JSC S&MA Analysis Branch

NASA Perspective on Leading Indicators and Dashboarding

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Dashboards

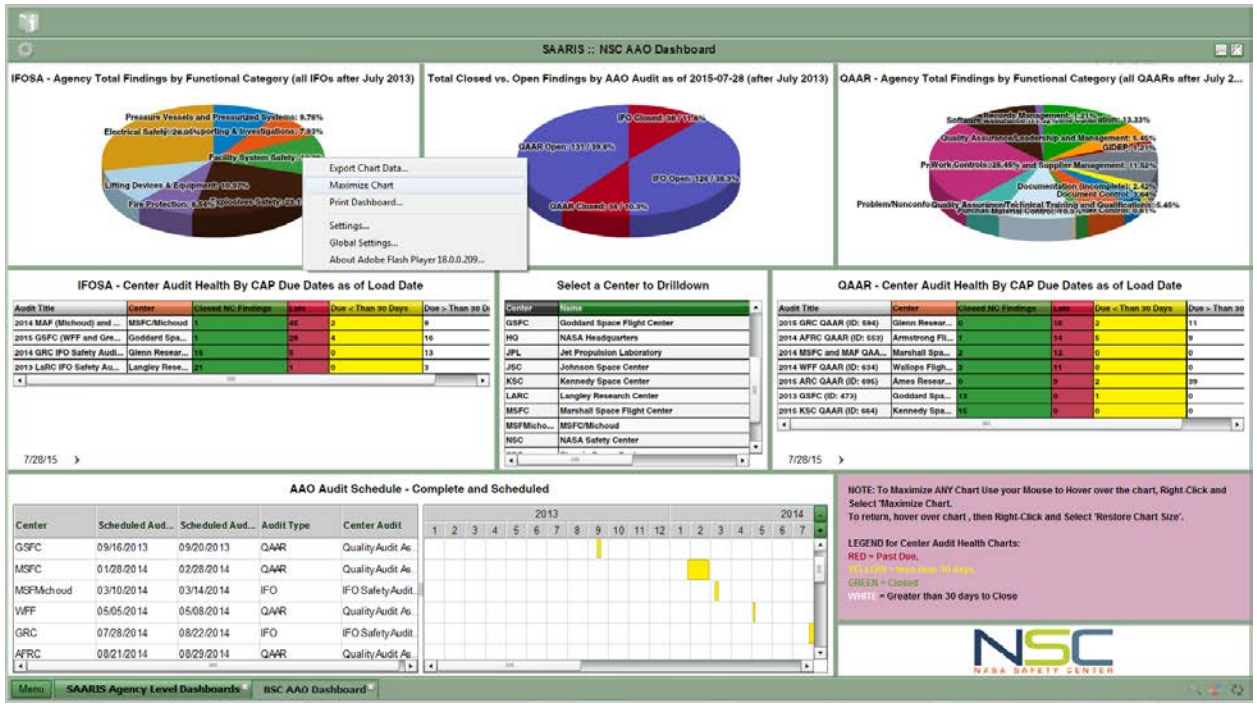
- **Purpose – To convey information to programs, projects, Centers on the status of certain activities/requirements.**
- **Pro's – Promotes communication of key information.**
- **Con's – May not have all the right information to make a fully informed decision.**

NASA Safety/Quality Audit Dashboard

- **Dashboard was built as a tool to allow NASA headquarters and Centers to access "real time" audit data**
  - "Real time" because it is automatically updated after each audit
- **Shows audit results, corrective action progress, audit schedules for both Institutional, Facility, Operational (IFO) Safety and Quality Audits (QAAR)**
- **Flags corrective actions with color codes that are due within 30 days or late**
- **Allows agency level view to see if there are and Centers that are outliers**

