



Understanding Risk Tolerance and Building an Effective Safety Culture

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May 9, 2018



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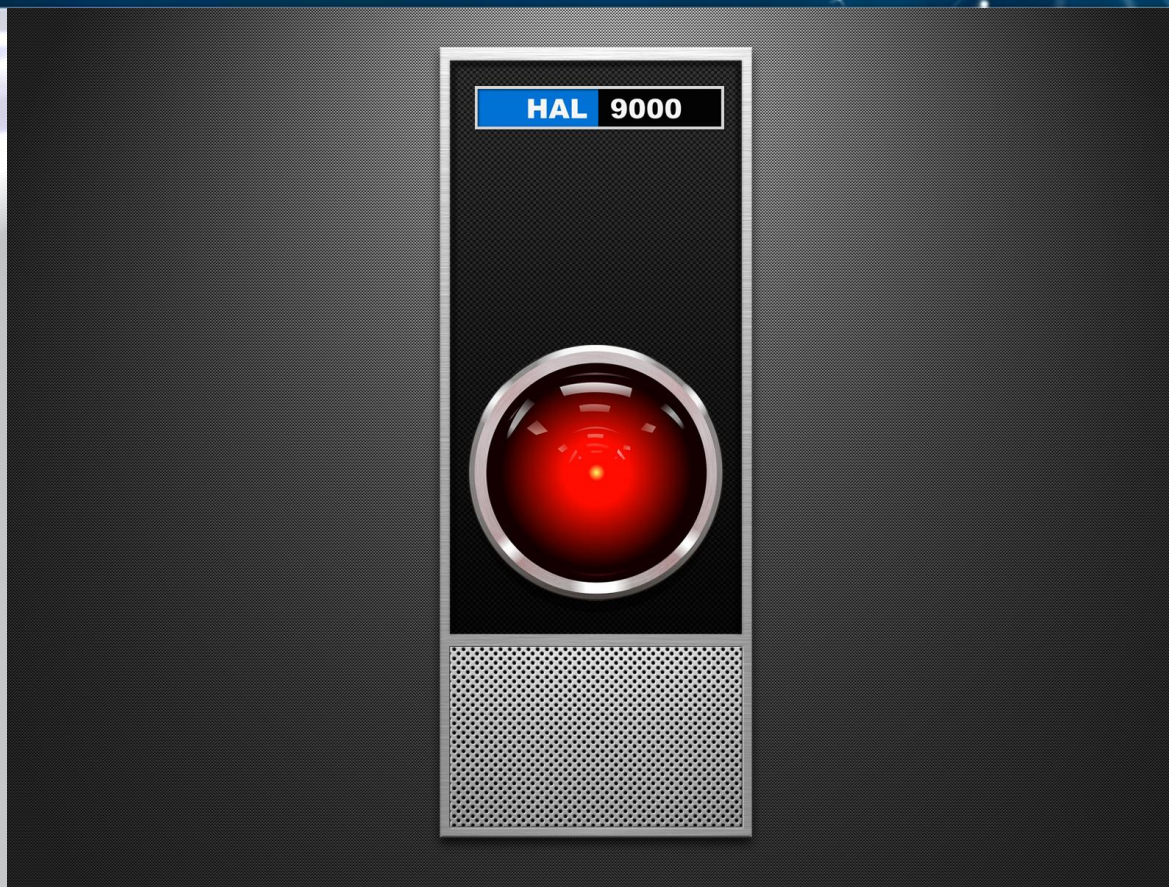


NASA Risk and Safety Culture

- **Understanding Risk Tolerance**
 - Working with Imperfect Humans
 - Learning How to Identify “Smart Risks”
 - Risk Management Processes
- **NASA’s Safety Culture**
 - Reducing Error by Cultivating Skill-Based Behavior
 - Bolstering Trust Throughout Operations
 - Looking at Catastrophic Events Through the Safety Culture Lens
 - Comparing Safety Culture Objectives
- **Exercise – Risk Mitigation Planning**



Words of Wisdom



"It can only be attributable to human error."
-- HAL 9000 (2001: A Space Odyssey)



What is the impact of Human Factors?

