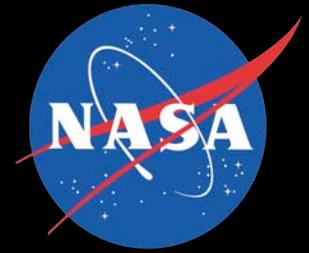


# *Capturing Space Shuttle & International Space Station Knowledge for Exploration Systems: Lessons Learned*



**David M. Lengyel**  
Risk and Knowledge Management Officer  
Exploration Systems Mission Directorate  
NASA Headquarters

**APPEL Masters Forum 18**  
**Cocoa Beach, Florida**  
**14 May 2009**



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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**

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# *Knowledge Transfer 101*

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## Knowledge May Be Transferred By:

- **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***

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## ***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*

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**Practice 1: Continuous Risk Management**

**Practice 2: Process 2.0**

**Practice 3: Knowledge-Based Risks**

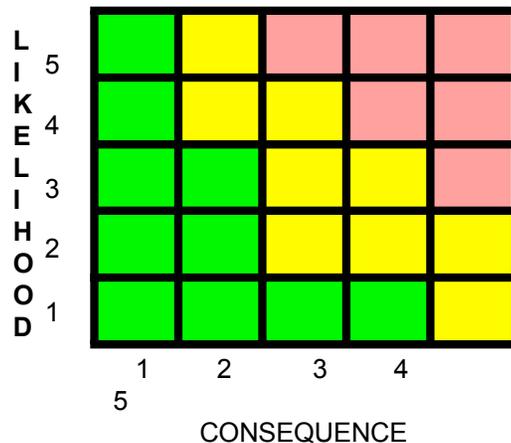
**Practice 4: Web-Enabled Teams**

**Practice 5: Knowledge Sharing Forums**

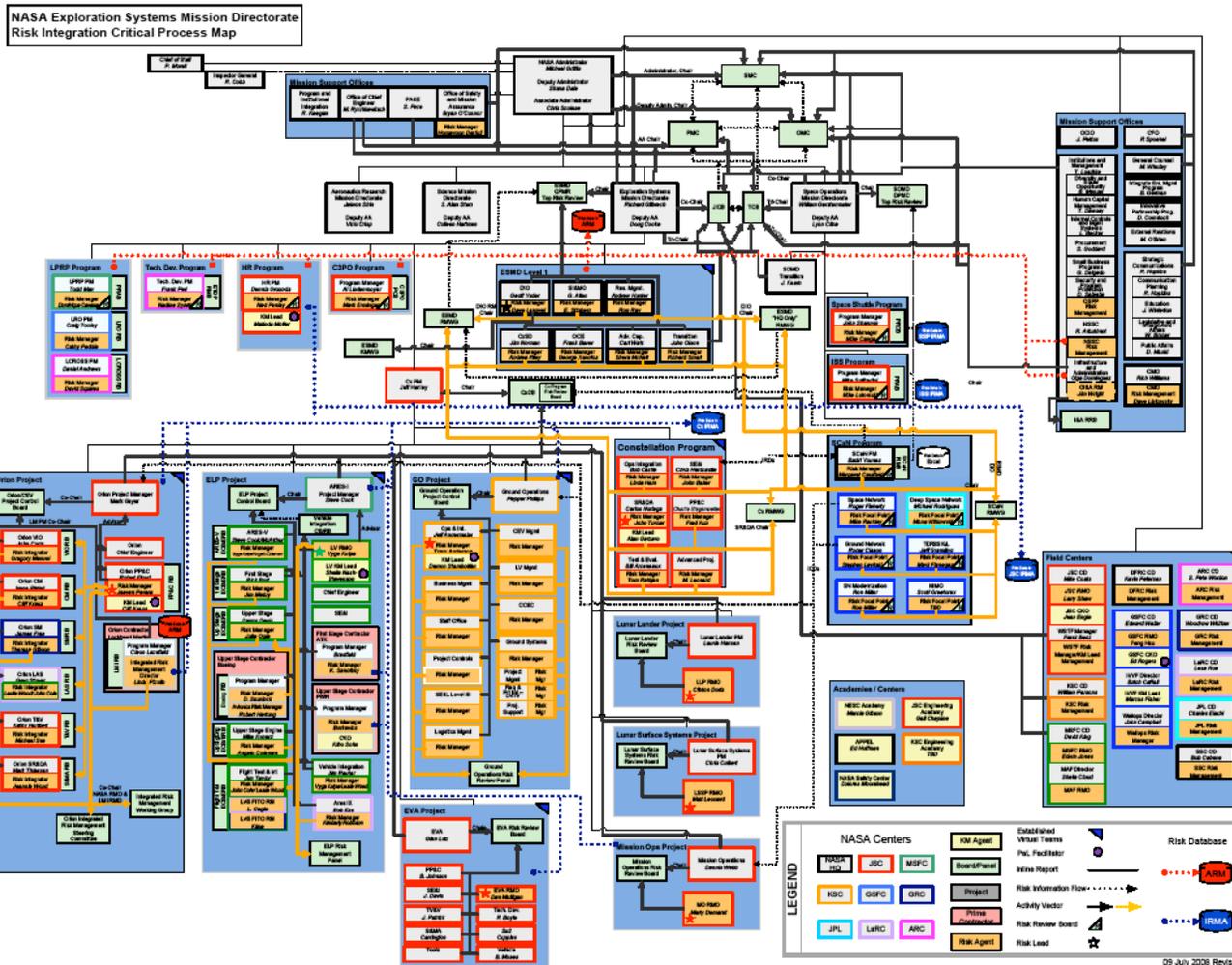
**Practice 6: Risk Management Case Studies**