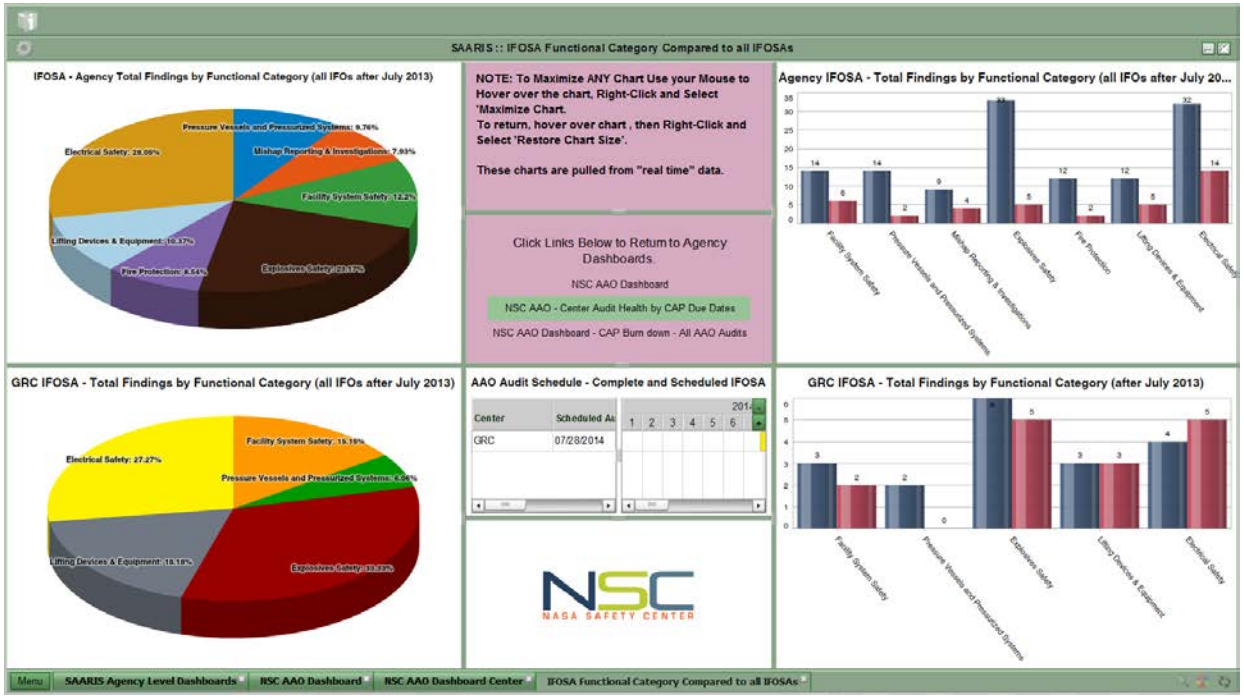
Agency Level Dashboard

- **Top level dashboard shows high level audit results, corrective action status, and audit schedule at Agency level**
- **Allows user to drill down to different areas or specific Centers**



