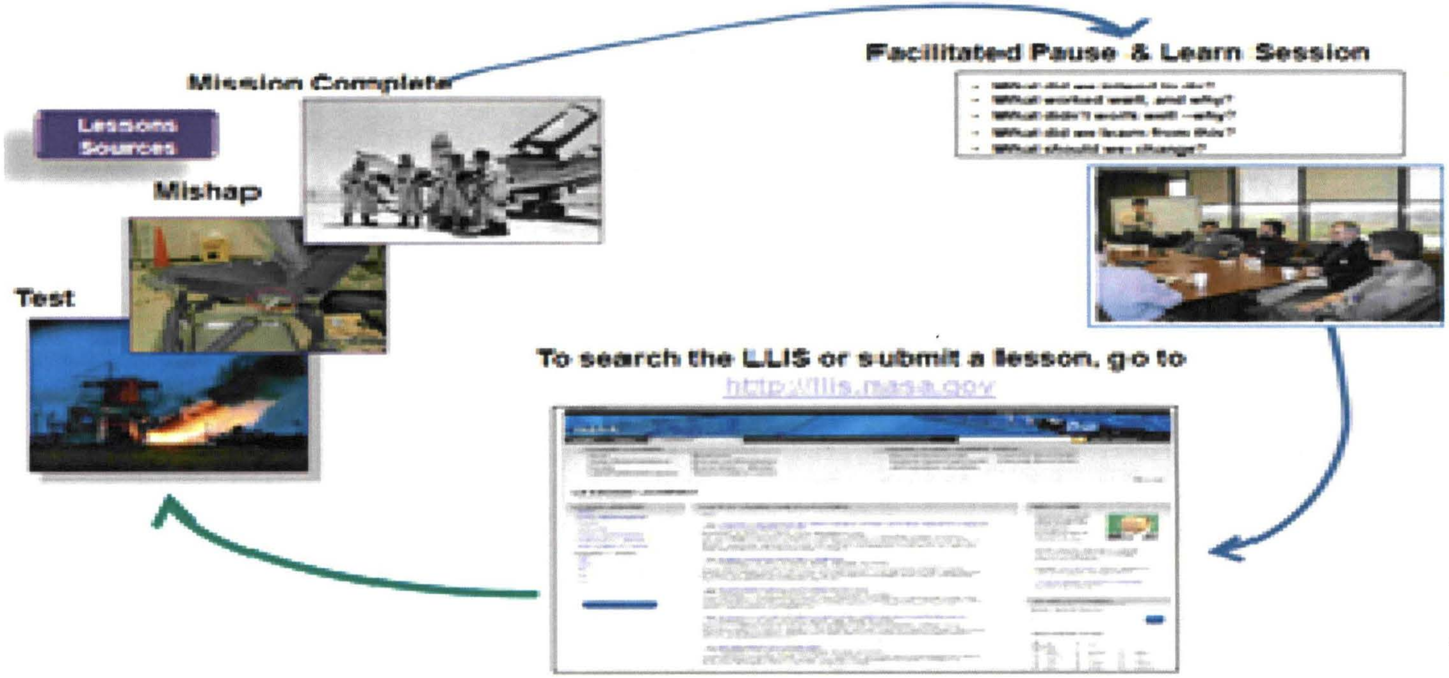


Solution

- One tool used to transfer knowledge between program and projects is the Lessons Learned Information System (LLIS).
- Most lessons come from NASA in partnership with support contractors.
- A search for lessons that might impact a new design is often performed by a contractor team member.
- Knowledge is not found with only one person, one project team, or one organization. Sometimes, another project team, or person, knows something that can help your project or your task.

The LLIS process – Life Cycle

The lessons learned life cycle involves sources such as engineering design teams, mishap reports, research, science, operations, administration, procurement, management, safety, maintenance, training, flight or ground-based systems, facilities, medicine, etc.