# 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.....

## ***Practice 3: Knowledge-Based Risks***

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### ***Definition***

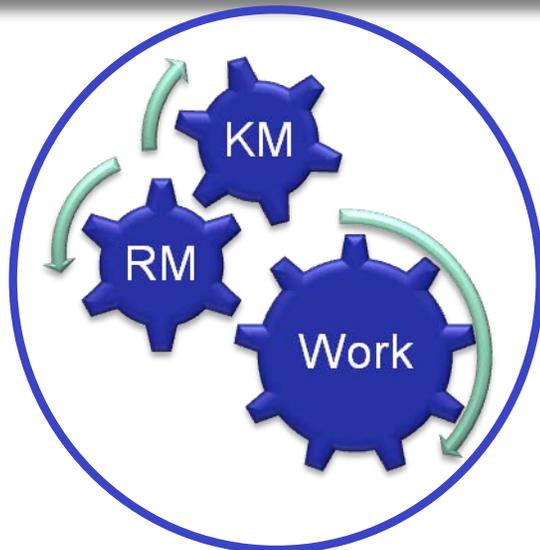
#### **Knowledge-Based Risk *n.***

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***

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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...**

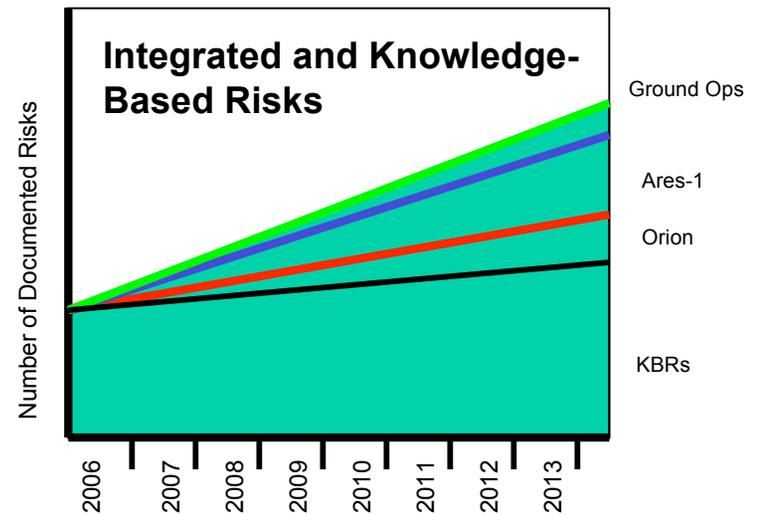
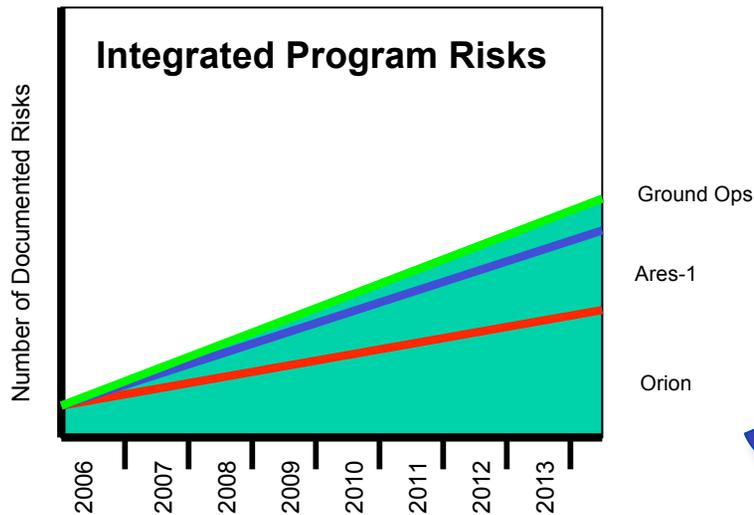
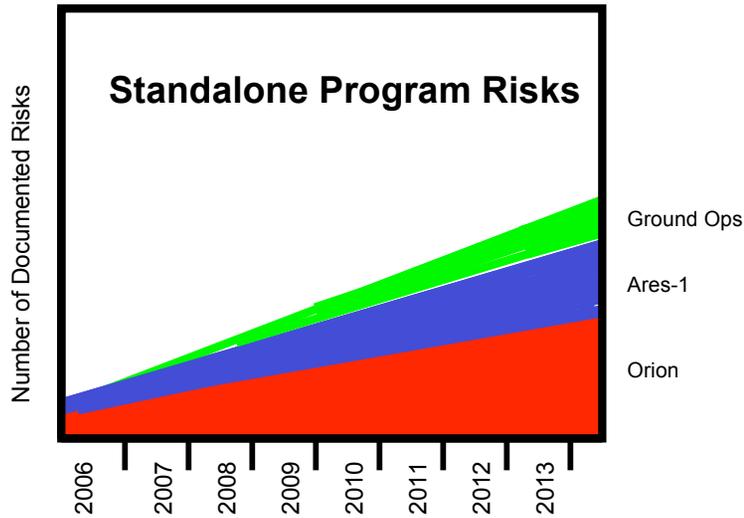
**Capture Lessons...**

**Reuse...**

**Repeat...**

# Knowledge-Based Risks Over Time

*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*



# Knowledge-Based Risks in Risk Tool

**ACTIVE RISK MANAGER**  
RISK REVIEW

File Edit New View Link Analysis Reports Tools Help

Activities

- NASA
  - ARMD
  - ESMD
  - SMD
  - SOMD
  - Knowledge Based Risks
    - Program & Project Management - 01
      - Program Management
      - Project Management
    - Systems Engineering - 02
    - Safety & Mission Assurance - 03
    - Science / Technology - 04
    - Payloads - 05
    - Aircraft & Spacecraft - 06
    - Mission Operations - 07
    - Launch Vehicle / Services - 08
    - Ground Systems - 09
    - Systems Integration & Testing - 10
    - Education & Public Outreach - 11

**NASA Standard WBS**

**ARM allows automated delivery of new KBRs**

# Knowledge-Based Risks in Portal

**Risk Statement:** Given that building to higher precision is expensive, there is a possibility that specifying design tolerances tighter than can be measured will increase the cost to manufacture the design and increase the risk that the design would be automatically disqualified.

**Video:** Over-Specification of Design Tolerances – KBR 5047 2.0 Systems Engineering

**Transcript:** Over-Specification of Design Tolerances – Identification of Risk

**Related Knowledge Bundles:**

- Design Tolerances – Mitigation of Risk
- Design Tolerances – Extra Content

**Related Content:**

- NASA Systems Engineering Handbook Rev 1, pg 65-67 & 7.2 & APP C, Dec. 2007
- DDT&E Consideration fo Safe and Reliable Human Rated Spacecraft Systems, Chapters 2.3 & 2.4, May 2007
- INCOSE Systems Engineering Handbook v3.1.