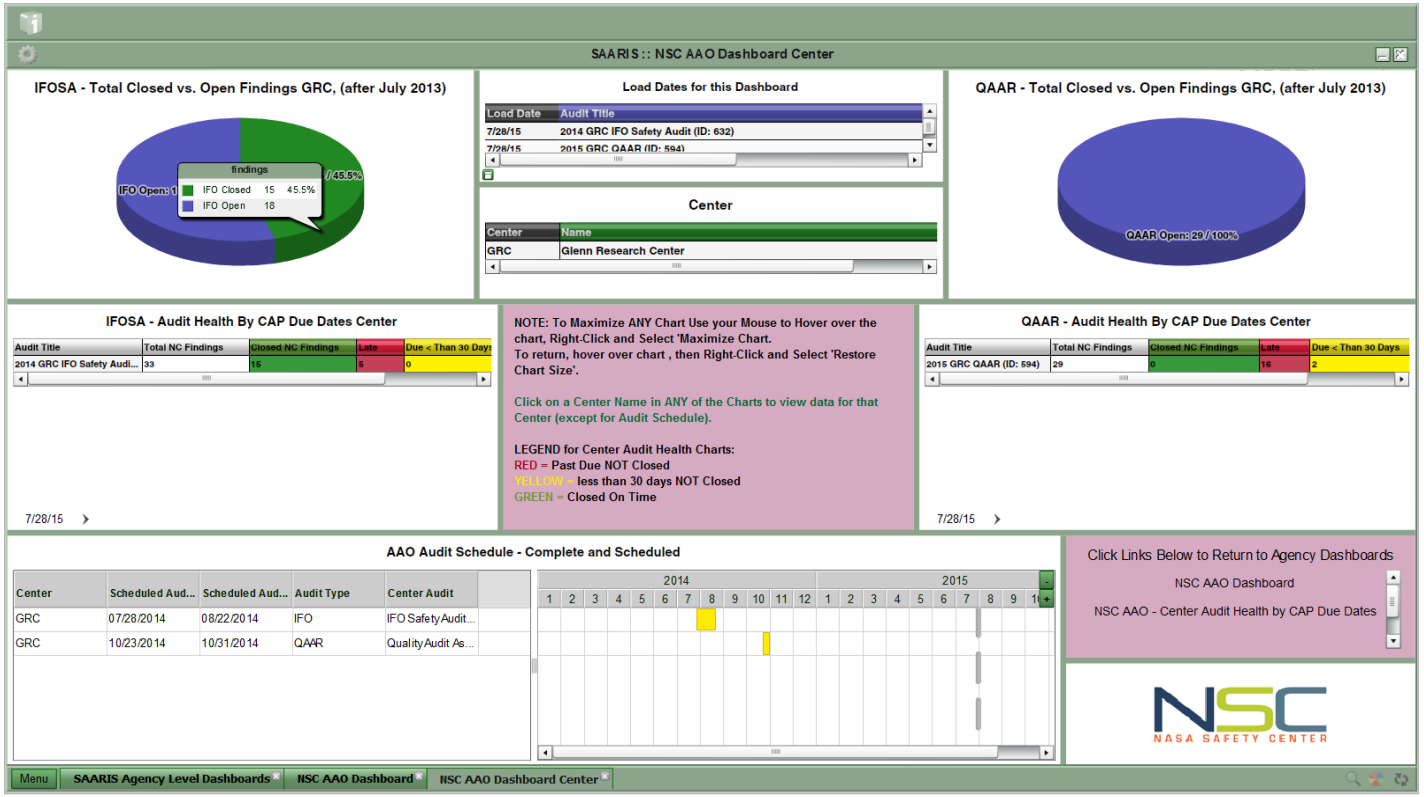
Agency Level Dashboard

- **Agency level allows drilling down further into various areas such as findings by category**
- **Allows user to drill down to each Center for the same**



Center Level Dashboard

- **Center Specific audit data similar to Agency level, but for that Center only**



NASA Flight Safety Dashboard

- **Dashboard was built as a tool to communicate risk across programs, mission phases, and overall mission risk to Program Management.**
- **Shows program specific Probabilistic Risk Assessment (PRA) results used for verification of probabilistic requirements.**
- **Shows whether program specific PRA results meet agency level probability of Loss of Crew (LOC) Thresholds, Program level LOC requirements, and Program level Technical Performance Metrics (TPMs)**

Comparison of Mission Loss of Crew Estimates and Requirements

	Pre-launch and Ascent		In-Space [2]		EDL and Post Landing [5]	Mission
	A	B	A	B	B	
Agency Threshold	1 in 300		1 in 150		1 in 300	1 in 75
ESD Reqmt (ESD 10002, Table R-16)	**1 in 550**	**1 in 1400**	**TBD**	**TBD**	**1 in 650**	**TBD**
ESD TPM Objectives	1 in 400 TPM 1.a		TBD	TBD	TBD	1 in 130 TPM 4.a
PRA Version 2 Estimate[1] (1/1/2020) Best Estimate (by program)	1 in xxx	1 in xxx	*1 in xxx*	*1 in xxx*	*1 in xxx*	1 in xxx
PRA Version 2 Estimate[1] (1/1/2020) Best Estimate (by phase)	1 in xxx		*1 in xxx*		*1 in xxx*	1 in xxx