The LLIS process – Gathering

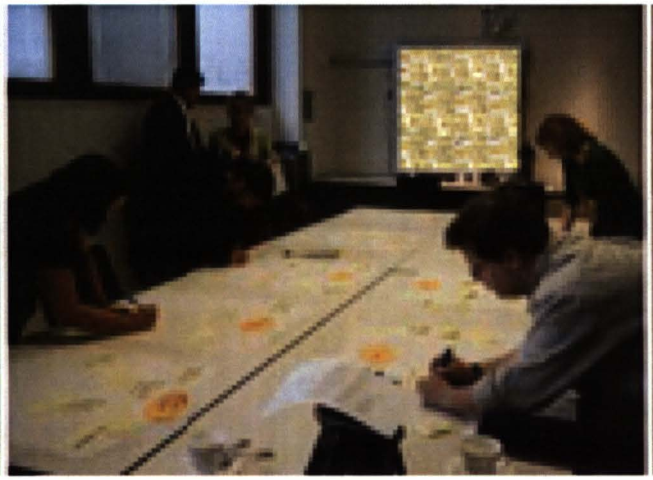
- Key decision points and design milestones are potential lessons learned points.

- The team should try to focus on five questions:
  - What did we intend to do?
  - What worked well and why?
  - What didn't work well and why?
  - What did we learn from this?
  - What should we change?

- These questions and others are used to extract the root causes and contributing factors of the lessons, and then the lessons are submitted for expert peer review for possible inclusion into LLIS.

The LLIS process – Gathering

A successful knowledge-sharing workshop allows all team members to contribute ideas, and discipline leads often "distill" the input down to a few major points for action.


Lesson Learned Components

The date this lesson occurred

A person who would know about this lesson

Includes part of: the event leading to lesson, the lesson, and the recommendations.

Describe the situation leading to the Lesson

What did you learn from this experience?

What do you suggest to others to do in the future?

Related standards or documents

Search terms

Lessons Learned Entry: 1779

Lesson Info:
- Lesson Number: 1779
- Lesson Date: 2007-5-6
- Submitting Organization: KSC
- Submitted by: Michael Bell
- POC Name: Wayne Kee
- POC Email: Wayne.M.Kee@nasa.gov
- POC Phone: 321-867-6723

Subject:

Power Outage

Abstract:

A total loss of power at Orsino Substation occurred at 12:06 pm on Friday March 2, 2007. The power loss affected all facilities south of Schwartz Road at Kennedy Space Center, except the Assembly and Refurbishment Facility (ARF). The cause of the power loss was a failure of Florida Power & Light (FPL) 115KV line feeding the Orsino Substation. FPL arrived at 1:08 pm and rerouted the power and restored service to the Orsino Substation at 1:36 pm. All infrastructure systems came online as expected with no anomalies. Personnel affected by the power outage were released on Administrative leave.

Description of Driving Event:

The cause of the power loss was a failure of Florida Power & Light (FPL) 115KV line feeding the Orsino Substation.

Lesson(s) Learned:

1. Employees were not familiar with the long-standing policy and procedure for evacuating employees with disabilities as described in the Consolidated Comprehensive Emergency Management Plan (CCEMP), JDP-KSC-P-3001.
2. Practical usage of National Incident Management System (NIMS) is needed above training curriculum. Also, the command and control structure changes from the Center Director to the Incident Commander.
3. Personnel should be placed on administrative leave when there is an uncertainty of loss of power duration.
4. Identify facilities that have internal battery operated fire alarm paging systems and utilize these systems to make announcements in the affected areas.

Recommendation(s):

1. NIMS Training will continually be emphasized to our emergency responders at all levels. Follow the National Incident Management System (NIMS) adopted in the CCEMP.
2. Personnel should be placed on administrative leave when there is an uncertainty of loss of power duration. Contributing factors to personnel dismissal: Emergency lighting (only lasting 60-90 minutes during power loss), total darkness in facilities and loss of air conditioning without any backup.
3. Supply PAWS with battery back-up.
4. Adverse weather conditions must be written into appropriate policy especially when personnel egress facilities during emergencies.
5. Assure appropriate emergency lighting sources in stairwells and hallways are available with backup.