- 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***

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## **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***

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## **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

Are We Learning From Past Programs? - Windows Internet Explorer

http://ea.jsc.nasa.gov/Ea\_web/html/emplsrv/academy/training\_cds/0000093/index\_files/Default.htm#nopreload=0

File Edit View Favorites Tools Help

Are We Learning From Past Programs?

Are We Learning From Past Programs?  
ARE WE LEARNING FROM PAST PROGRAMS?  
Examine Selected Shuttle Lessons Learned  
Introduction  
Outline - Introduction  
Shuttle Elements  
Liftoff and Ascent Aerodynamics  
STS-1 SRB Ignition Overpressure (IOP)  
STS-1 SRB IOP (Continued)  
Figure 1: STS-1 and STS-2 SRB IOP Suppre...

0 01:30 / 1:37:47

A PRODUCT OF THE  
EA ENGINEERING ACADEMY

HOME REFERENCES HELP PROBLEMS?

Done Internet 100%

[http://ea.jsc.nasa.gov/Ea\\_web/HTML/emplsrv/academy/training\\_cds/detail.asp?vid=93](http://ea.jsc.nasa.gov/Ea_web/HTML/emplsrv/academy/training_cds/detail.asp?vid=93)

## ***Practice 6: Risk Management Case Studies***

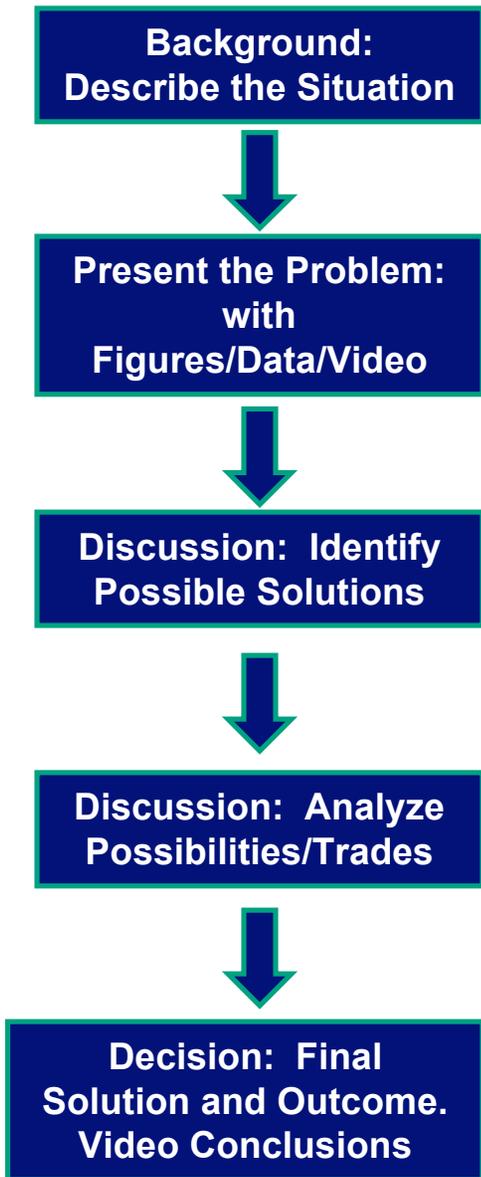
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- Given the number of control mass-related risks in our system, ESMD developed our first risk management case study using the Shuttle Program's Super Light Weight Tank (SLWT) Project (weight reduction effort) .
- These cases are intended to highlight 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.

### RM cases are divided into four sections:

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

# Risk Management Case Studies – Structure & Delivery



**Facilitated Group Discussion**

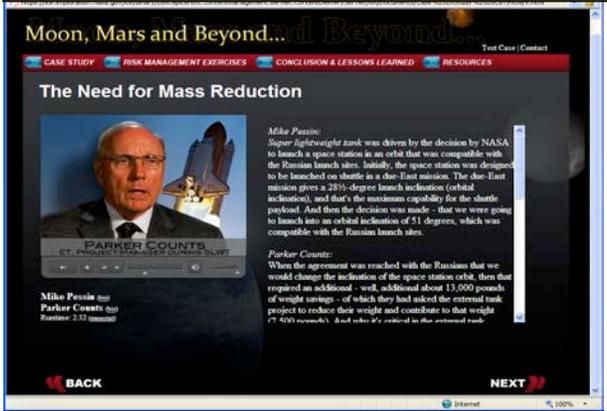
“Answers” are not given. They are arrived at by the group members through facilitated interaction.



