Capturing Space Shuttle & International Space Station Knowledge for Exploration Systems: Lessons Learned

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"It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so."
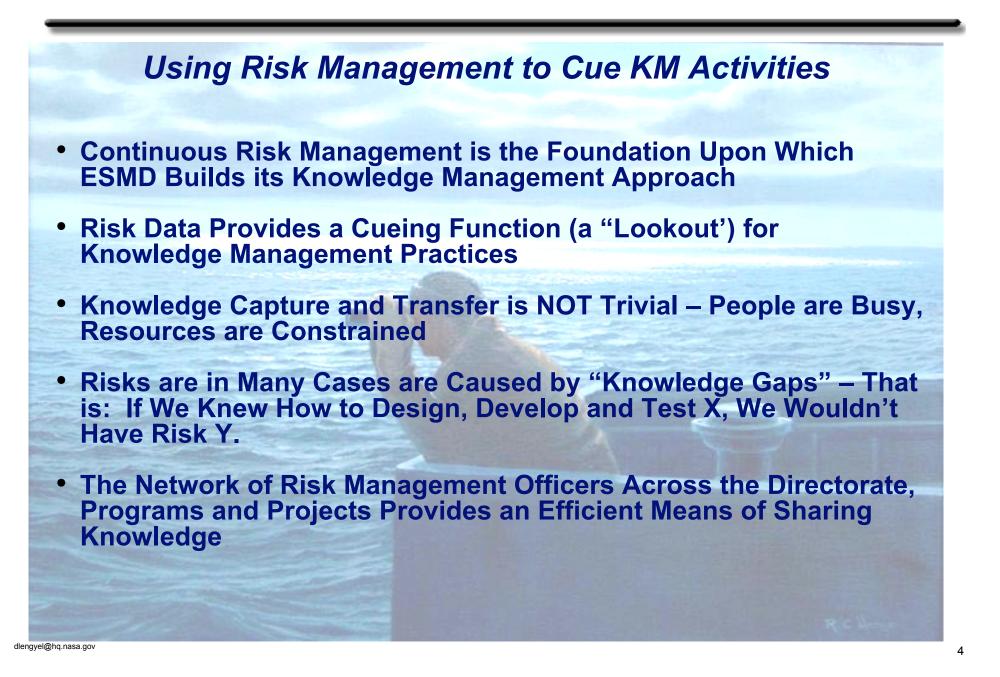
Mark Twain

Knowledge Transfer 101

<u>Knowledge May Be Transferred By:</u>

- **Transferring People With The Knowledge**
- **Peer Assists**
- **Knowledge Sharing Forums**
- **Coaching / Mentoring**
- **Focused Training**
- **Codifying Lessons in Programs Documents, Procedures, Standards and Other Command Media**
- **Case Studies**
- **Narrative Reports**
- **Lessons Learned Databases**
- **Other**

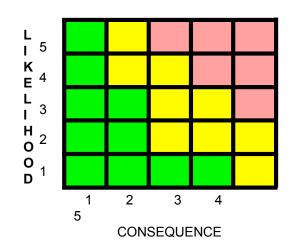*We Have Done Many of These Things!*

So Tell Me Something New….!

ESMD Strategy: Integrated Risk & Knowledge Management

Using Risk Management to Cue KM Activities

- **Continuous Risk Management is the Foundation Upon Which ESMD Builds its Knowledge Management Approach**

- **Risk Data Provides a Cueing Function (a "Lookout') for Knowledge Management Practices**

- **Knowledge Capture and Transfer is NOT Trivial – People are Busy, Resources are Constrained**

- **Risks are in Many Cases are Caused by "Knowledge Gaps" – That is: If We Knew How to Design, Develop and Test X, We Wouldn't Have Risk Y.**

- **The Network of Risk Management Officers Across the Directorate, Programs and Projects Provides an Efficient Means of Sharing Knowledge**