- **Estimates range from 65-90% of catastrophic mishaps are due to human error.**
 - NASA's human factors-related mishaps causes are estimated at ~75%
- **As much as we'd like to error-proof our work environment, even the most automated and complex technical endeavors require human interaction...and are vulnerable to human frailty.**
- **Industry and government are focusing not only on human factors integration into hazardous work environments, but also looking for practical approaches to cultivating a strong Safety Culture that diminishes risk.**

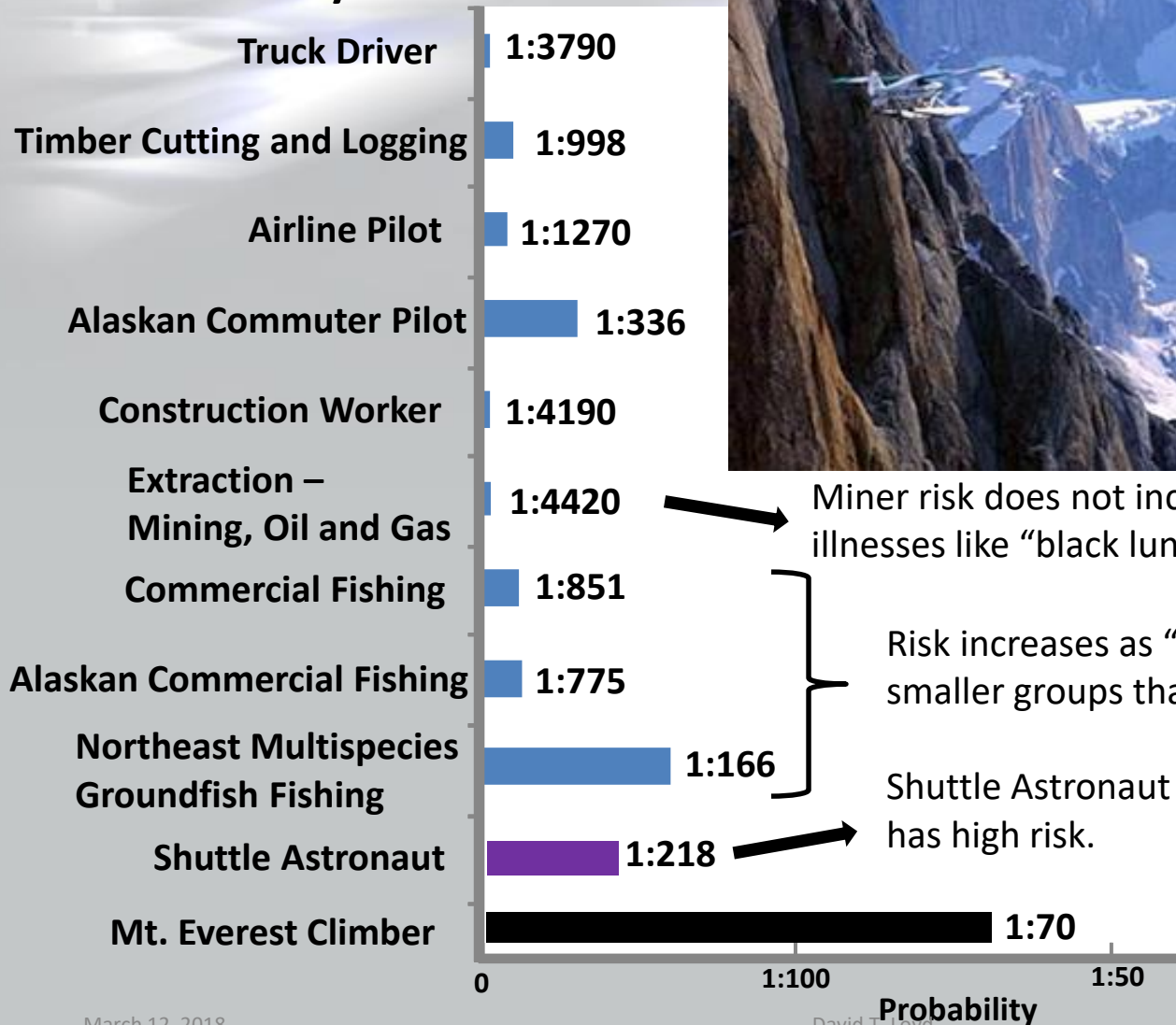
Some Risk Management Philosophy...

As much as we'd like to be able to predict error, the reality is that we must measure known performance characteristics to identify vulnerabilities, mitigate greatest risk, and enable prudent response to the next accident.



High Risk Occupations vs. Space Flight

Person-Fatality Risk Per Year



Miner risk does not include fatalities due to chronic illnesses like “black lung.”

Risk increases as “drill down” into smaller and smaller groups that drive the risk.

Shuttle Astronaut risk is a very small group that has high risk.



Risk Tolerance & Failing Smart

NASA is known for Gene Kranz's famous quote,

"Failure is not an option."

It is not an option anyone chooses, but it is a reality we must confront.



How to identify a smart risk....

- Can we afford the consequence of failure?
- Can we learn from the mistake?
- Can we get back up and try again?
- Do we own the risk in the first place?