Evidence of Recurrence Control Effectiveness:

N/A

Documents Related to Lesson:

KSC Lessons Learned Industrial Area Power Outage, Tech Doc # 07_04_04_0_LLPOWER
Consolidated Comprehensive Emergency Management Plan, (CCEMP) JHB 2000, Rev D
Warning, Alerting and Evacuation, JDP-KSC-P-3001
Fire Response, JDP-KSC-P-3003
Loss of Utilities, JDP-KSC-P-3012

Mission Directorate(s):
- Space Operations

Additional Key Phrase(s):
- Additional Categories. Emergency Preparedness
- Additional Categories. Facilities
- Additional Categories. Fire Protection

Additional Info:
- Project: Emergency Preparedness Program

Approval Info:
- Approval Date: 2007-07-26
- Approval Name: ghenderson
- Approval Organization: HQ

The LLIS process – Review Process

- The goal for review of a new lessons learned entry is to enhance the learning potential from the experience described in the entry.

- The reviewers work with the submitter to provide feedback so the description of the situation is clear and ask technical questions so the write up is accurate.

- The committee reviews the lesson so it has a meaning that can be understood even by those outside of NASA.

The LLIS process – Review Process

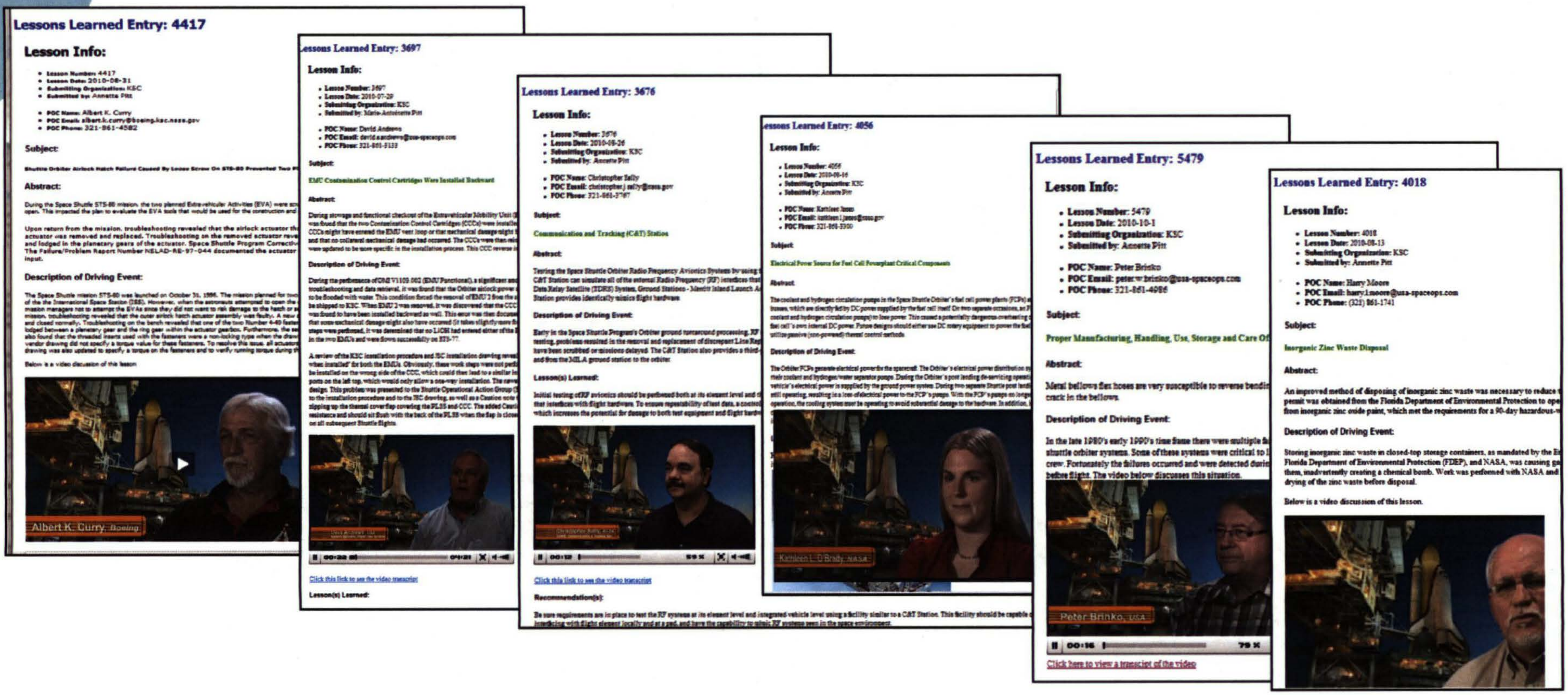
- It is important to provide good situational context information to be able to understand how the lesson could be applied in the future.
- The review team assists the lessons submitter in capturing pertinent details such as;
  - size and magnitude of the project
  - type of project
  - how the team discovered the situation