- **High Level Assumptions**
  - **1**
  - **2**
  - **3**

Leading Indicators

- **Purpose – To anticipate and mitigate problems prior to an accident**
- **Pro's – Proactive**
- **Con's – Not foolproof, can't catch everything. Can be expensive.**

Leading Indicators

- **NASA has employed a fleet lead program for programs like the Space Shuttle and International Space Station (ISS).**
- **For certain equipment (e.g. Auxiliary Power Units), ground based units are operated and maintained with run time/cycles over that experienced by the fleet to proactively sense age related problems before they occur in flight.**
- **For the Space Shuttle Program, NASA had developed an accident sequence precursor program that evaluated anomalies during flight to determine if they were risk significant.**
  - Patterned after the U.S. Nuclear Regulatory Commission's program, but wasn't fully implemented before the end of the program.

Today's "Take Aways"

- **Dashboards/leading indicators help communicate information to decision makers and predict potential problems before they occur.**

- **Concern is that you are communicating the right information and not confusing the reader or decision maker.**

Questions?

Backup Charts

What is PRA?

- **PRA is a comprehensive, structured, and disciplined approach to identifying and analyzing risk in engineered systems and/or processes. It attempts to quantify rare event probabilities of failures. It attempts to take into account all possible events or influences that could reasonably affect the system or process being studied. It is inherently and philosophically a Bayesian methodology. In general, PRA is a process that seeks answers to three basic questions:**
  - ✓ **What kinds of events or scenarios can occur (i.e., what can go wrong)?**
  - ✓ **What are the likelihoods and associated uncertainties of the events or scenarios?**
  - ✓ **What consequences could result from these events or scenarios (e.g., Loss of Crew, Loss of Mission, Loss of Hydrocarbon Containment, Reactor Core Damage Frequency)?**
- **There are other definitions and questions that it can help answer.**
- **The models are developed in "failure space". This is usually different from how designers think (e.g. success space).**
- **PRAs are often characterized by (but not limited to) event tree models, fault tree models, and simulation models.**

NASA Examples

- **Mission Level Risk Assessment**
  - Low Earth Orbit Operation (e.g. Shuttle and Station)
  - Cis-Lunar Cross Program Missions (e.g. Distant Retrograde Orbit)
  - Deep Space Gateway Design, Development, and Operation
  - Deep Space Transport Design, Development, and Operation
- **System Level Risk Assessment**
  - Orion Design and Operation
  - Space Launch Systems (SLS) Design and Operation
  - Ground Systems Development & Operation (GSDO) Design and Operation
  - Commercial Crew Partner Vehicles
- **Focused risk trade studies between current and proposed process/design. For example:**
  - Orion Service Module Propulsion System
  - SLS Engine Out Capability
  - GSDO Emergency Egress
  - XPRA Manual Steering, Post-Landing Crew Recovery

When can PRA be Performed?

NEW DEVELOPMENTS

The ideal time to conduct a PRA is at the beginning of the design process to incorporate the necessary safety and risk avoidance measures throughout the development phase at minimal cost.