Integrated Risk & Knowledge Management Practices

Practice 1: Continuous Risk Management

Practice 2: Process 2.0

Practice 3: Knowledge-Based Risks

Practice 4: Web-Enabled Teams

Practice 5: Knowledge Sharing Forums

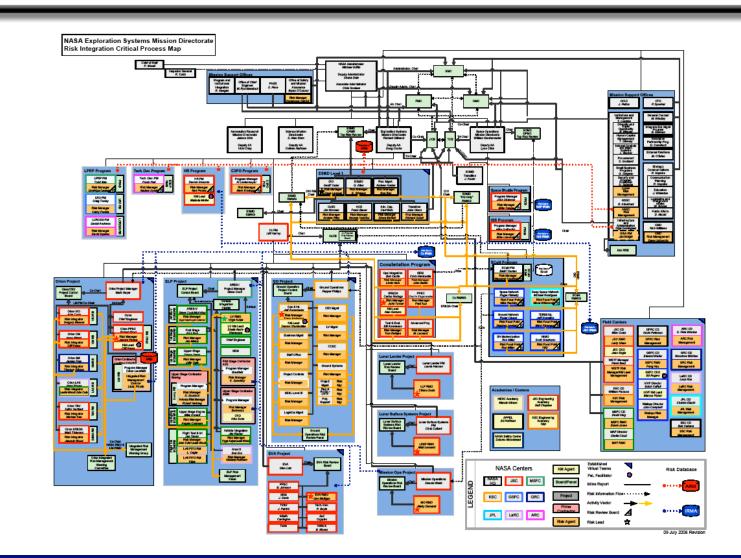**Practice 6: Risk Management Case Studies**

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Practice 1: Continuous Risk Management (CRM)

- **CRM is performed at all levels (Directorate, Program, Project, and below)**

- **Utilizing an enterprise risk management approach**

- **Perform horizontal integration thru extensive network of risk management working groups**

- **Perform vertical integration thru escalation process**

- **Approximately 1000 open risks across ESMD**

ESMD Risk Management Critical Process Map

…..understanding critical information pathways and organizational interfaces…….

Definition

Knowledge-Based Risk *n.*

1. A risk record, with associated knowledge artifacts, that provides a story-telling narrative of how this risk was mitigated – and – what worked or didn't work.

2. A means of transferring knowledge in a risk context.

Knowledge-Based Risks Strategy

1. Integrates the existing Continuous Risk Management (CRM) paradigm with knowledge management
2. Convey risk-related lessons learned and best practices to ESMD personnel
3. Focuses on integrating transfer of knowledge through existing work processes – is recursive in nature
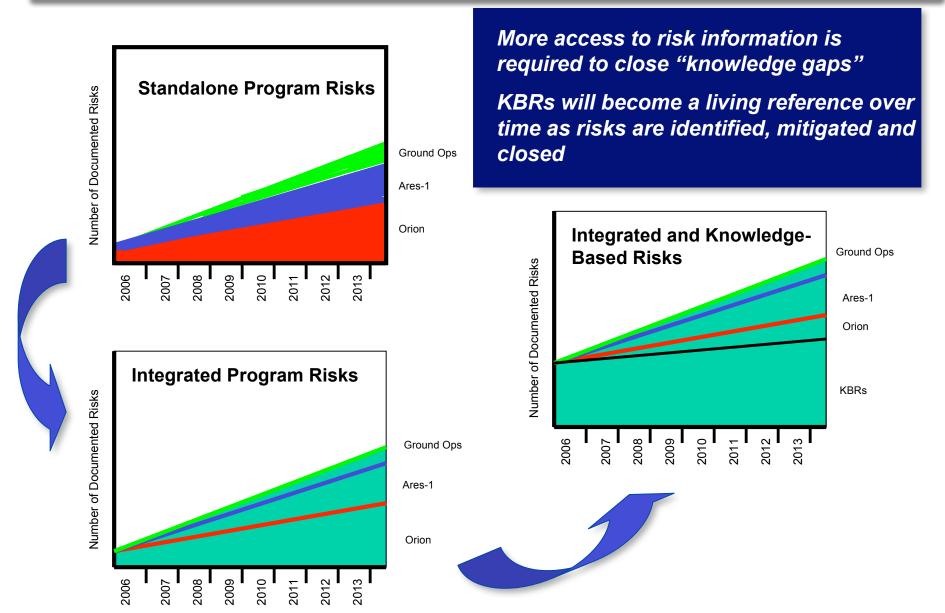4. Does not add an additional burden to the workforce to incorporate new KM tools and concepts