How Lessons Learned are Shared

Kennedy Engineering Academy Forums are held to disseminate the results to a wide audience.

How Lessons Learned are Shared

As the Space Shuttle Program was ending, lessons learned were recorded in a video format, using interviews to bring out more context and background information. In addition, visual and audio aids contribute to the learning process. The videos are included as part of the lessons learned entry.



Lessons Use – Systems Engineering

- As part of the entrance criteria for design reviews, projects query the lessons learned information system to determine which lessons might impact their project design.
- A lessons learned search may spark additional questions to be researched or investigated
- Past lessons learned submitters may be contacted or consulted on the new design.
- The LLIS can serve as an expert locator or knowledge matching engine

Examples of Lessons Learned

The design process for KSC subsystems in various stages of the design cycle were sampled for this paper.

- For 8 of the systems, between 1 and 41 different search terms were used to search the LLIS (median of 9 different search terms used)
- These searches resulted in 4 to 270 "hits."
- The team must review these search results and decide how to apply the information.

Examples of Lessons Learned

- The following table shows how often the development teams have applied the recommendations they found by using the LLIS.

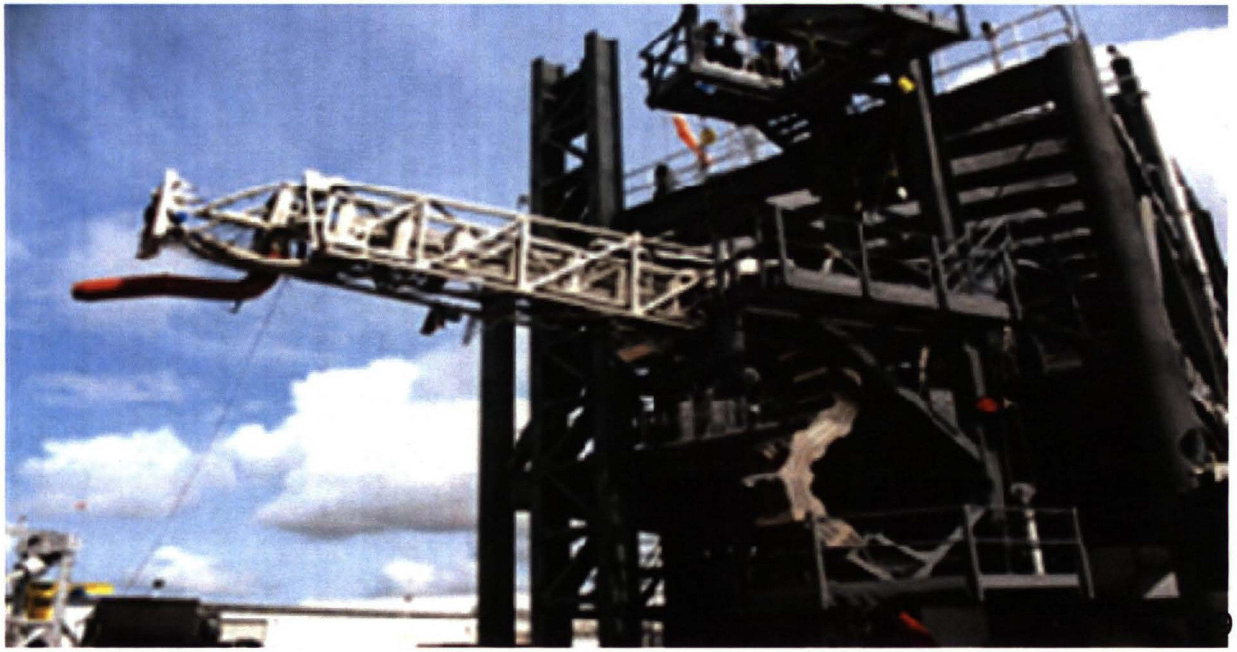
Project Name	Search Results Returned	Results Utilized	% Results Utilized
Mobile Launcher Cryogenic Systems Design LH_2 System	18	18	100%
Mobile Launcher Cryogenic Systems Design LO_2 System	52	14	27%
Tail Service Mast Umbilical (TSMU), Mobile Launcher Element	4	4	100%
Offline Processing Integration High Pressure Gas Servicing	270	39	14%
Mobile Launcher, Breathing Air System	90	38	42%