**The Solo User**

**Web-based Collaboration (wiki)**

Computer “simulates” facilitation for the individual user.



# Super Light Weight Tank Case Study

ESMD Case Study - Windows Internet Explorer  
https://ice.exploration.nasa.gov/ice/binary/com.epicentric.contentmanagement.servlet.ContentDeliveryServlet/km/Documents/Case%2520Study%2520CBT/html/9.html

## Moon, Mars and Beyond...

Text Case | Contact

CASE STUDY RISK MANAGEMENT EXERCISES CONCLUSION & LESSONS LEARNED RESOURCES

### The Need for Mass Reduction

**PARKER COUNTS**  
ET, PROJECT MANAGER DURING SLWT

**Mike Pessin** (bio)  
**Parker Counts** (bio)  
Runtime: 2:32 (transcript)

**Mike Pessin:**  
*Super lightweight tank* was driven by the decision by NASA to launch a space station in an orbit that was compatible with the Russian launch sites. Initially, the space station was designed to be launched on shuttle in a due-East mission. The due-East mission gives a 28½-degree launch inclination (orbital inclination), and that's the maximum capability for the shuttle payload. And then the decision was made - that we were going to launch into an orbital inclination of 51 degrees, which was compatible with the Russian launch sites.

**Parker Counts:**  
When the agreement was reached with the Russians that we would change the inclination of the space station orbit, then that required an additional - well, additional about 13,000 pounds of weight savings - of which they had asked the external tank project to reduce their weight and contribute to that weight (7 500 pounds). And why it's critical in the external tank.

BACK NEXT

Internet 100%

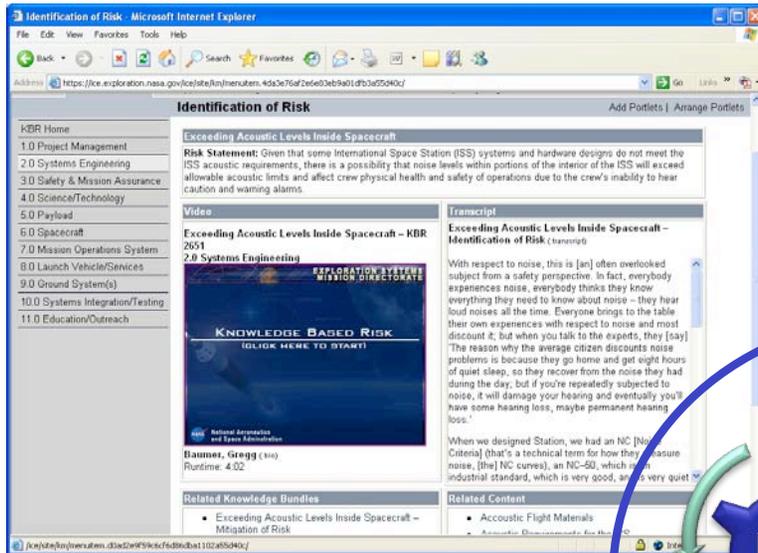
<https://ice.exploration.nasa.gov/ice/site/km/cs/>

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

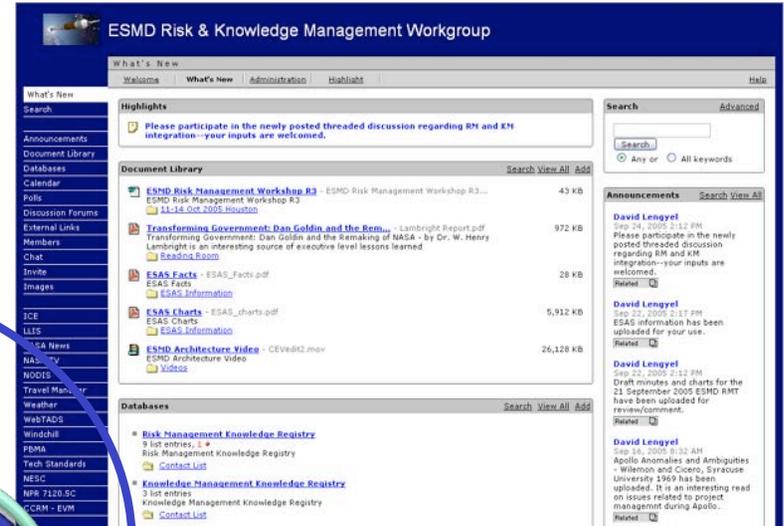
The desired learning objectives include: understanding complex technical and programmatic issues in a risk management framework; demonstrating risk identification and mitigation planning capabilities