NASA's Risk Scorecard

LIKELIHOOD RATING			
L I K E L I H O O D	5	Very Likely	Expected to happen. Controls have minimal to no effect.
	4	Likely	Likely to happen. Controls have significant limitations or uncertainties.
	3	Possible	Could happen. Controls exist, with some limitations or uncertainties.
	2	Unlikely	Not expected to happen. Controls have minor limitations or uncertainties.
	1	Highly Unlikely	Extremely remote possibility that it will happen. Strong controls in place.



JSC RISK MATRIX					
LIKELIHOOD	5				
	4				
	3				
	2				
	1				
		1	2	3	4
Consequences					



SEVERITY	
■	High – Mitigate; implement new processes, change requirements, or re-baseline
■	Moderate – Manage/consider alternative processes, or Accept
■	Low – Manage within normal processes; or Close

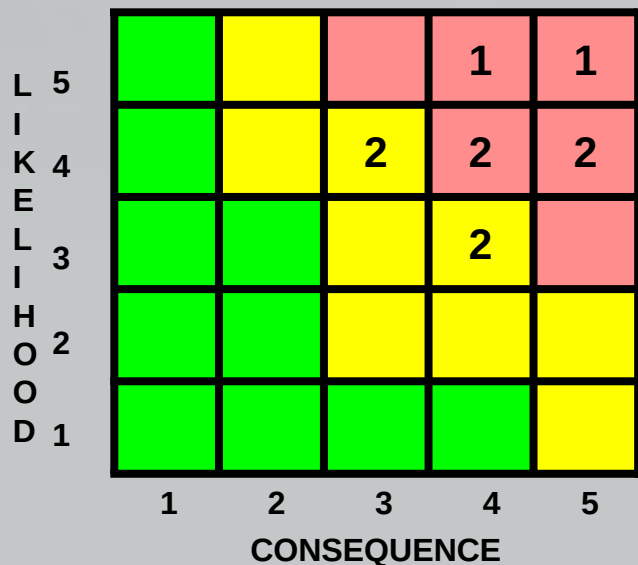


CONSEQUENCE	Subcategories	1	2	3	4	5
HSE (Health, Safety, Environment)	Personnel	Minor injury; Minor OSHA violation	Short-term injury; Moderate OSHA violation	Long-term injury, impairment or incapacitation; Significant OSHA violation	Permanent injury or incapacitation; Major OSHA violation	Loss of life
	System, Facility	Minor damage to asset	Moderate impact or degraded performance	Loss of non-critical asset	Damage to a critical asset	Loss of critical asset or emergency evacuation
	Environment	Minor or non-reportable hazard or incident	Moderate hazard or reportable violation	Significant violation; Event requires immediate remediation	Major violation; Event causes temporary work stoppage	Catastrophic hazard
TECHNICAL	Performance	Minor impact to mission objectives or requirements	Incomplete compliance with a key mission objective	Noncompliance; Significant impact to mission	Noncompliance; Major impact on Center or Spaceflight mission	Failure to meet mission objectives
CENTER CAPABILITIES	Infrastructure	Minor impact or reduced effectiveness	Moderate impact or damage to infrastructure	Significant damage to infrastructure or reduced support	Mission delays or major impacts to Center operations	Extended loss of critical capabilities
	Workforce	Minor impact to human capital	Moderate impact to human capital	Significant impact; Loss of critical skill	Major impact; Loss of skill set	Loss of Core Competency
COST	Organizational or CMO Impact	<2% Budget increase or <\$1M CMO Threat	2-5% Budget increase or \$1M-\$5M CMO Threat	5-10% Budget increase or \$5M-10M CMO Threat	10-15% Budget increase or \$10M-\$60M CMO Threat	>15% Budget increase or >\$60M CMO Threat;
SCHEDULE	--	Minor milestone slip	Moderate milestone slip; Schedule margin available	Project milestone slip; No impact to a critical path	Major milestone slip; Impact to a critical path	Failure to meet critical milestones



Institutional Risk Management

- Risk management forums are active for individual programs and the institution, but risk assessment criteria is consistent.
- Though program and institutional operating budgets are separate, risks are cross-communicated to identify potential impacts.