EXISTING SYSTEMS

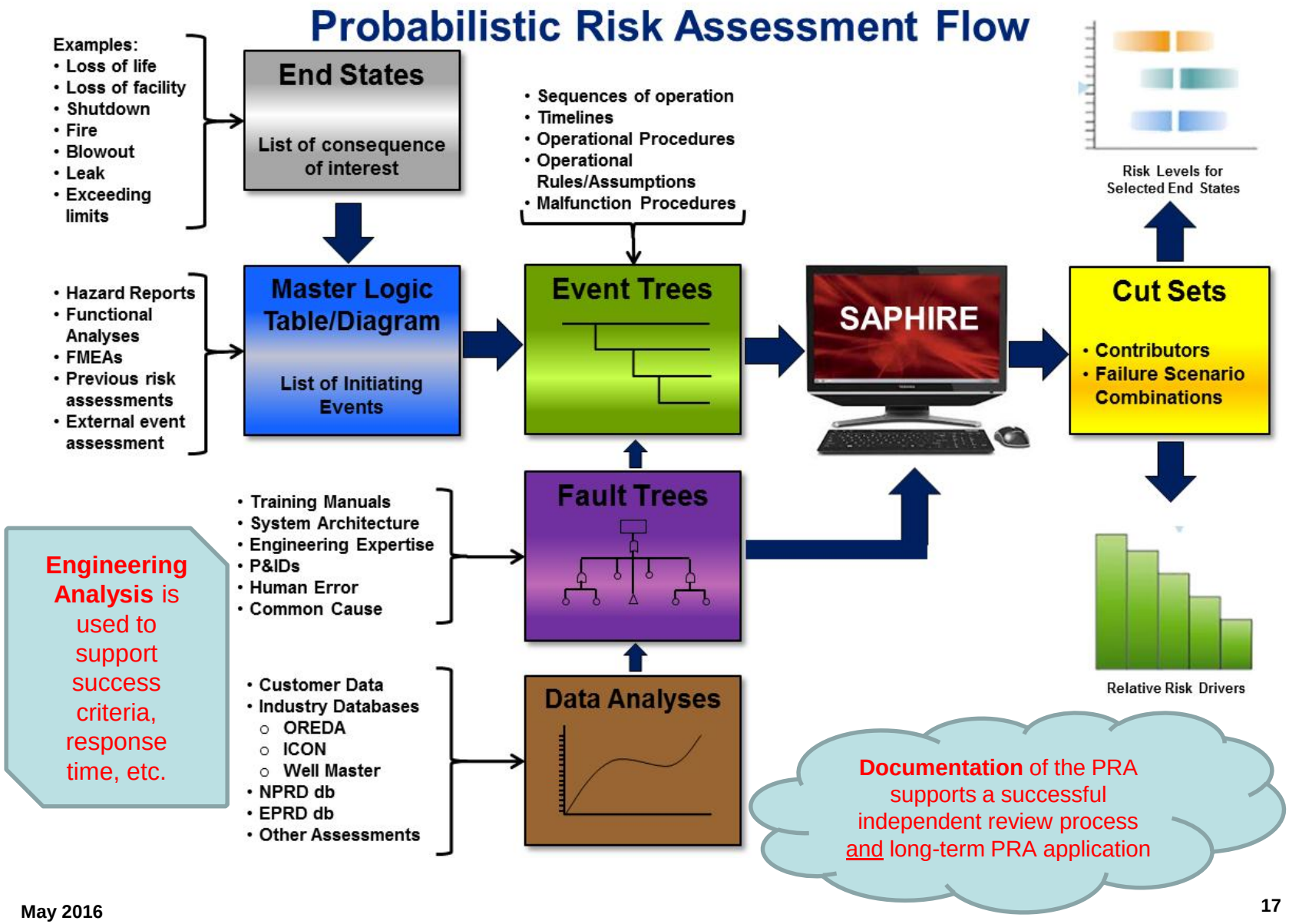
PRA can be applied to existing systems to identify and prioritize risks associated with operations. PRAs can evaluate the impact of system changes and help avoid compromises in quality or reliability while increasing productivity.

INCIDENT RESPONSE

In the event of unexpected downtime or an accident, a good PRA team can assess the cause of the failure and develop appropriate mitigation plans to minimize the probability of comparable events in the future.

In a nutshell, PRA can be applied from concept to decommissioning during the life cycle, including design and operations.