Cases may be instructor-led or self-paced (or a combination of both)

# Fusion of Risk and Knowledge Management to Enable Effective Work



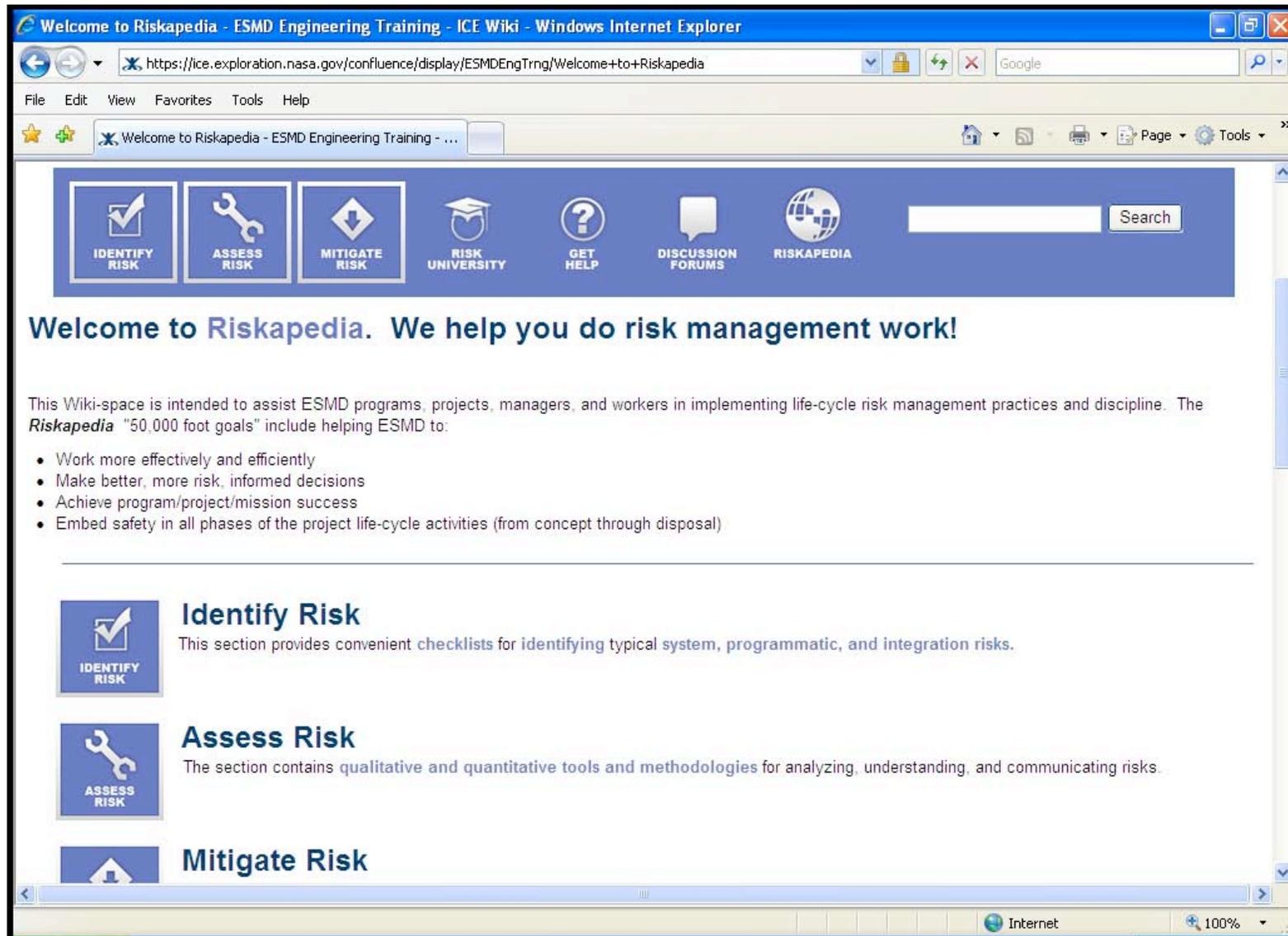
Web-Enabled Teams / Portals / Wikis



P20s / Case Studies / Knowledge-Sharing Forums



# What's On The Horizon? Riskapedia



The screenshot shows a web browser window titled "Welcome to Riskapedia - ESMD Engineering Training - ICE Wiki - Windows Internet Explorer". The address bar contains the URL: <https://ice.exploration.nasa.gov/confluence/display/ESMDEngTrng/Welcome+to+Riskapedia>. The browser interface includes a menu bar (File, Edit, View, Favorites, Tools, Help) and a toolbar with various icons. The main content area features a blue navigation bar with icons for "IDENTIFY RISK", "ASSESS RISK", "MITIGATE RISK", "RISK UNIVERSITY", "GET HELP", "DISCUSSION FORUMS", and "RISKAPEDIA". A search box is located to the right of these