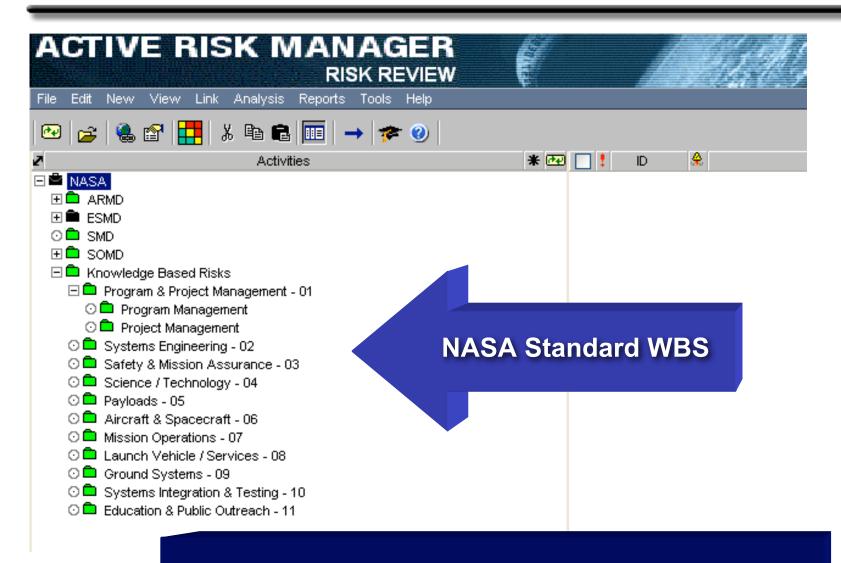**Perform CRM…**

Capture Lessons…
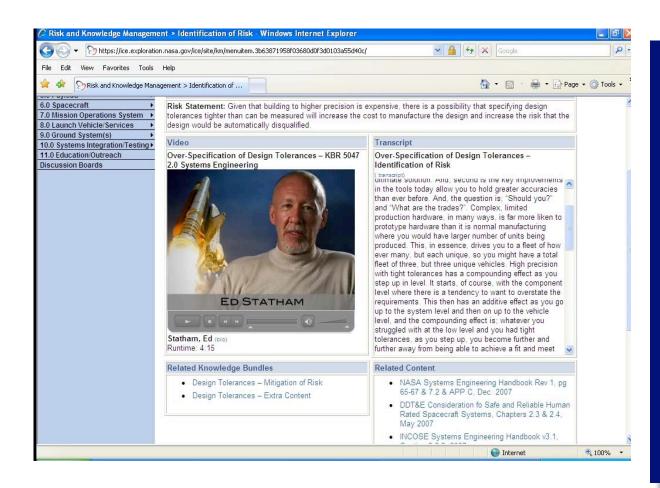
Reuse…

Repeat…

Knowledge-Based Risks Over Time

Standalone Program Risks

Number of Documented Risks

Ground Ops
Ares-1
Orion

2006 2007 2008 2009 2010 2011 2012 2013

More access to risk information is required to close "knowledge gaps"

KBRs will become a living reference over time as risks are identified, mitigated and closed

Integrated and Knowledge-Based Risks

Number of Documented Risks

Ground Ops
Ares-1
Orion
KBRs

2006 2007 2008 2009 2010 2011 2012 2013

Integrated Program Risks

Number of Documented Risks

Ground Ops
Ares-1
Orion

2006 2007 2008 2009 2010 2011 2012 2013

Knowledge-Based Risks in Risk Tool

Knowledge-Based Risks in Portal

- **Embedded 3-5 min Video Nugget with Transcript**

- **Related Knowledge Bundles**

- **Related Content – Reports, Documents, etc.**

- **Threaded Discussion (Blog) Feature Allows Comments on Each KBR**

- **Hosted on ESMD R&KM portal**

https://ice.exploration.nasa.gov/ice/site/km/kbr/

Examples of Station and Shuttle KBRs Captured to Date

Station KBRs

- Exceeding Acoustic Levels Inside Spacecraft
- Integrating Redundancy into Highly Reliable Systems
- Failures of On-Orbit Mated Interfaces Can Affect Mission Success
- Insufficient Stowage Space Within Crew Habitable Areas
- Fasteners Seizing or Binding On Orbit
- Improper Application and Verification of Bolted Fasteners
- ISS Flight Elements Not Mating and Functioning On Orbit
- SARG (Candidate)
- ECLSS (Candidate)

Shuttle KBRs

- Metal [Tin] Whiskers
- Adequate Instrumentation
- Factors of Safety
- Over-Specification of Design Tolerances
- Orbiter Corrosion
- Missions Execution within the Vehicle's Capabilities and Constraints
- Mission Planning Lessons Learned from NASA's Heritage Programs
- Complex problem resolution procedures delay processing
- Cumbersome Pedigree Maintenance
- Confusing Codes in PRACA Database
- Space Systems Operations Criteria Compendium of MOD Lessons Learned
- COPVs (Candidate)
- ECO Sensor (Candidate)
- Flow Control Valves (Candidate)