Legend

▲ Top Center Risk (TCR)

△ Proposed Top Center Risk (Proposed TCR)

L x C	Title (Notional Risk Titles)	Org	LIKELIHOOD	Consequence				
				Cen Cap	SCH ED	COST	HS E	TECH
3 x 4	▲ Test system maintenance	#	3	2	2	4	4	2
4 x 5	▲ Mission essential resource limitations	##	4	4	5	2	1	4
4 x 3	▲ Equipment End-of-Life	##	4	3	1	1		3
4 x 3	▲ Building Refurbishments	##	4	3	3	1	1	2
5 x 5	▲ Comm Systems End-of-Life	##	5	5	4	3	5	5
4 x 4	▲ Building Maintenance Shortfall	##	4	3	3	4	2	2
3 x 4	▲ Assessment	##	3	2	3	2	4	3
4 x 4	▲ Capability Threat	##	4	4	3	1		4
4 x 4	▲ Water System-Repairs/Upgrades	##	4	4	4	4	2	3
5 x 4	△ Research equipment failure threat	##	5		4	4		4



Process Measures for High-Risk Facilities

- Industry and government organizations have recognized the value of monitoring leading indicators to identify potential risk vulnerabilities.
- NASA has adapted this approach to assess risk controls associated with hazardous, critical, and complex facilities.
- NASA's facility risk assessments integrate commercial loss control, OSHA Process Safety, API Performance Indicator Standard, and NASA Operational Readiness Inspection concepts to identify risk control vulnerabilities.



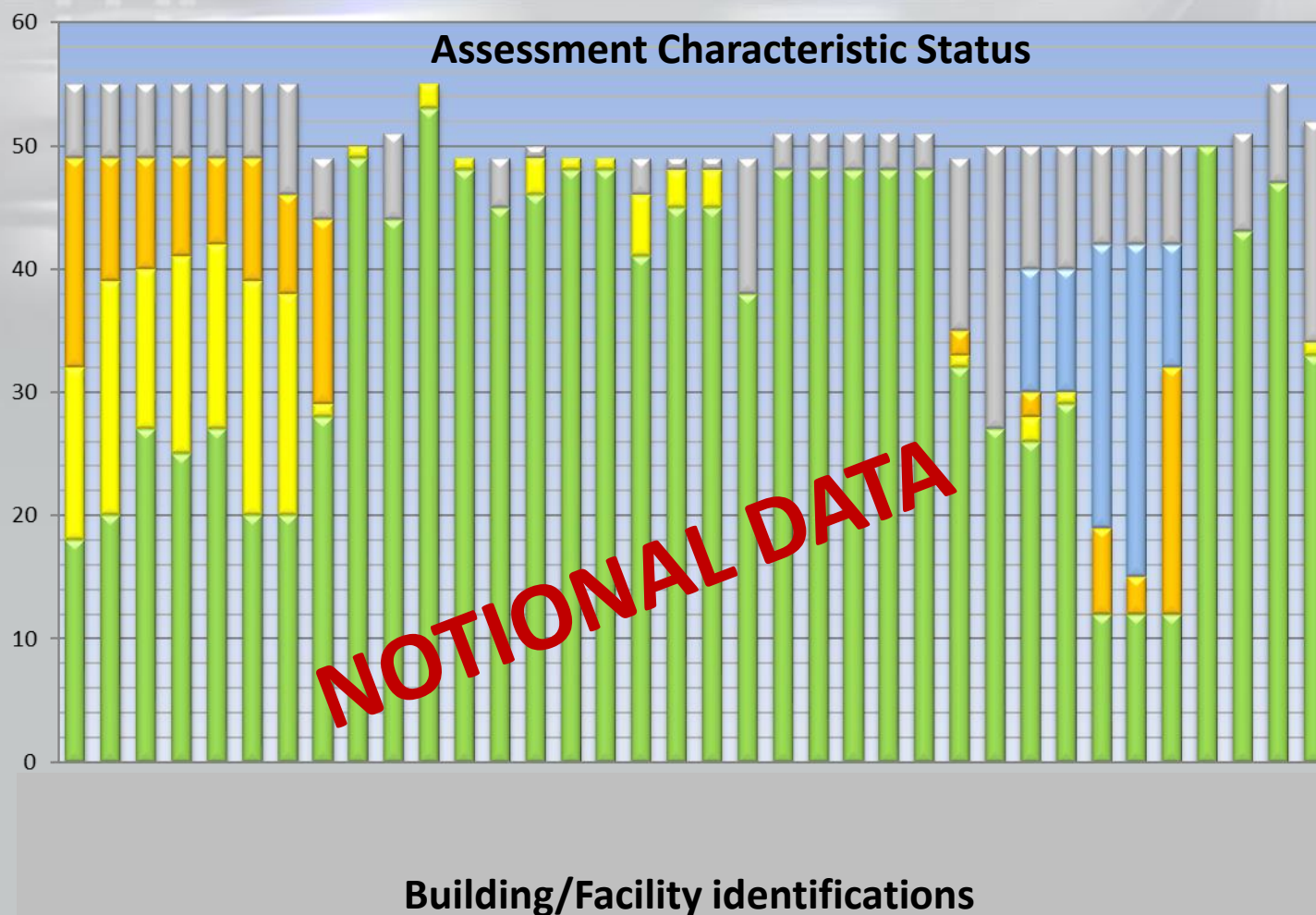
February 27-28, 2018

Examples of leading measure areas for high-risk facilities include:

- ✓ Maintenance and system integrity conditions;
- ✓ Operational qualifications;
- ✓ Challenges to safety systems and monitoring equipment;
- ✓ Communication and reporting system conditions;
- ✓ Accuracy of configuration management;
- ✓ Maintenance of operational procedures and emergency response plans.