icons. Below the navigation bar, the text reads: "Welcome to Riskapedia. We help you do risk management work!". A paragraph follows: "This Wiki-space is intended to assist ESMD programs, projects, managers, and workers in implementing life-cycle risk management practices and discipline. The *Riskapedia* "50,000 foot goals" include helping ESMD to:" followed by a bulleted list: 

- Work more effectively and efficiently
- Make better, more risk, informed decisions
- Achieve program/project/mission success
- Embed safety in all phases of the project life-cycle activities (from concept through disposal)

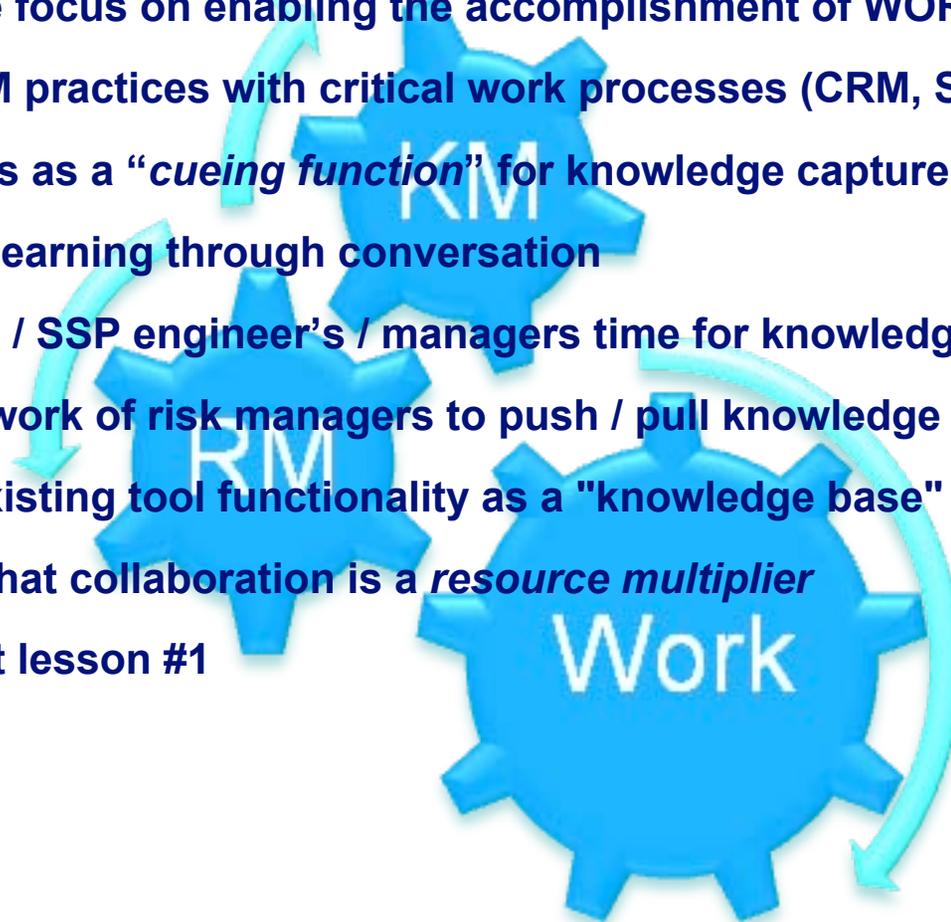
Below this list, there are three sections: "Identify Risk" (with a checklist icon), "Assess Risk" (with a wrench icon), and "Mitigate Risk" (with a house icon). Each section has a brief description of its content. The browser's status bar at the bottom shows "Internet" and "100%".