Practice 5: Knowledge Sharing Forums / Techniques

Knowledge Sharing Forums and Workshops:
- **Subject Matter Experts and senior project leaders share their insights, what they learned and what they might have done differently based on project experience.**
- **ESMD typically captures these forums and workshops in video / audio and posts to portal**
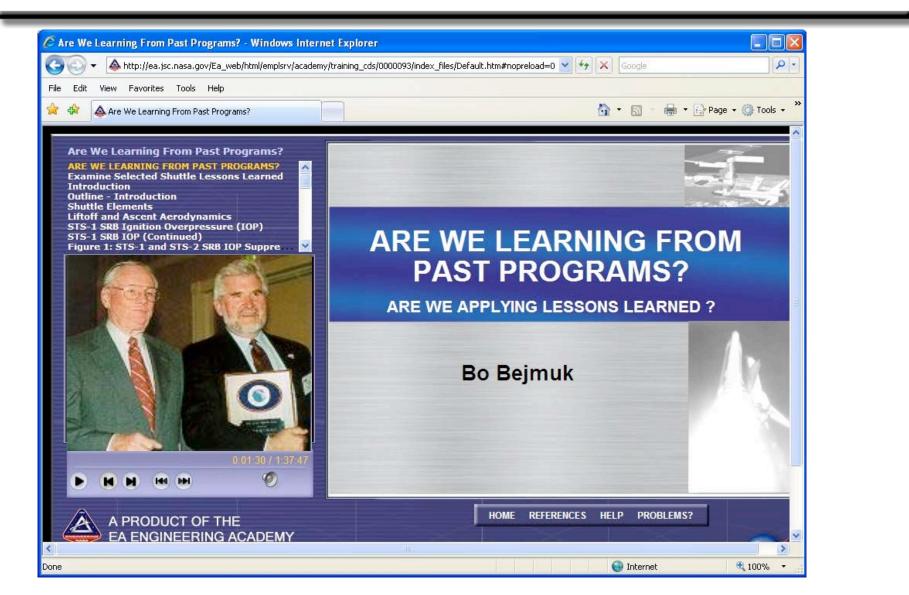
ESMD Alumni Sharing Events:
- **These events bring in alumni from Apollo, Space Shuttle, and other programs to discuss their experiences and lessons learned**
- **ESMD has invited selected alumni to brown bag lunches and other lessons learned forums**

APPEL Master's Forums:
- **Conducted twice annually**
- **ESMD has and will continue to participate in these events**

Knowledge Café technique (small group, structured and unstructured discussion and brainstorming) have been used to complement ESMD knowledge sharing events

Space Shuttle Knowledge Sharing Forum

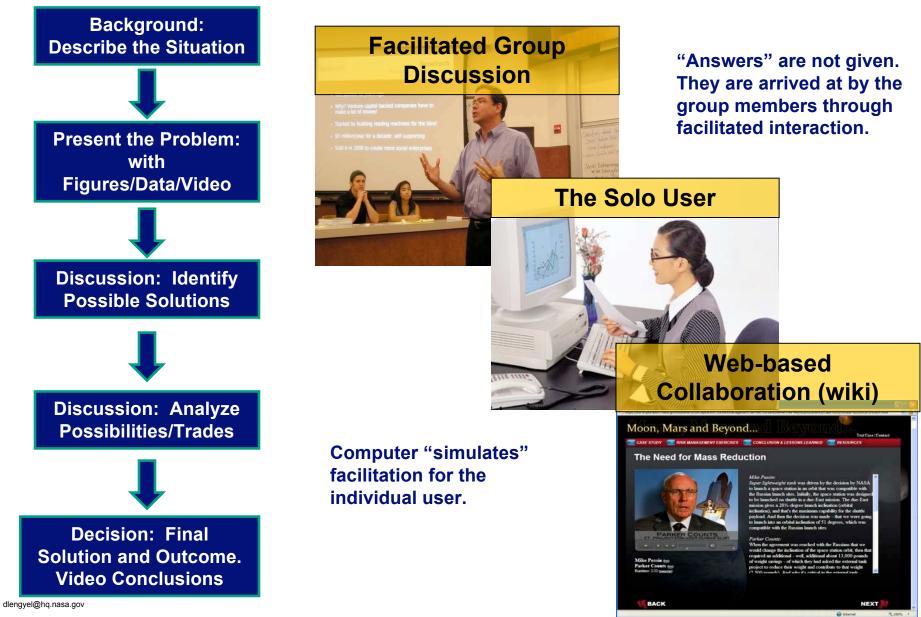http://ea.jsc.nasa.gov/Ea_web/HTML/emplsrv/academy/training_cds/detail.asp?vid=93