Facility Safety Risk Monitoring



Assessment Characteristic Key

Not Applicable	Elements of assessment are not applicable to the associated facility mission.
HATS Closed: Conforms	Items identified as nonconforming were resolved.
* Non-conformance	Documentation does not exist to support the checklist requirements.
Partially conforms	Significant information is available, but does not meet the intent of risk control, or it is out of date or unavailable.
Conforms	Documentation is available with the required information to meet checklist intent.

* A nonconformance is tracked until closure. Partial nonconformances represent opportunities for risk reduction but are not followed up until the next scheduled assessment.



Minimizing Human Error and Cultivating a Reduced Risk Environment

Rasmussen's 3 Human Responses to Operator Information Processing

1. **Skill-based:** requires little or no cognitive effort.
2. **Rule-based:** driven by procedures or rules.
3. **Knowledge-based:** requires problem solving/decision making.



"The fewer rules a coach has, the fewer rules there are for players to break."

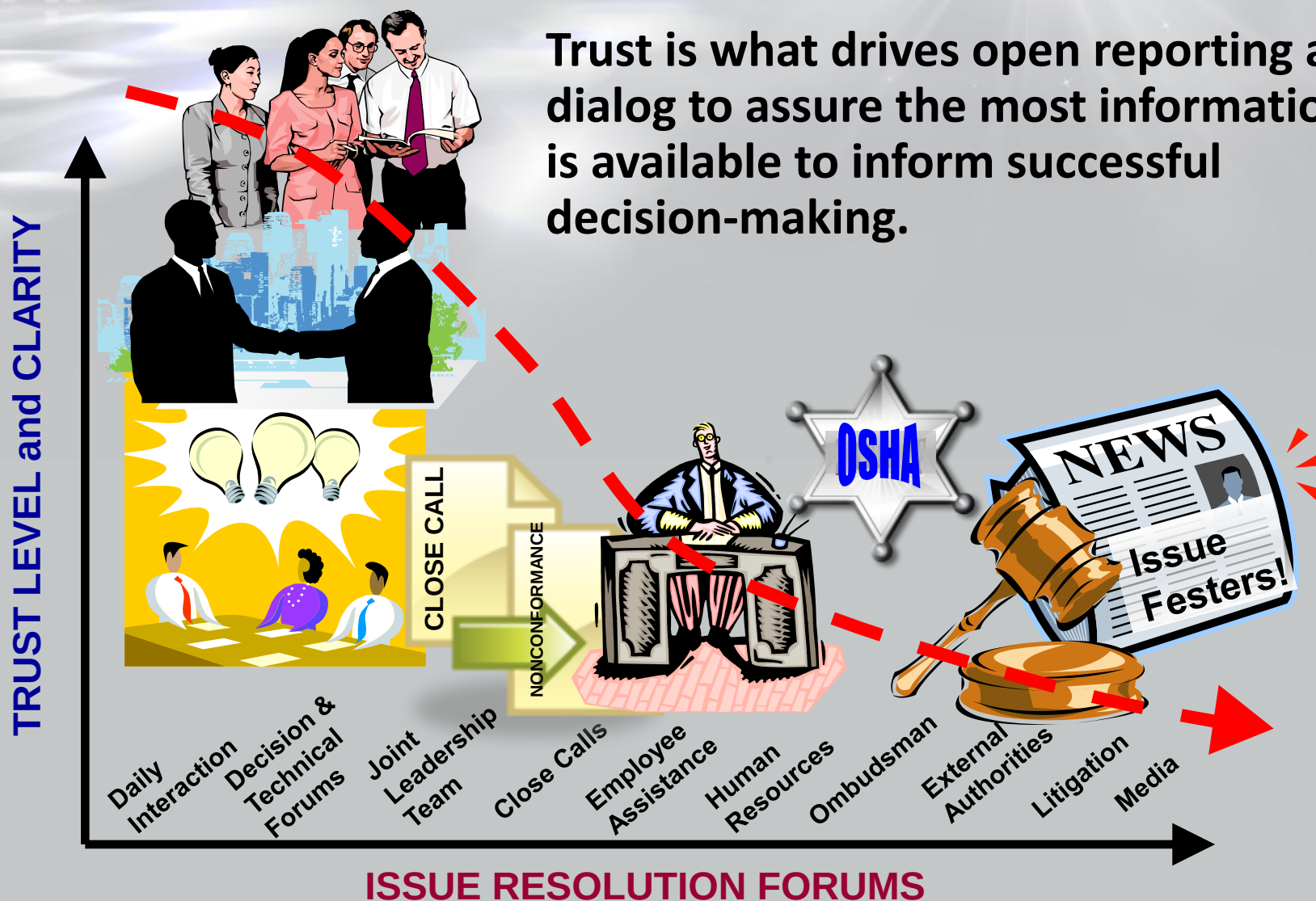
John Madden

"Successful design is not the achievement of perfection but the minimization and accommodation of imperfection."

Henry Petroski

Trust is the foundation of an effective Safety Culture

Trust is what drives open reporting and dialog to assure the most information is available to inform successful decision-making.





How Safety Culture Promotes Operational Excellence



- **By advocating a pervasive Safety Culture, we can provide our workforce with:**
 - Clear emphasis on continuous learning.
 - Encouragement to develop intuitive personal values.
 - Guidelines for decision-making behavior that focuses on long-term success.
 - Reinforcement to build trust by reporting and communicating concerns and ideas.
- **Practicing an effective Safety Culture:**
 - Builds Skill-based and Knowledge-based response mechanisms,
 - Reduces dependence on Rule-based response,
 - And breaks down barriers to Trust.



The NASA Safety Culture



"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth."

– John F. Kennedy address to Congress, May 25, 1962



- Space-related tragedies have marked our safety culture evolution.
- It's not possible to perpetuate a safety culture in space without taking care of each other on the ground and at home.



NASA's Safety/Risk Culture Model

“An environment characterized by safe attitudes and behaviors modeled by leaders and embraced by all that fosters an atmosphere of open communication, mutual trust, shared safety values and lessons, and confidence that we will balance challenges and risks consistent with our core value of safety to successfully accomplish our mission.”