Vehicle Support Post (VSP) team

- The Vehicle Support Post (VSP) team focused on gathering all relevant information for better planning and improving the design and implementation of the VSP subsystem while preventing or minimizing risks to the VSP project.
- A search of the database returned Lessons Learned Entry 0588, Solid Rocket Booster (SRB) Holddown Post Incident.
- The team used this lesson to improve shipping/handling pallets and containers to provide adequate restraint of the VSP.

Vehicle Support Post (VSP)

- This lesson concerned an expensive piece of ground support equipment hardware that slid off a forklift while it was being moved up a slight ramp at the Launch Equipment Test Facility



Tail Service Mast Umbilical (TSMU) team

- The lessons were evaluated by the design team for applicability.

Project Name	Search Results Returned	Results Utilized	% Results Utilized
Tail Service Mast Umbilical (TSMU), Mobile Launcher Element	4	4	100%

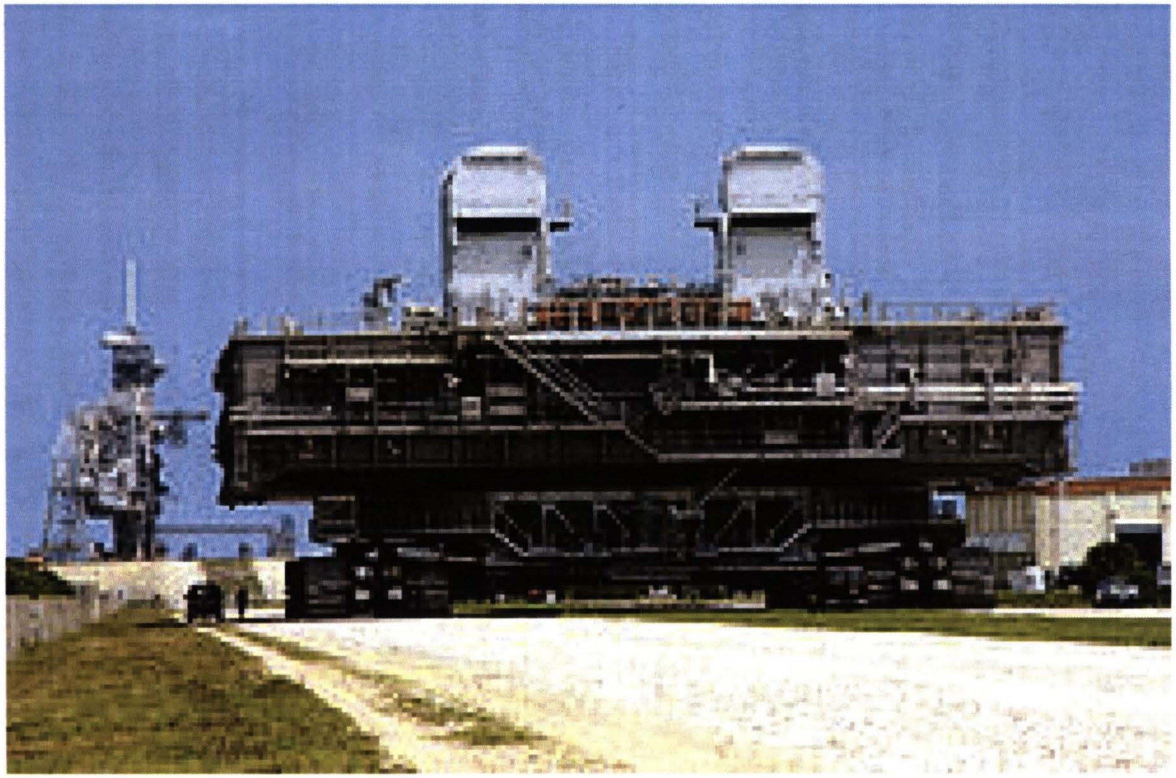
Tail Service Mast Umbilical (TSMU) lesson actions are listed below