Practice 6: Risk Management Case Studies

- **Given the number of control mass-related risks in our system, ESMD developed our first <u>risk management</u> case study using the Shuttle Program's Super Light Weight Tank (SLWT) Project (weight reduction effort) .**

- **These cases are intended to highlight key transferrable aspects of risk management, which may vary slightly from a particular case study to the next. Transferrable principles include the identification of risks, evaluation of risks, mitigation of risks, risk trades, and risk management processes.**

<u>RM cases are divided into four sections:</u>

- **Case Study (Reading Package / Charts / Video Content)**
- **Risk Management Exercises (Identification / Mitigation Planning)**
- **Conclusions and Lessons Learned**
- **Resources**

Risk Management Case Studies – Structure & Delivery

Background: Describe the Situation

⬇

Present the Problem: with Figures/Data/Video

⬇

Discussion: Identify Possible Solutions

⬇

Discussion: Analyze Possibilities/Trades

⬇

Decision: Final Solution and Outcome. Video Conclusions

Facilitated Group Discussion

The Solo User

Web-based Collaboration (wiki)

"Answers" are not given. They are arrived at by the group members through facilitated interaction.

Computer "simulates" facilitation for the individual user.
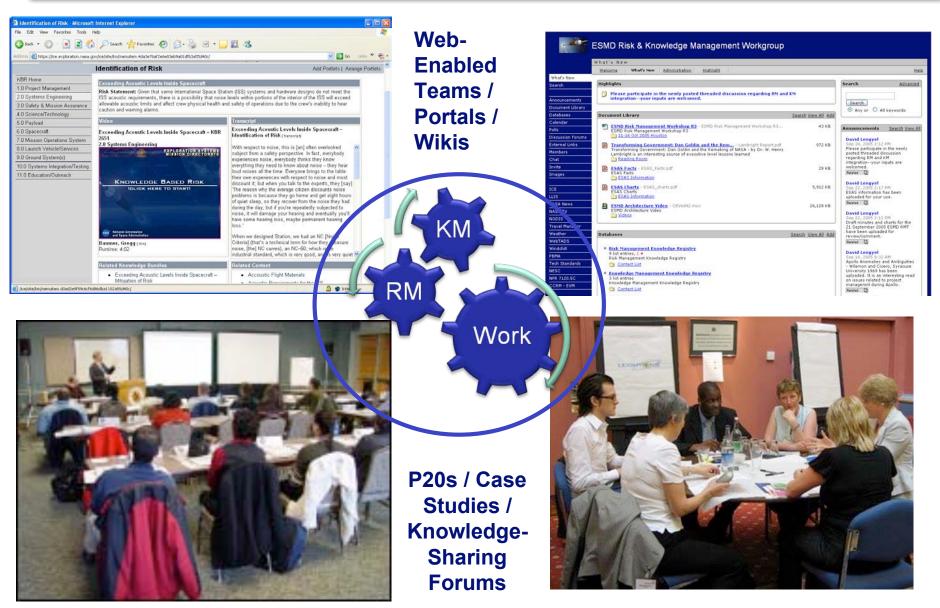
Super Light Weight Tank Case Study