An effective safety culture is characterized by the following subcomponents:

Reporting Culture - We report our concerns

Just Culture - We have a sense of fairness

Flexible Culture - We change to meet new demands

Learning Culture - We learn from our successes and mistakes

Engaged Culture - Everyone does his or her part





Using the Safety Culture Model to Analyze NASA's History



Challenger – January 28, 1986



Columbia – February 1, 2003

Reporting – With both tragedies, launch process deficiencies, such as O-ring susceptibility in cold temperatures (Challenger) and foam shedding (Columbia), were passively reported problems, yet were not considered serious hazards.

Just – Some engineers were reluctant to raise concerns when faced with a return of an “in God we trust - all others bring data” attitude.

Flexible – With both incidents, the Shuttle Program was experiencing schedule pressure challenges.

Learning – With “normalization of deviance,” O-ring burn-through and foam impact had become classified as “in-family” and as a negligible risk.

Engaged – NASA management lacked involvement in critical discussions.

NASA Safety Culture Model Applied to Deepwater Horizon

Deepwater Horizon – April 20, 2010

Reporting – Procedures were subjected to last-minute distribution, last minute decision.

Just – Concerns of rig workers regarding test results were muted, not heeded or explored .

Flexible – All involved seemed prepared to exercise flexibility, but this may be indicative of insufficient process discipline.

Learning – Invalid confidence in new slurry, vents from Mud-Gas Separator (MGS) allowed gas to enter rig spaces, insufficient planning for contingencies.

Engaged – Incorrect reading of pressure tests, lack of recognition or timely control action related to kicks, diverted flow through MGS instead of overboard, reluctance to activate Blow-Out Preventer (BOP), reluctance to activate the Emergency Disconnect System, BOP testing and maintenance.





Safety Culture – Comparing Oil & Gas with NASA

- In 2013, the Bureau of Safety and Environmental Enforcement (BSEE) released policy on Safety Culture emphasized for adoption across the Oil and Gas industry.
- The “*Nine Characteristics of a Strong Safety Culture*” are closely aligned with Safety Culture attributes adopted by NASA.

NASA’s Safety Culture

Reporting Culture – We report our concerns.

Just Culture – We have a sense of fairness.

Flexible Culture – We change to meet new demands.

Learning Culture – We learn from our successes and mistakes.

Engaged Culture – Everyone does his or her part.