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

## ***Top Risk & Knowledge Management Lessons to Date***

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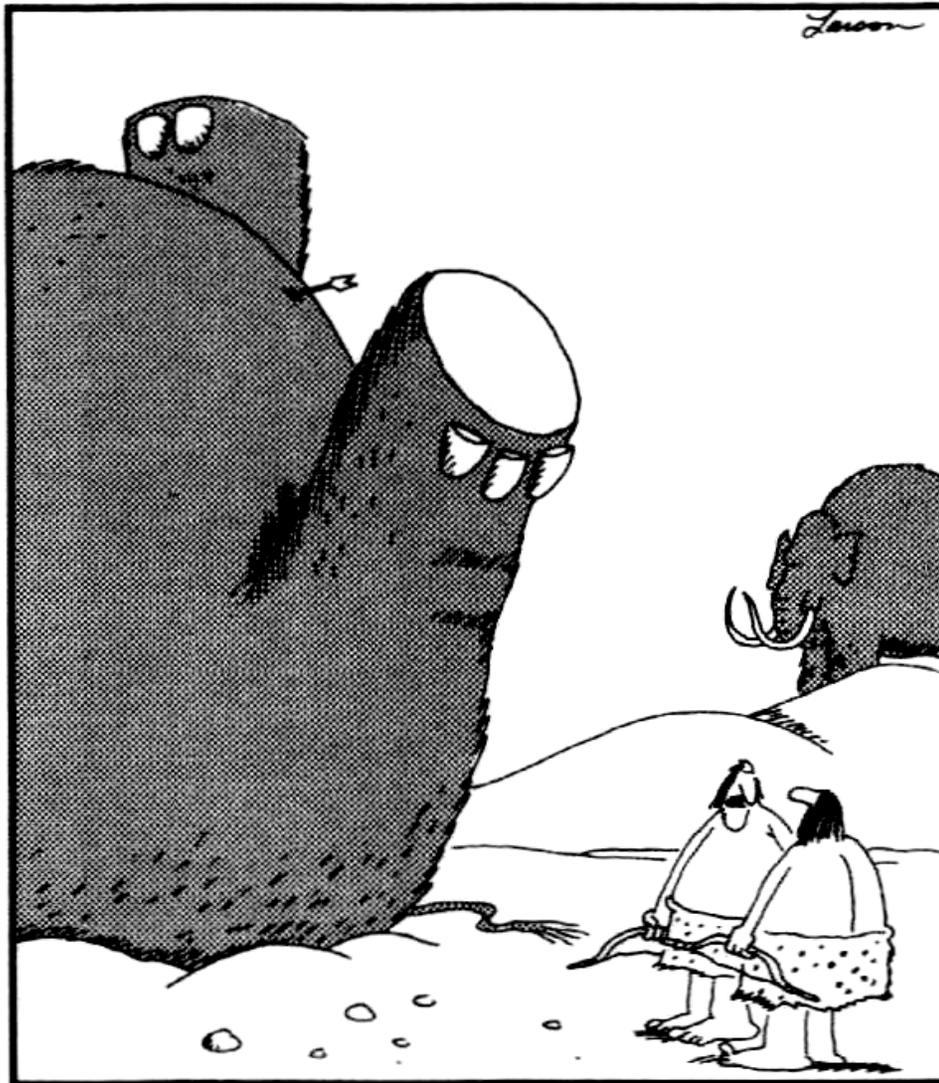
**“You've got to be very careful if you don't know where you're going, because you might not get there.”**

**Yogi Berra**

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# Questions?

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“We should write that spot down.”

**Contact Information:**  
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Office: (202) 358-0391  
Cell: (202) 253-1762

# ***Additional Resources***

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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](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/>