https://ice.exploration.nasa.gov/ice/site/km/cs/

ESMD RM cases studies are portal-based, multi-media teaching aids

The desired learning objectives include: understanding complex technical and programmatic issues in a risk management framework; demonstrating risk identification and mitigation planning capabilities
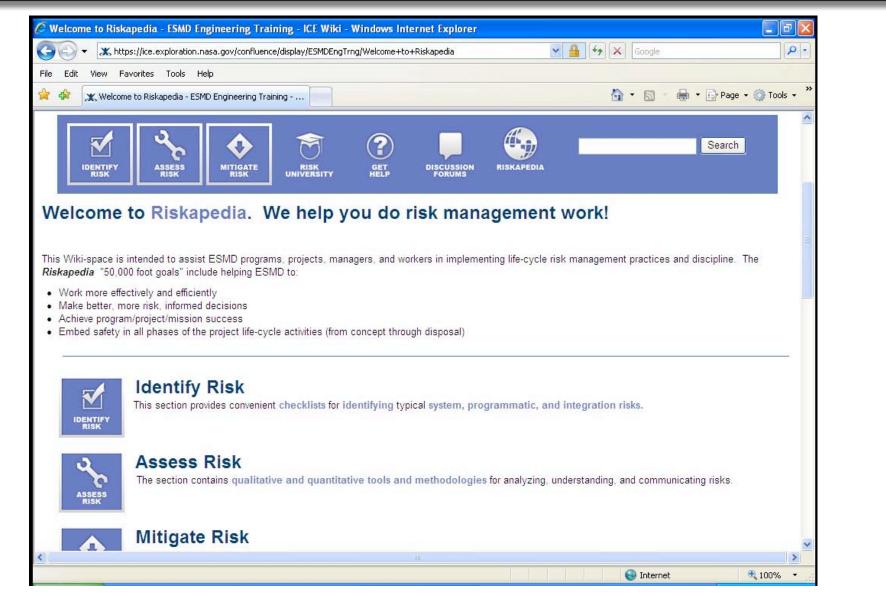
Cases may be instructor-led or self-paced (or a combination of both)

Fusion of Risk and Knowledge Management to Enable Effective Work

Web-Enabled Teams / Portals / Wikis

P20s / Case Studies / Knowledge-Sharing Forums

What's On The Horizon? Riskapedia

https://ice.exploration.nasa.gov/confluence/display/ESMDEngTrng/Welcome+to+Riskapedia

Top Risk & Knowledge Management Lessons to Date

- **Maintain the focus on enabling the accomplishment of WORK**

- **Integrate KM practices with critical work processes (CRM, SE, etc.)**

- **Employ risks as a "*cueing function*" for knowledge capture / transfer**

- **Emphasize learning through conversation**

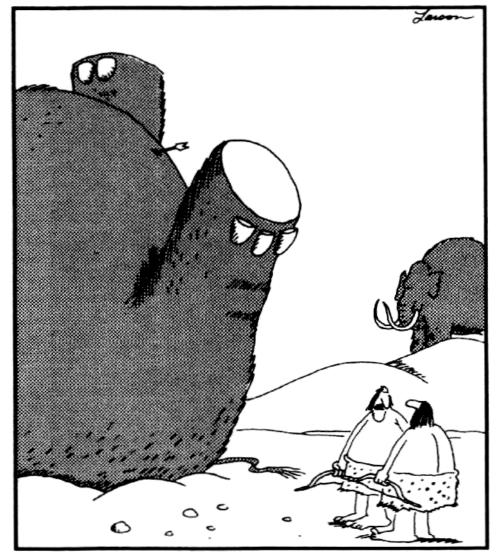- **Respect ISS / SSP engineer's / managers time for knowledge capture**

- **Use the network of risk managers to push / pull knowledge**

- **Maximize existing tool functionality as a "knowledge base"**

- **Recognize that collaboration is a *resource multiplier***

- **Never forget lesson #1**

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"**You've got to be very careful if you don't know where you're going, because you might not get there.**"

[Yogi Berra](#)

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Questions?

"We should write that spot down."

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Additional Resources

ESMD Risk & Knowledge Management Portal: https://ice.exploration.nasa.gov/ice/site/km/

ESMD Risk & Knowledge Management Wiki:

https://ice.exploration.nasa.gov/confluence/display/ESMDRiskAndKM/Home

JSC Knowledge On-Line: http://knowledge.jsc.nasa.gov/

JSC Engineering Academy: http://ea.jsc.nasa.gov/Ea_web/html/emplsrv/academy/index.asp

Shuttle Portal: https://sspweb.jsc.nasa.gov/

ISS Portal: http://iss-www.jsc.nasa.gov/ss/issapt/

MOD Apollo Training Material:

http://modspops.jsc.nasa.gov/mod/DA4/CxTraining/Apollo/TrainingMaterial/default.aspx

MOD Apollo Familiarization Wiki:

http://modspops.jsc.nasa.gov/mod/DA4/CxTraining/Apollo/Apollo%20Wiki/Home.aspx

NESC Academy: http://www.nescacademy.org/home/index.aspx

Launch Space Systems e-Library (LASSE): https://lasse.msfc.nasa.gov (Contact MSFC/Eric Hyde for Access)

U.S. Space & Rocket Center Archives: http://www.ussrc.uah.edu/

Process-Based Mission Assurance (PBMA): http://pbma.nasa.gov/

Government Accountability Office: http://gao.gov/index.html

NASA Lessons Learned information System: http://nen.nasa.gov/portal/site/llis/LL/