BSEE’s Nine Characteristics of a Strong Safety Culture

Hazard identification and risk management

Effective Safety and Environmental Communication

Environment for raising concerns

Respectful work environment

Work processes

Continuous improvement

Inquiring attitude

Personal accountability

Leadership commitment to safety values and actions

Bureau of Safety and Environmental Enforcement (BSEE) Nine Characteristics of a Strong Safety Culture



- 1. Leadership commitment to safety values and actions:** leaders demonstrate a commitment to safety and environmental stewardship in their decisions and behaviors. leaders visibly demonstrate this commitment through how they allocate resources within the organization and prioritize safety relative to production
- 2. Respectful work environment:** trust and respect permeate the organization, with a focus on teamwork and collaboration
- 3. Environment for raising concerns:** a work environment is maintained in which personnel feel free to raise safety and environmental concerns without fear of retaliation, intimidation, harassment, or discrimination
- 4. Effective safety and environmental communication:** communications maintain a focus on safety and environmental stewardship; knowledge and experience are shared throughout the organization.
- 5. Personal accountability:** all individuals take personal responsibility for process and personal safety, as well as environmental stewardship
- 6. Inquiring attitude:** individuals avoid complacency and continuously consider and review existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action; workers are expected to question work practices as part of everyday conversations without hesitation
- 7. Hazard identification and risk management:** issues potentially impacting safety and environmental stewardship are promptly identified, fully evaluated, and promptly addressed or corrected commensurate with their significance
- 8. Work processes:** the process of planning and controlling work activities is implemented in a manner that maintains safety and environmental stewardship while ensuring use of the correct equipment, used in the correct way, for the correct work
- 9. Continuous improvement:** opportunities to learn about ways to ensure safety and environmental stewardship are sought out and implemented

Reducing Risk Vulnerabilities

- **NASA, like the other hazardous industries, has suffered very catastrophic losses.**
- **Human error will likely never be completely eliminated as a factor in our failures.**
- **Acknowledging human frailty and the potential for failure bolsters our ability to manage risks and mitigate the worst consequences.**
- **Building an effective Safety Culture bolsters skill-based performance that minimizes risk and encourages operational excellence.**





Exercise – Risk Mitigation Planning

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HOUSTON, TEXAS



Risk Mitigation Strategies

For each of the following workplace pictures:

1. Identify at least one risk using any method you choose.
2. Determine potential severity the risk represents and the associated probability of occurrence.
3. Identify what parties share in the risk and should be consulted in managing it.
4. Identify necessary action to eliminate the risk.
5. Prepare a mitigation plan for reducing potential risk impact addressing either severity reduction or probability reduction.
6. Identify under what circumstance the risk could be accepted “as is”.

What would a strong safety cultural look like in this workplace?