- Focus on designing personnel access and safety limits.
- Coordinate with the Hazardous Gas (HazGas) Subsystems project team to determine an efficient configuration of HazGas sensors to minimize risks.
- Use a new release mechanism that eliminates the safety hazards associated with explosives, and provides a cost savings, by being reusable.
- Use mechanical positioning mechanisms to perform the mating of the ground umbilical.

The Mobile Launcher Cryogenic LO2 Systems

- The design team searched the LLIS and was able to apply 14 relevant recommendations from the 52 items they reviewed, resulting in 27% utilization.
- A sample of recommendations from the lessons are listed below;
  - Minimize leakage by utilizing welded connections, pneumatic systems for controlling cryogenic valves, and purging system for valves flowing LH2 (from Lessons Learned Entry: 0034).
  - Design/install a new leak detector sensor console to accommodate additional leak detectors (from Lessons Learned Entry: 0107).
  - Design and install permanent safe access platforms (from Lessons Learned: 0112).
  - Design a mechanism that will prevent the ET GH2 vent arm from rebounding back into an SRM (from Lessons Learned Entry: 0157).
  - Perform outdoor wind tunnel testing of vent/relief valve to provide data, quantifying leak rates below which the hazard is eliminated (from Lessons Learned Entry 0184).

Mobile Launcher Breathing Air System



Project Name	Search Results Returned	Results Utilized	% Results Utilized
Mobile Launcher Cryogenic Systems Design LO_2 System	52	14	27%

Summary

- Knowledge sharing is an everyday activity at the Kennedy Space Center through storytelling, Kennedy Engineering Academy presentations and through searching the Lessons Learned Information system.

- Project teams search the lessons repository to ensure the best possible results are delivered.

- The ideas from the past are not always directly applicable but usually spark new ideas and innovations.

Summary

- Teams have a great responsibility to collect and disseminate these lessons so that they are shared with future generations of space systems designers.

- Leaders should set a goal for themselves to host a set numbers of lesson learned events each year and do more to promote multiple methods of lessons learned activities.

- High performing employees are expected to share their lessons, however formal knowledge sharing presentation are not the norm for many employees.

References

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- [4] Kristen Purcell, Joanna Brenner, Lee Rainie. Search Engine Use 2012, Pew Internet & American Life Project, Mar 9, 2012, http://pewinternet.org/Reports/2012/Search-Engine-Use-2012.aspx , accessed October 10,2012, .

Acknowledgements

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