Risk to Oil & Gas Roughnecks





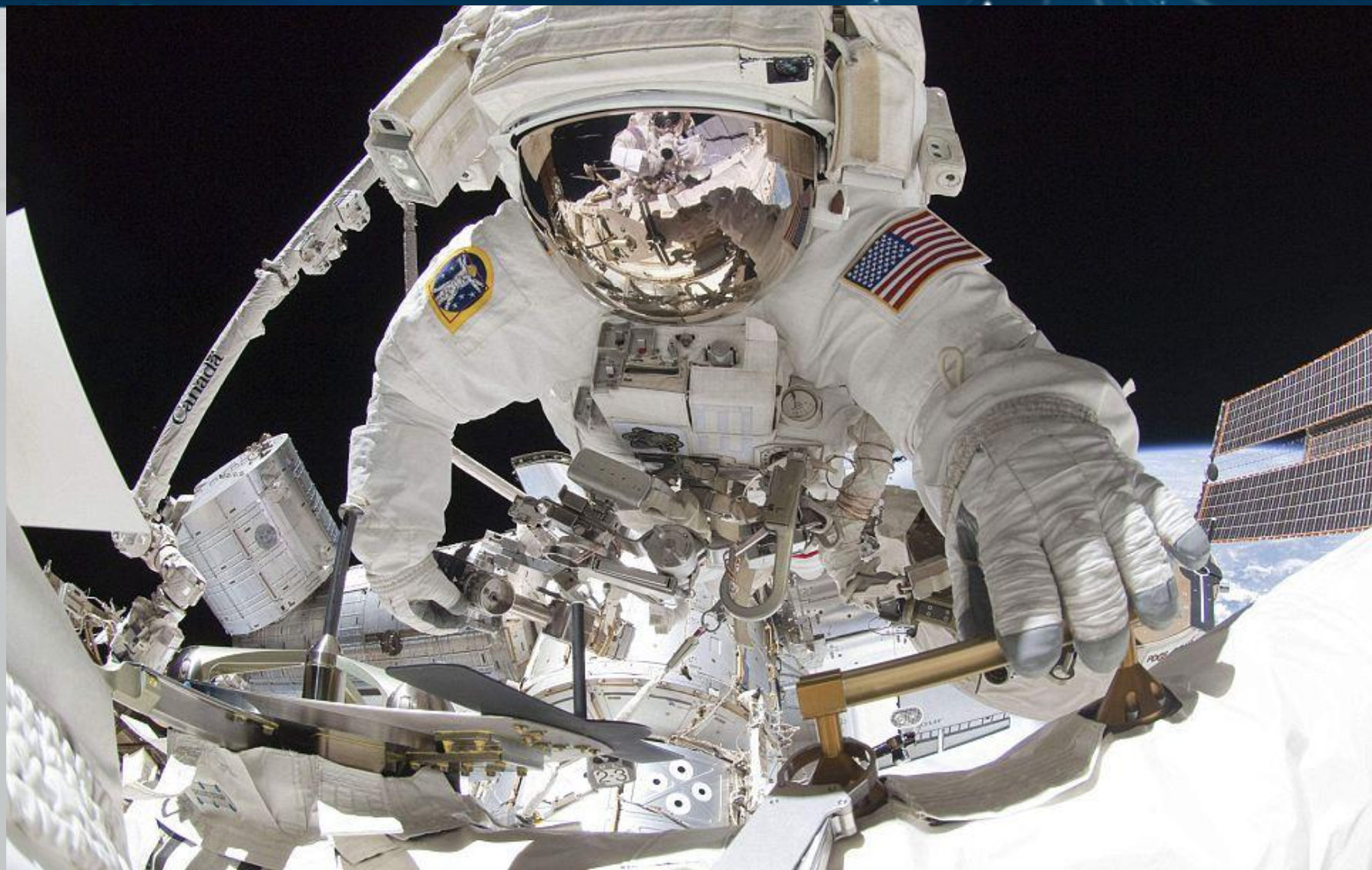
Risk Mitigation Strategies

Risk to Oil & Gas Roughnecks

Risk Statement	Pre-control Risk Level		Risk Owner(s)	Control (Elimination)	Mitigation Plan	Acceptable Risk?
	Probability	Severity				
Mechanical Impact – struck by rigging equipment.	Moderate	High	• Worker • Family • Company/ Employer • Regulation	Automation	• Training • JHA • Procedures • Supervision • PPE	Not without mitigation.
Motor Vehicle accidents.	Moderate	High	• Worker • Family • Company/ Employer • Public • Regulation	Automated driving Teleportation?	• Driver licensing • Seat belts • Defensive driver training • Remote monitoring and enforcement	Yes – with regulation penalties and claims costs.
Hazardous material exposure.	Moderate	Moderate	• Worker • Family • Company/ Employer • Regulation		• Gas monitoring • JHA • Supervision • Respiratory Protection	Not without mitigation.



Risk to Astronaut Extravehicular Activity



May 9, 2018

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Risk Mitigation Strategies

Risk to Astronaut Extravehicular Activity

Risk Statement	Pre-control Risk Level		Risk Owner(s)	Control (Elimination)	Mitigation Plan	Acceptable Risk?
	Probability	Severity				
Micrometeoroid/ Orbital Debris Impact	Low	High	• Crew • Family • NASA • Foreign Partner • American Public	• Robotic EVA • “Hard” suit design • Prohibit EVA	• Vehicle orientation for passive shielding • Emergency ingress	Yes – with passive shielding considerations.
External Sharp Edge EMU Tear/Damage	Moderate	High	• Crew • Family • NASA • Foreign Partner • American Public	• Robotic EVA • Prohibit EVA	• Crew training • Emergency ingress	Yes
Water Intrusion or internal suit failure	Low	High	• Crew • Family • NASA • EMU Manufacturer • Foreign Partner • American Public	• Robotic EVA • Prohibit EVA	• EMU PMs and contamination control • Emergency ingress	Not without mitigation.

Risk to Bar and Restaurant Operations





Risk Mitigation Strategies

Risk to Bar and Restaurant Operations

Risk Statement	Pre-control Risk Level		Risk Owner(s)	Control (Elimination)	Mitigation Plan	Acceptable Risk?
	Probability	Severity				
Workplace Violence	Low	High	• Worker • Customers • Family • Employer • Protective Services	• Forced lobotomies.	• Surveillance • Security • Employee training • Police notification	Yes – only if the employer had not been aware of the potential for violence in the workplace.
Alcohol/Drug Abuse	Moderate	Moderate	• Worker • Customers • Family • Employer • Protective Services	• Prohibit alcohol sales.	• Alcohol licensure • Surveillance • Employee training • Police notification	Not without mitigation.
Foodborne illness	Moderate	Low	• Worker • Customers • Family • Employer • Food supplier	• Limit/prohibit food availability.	• Municipal inspection • Sanitation protocols • Employee training	Not without mitigation.