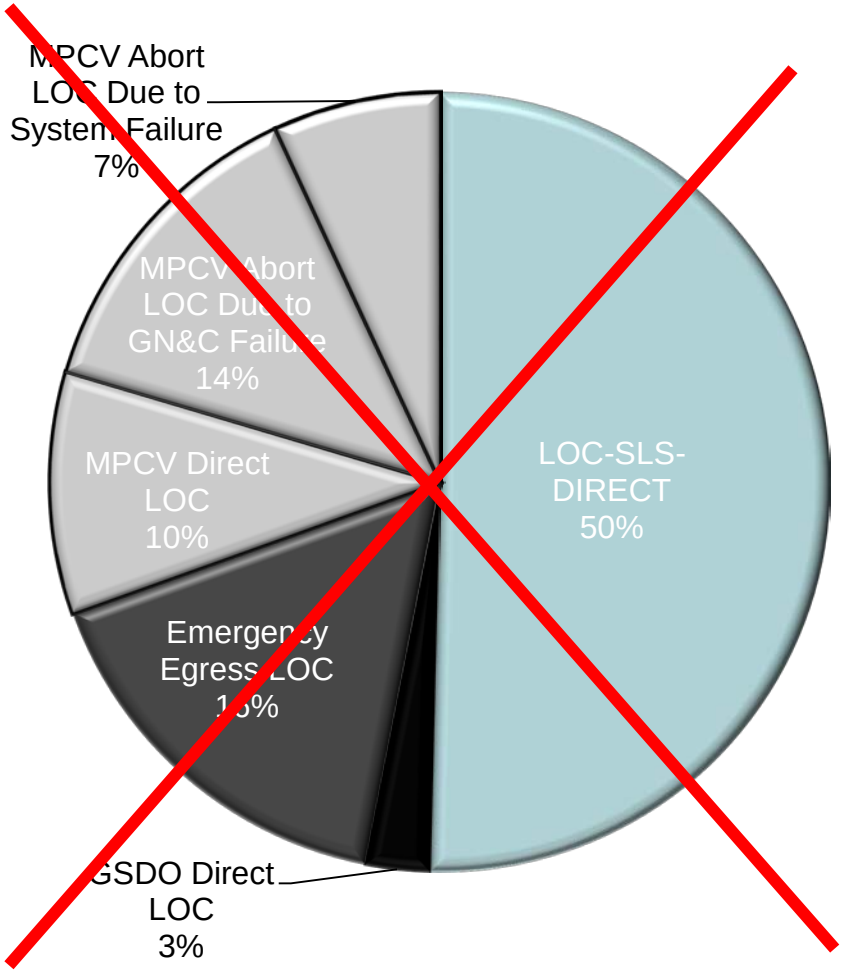
PRA Process


Probabilistic Risk Assessment Flow
Examples:
• Loss of life
• Loss of facility
• Shutdown
• Fire
• Blowout
• Leak
• Exceeding limits
End States
List of consequence of interest
• Sequences of operation
• Timelines
• Operational Procedures
• Operational Rules/Assumptions
• Malfunction Procedures
Risk Levels for Selected End States
• Hazard Reports
• Functional Analyses
• FMEAs
• Previous risk assessments
• External event assessment
Master Logic Table/Diagram
List of Initiating Events
Event Trees
SAPHIRE
Cut Sets
• Contributors
• Failure Scenario Combinations
• Training Manuals
• System Architecture
• Engineering Expertise
• P&IDs
• Human Error
• Common Cause
Fault Trees
Relative Risk Drivers
• Customer Data
• Industry Databases
○ OREDA
○ ICON
○ Well Master
• NPRD db
• EPRD db
• Other Assessments
Data Analyses
Engineering Analysis is used to support success criteria, response time, etc.
Documentation of the PRA supports a successful independent review process and long-term PRA application

What Not to Do in Presenting Risk Results

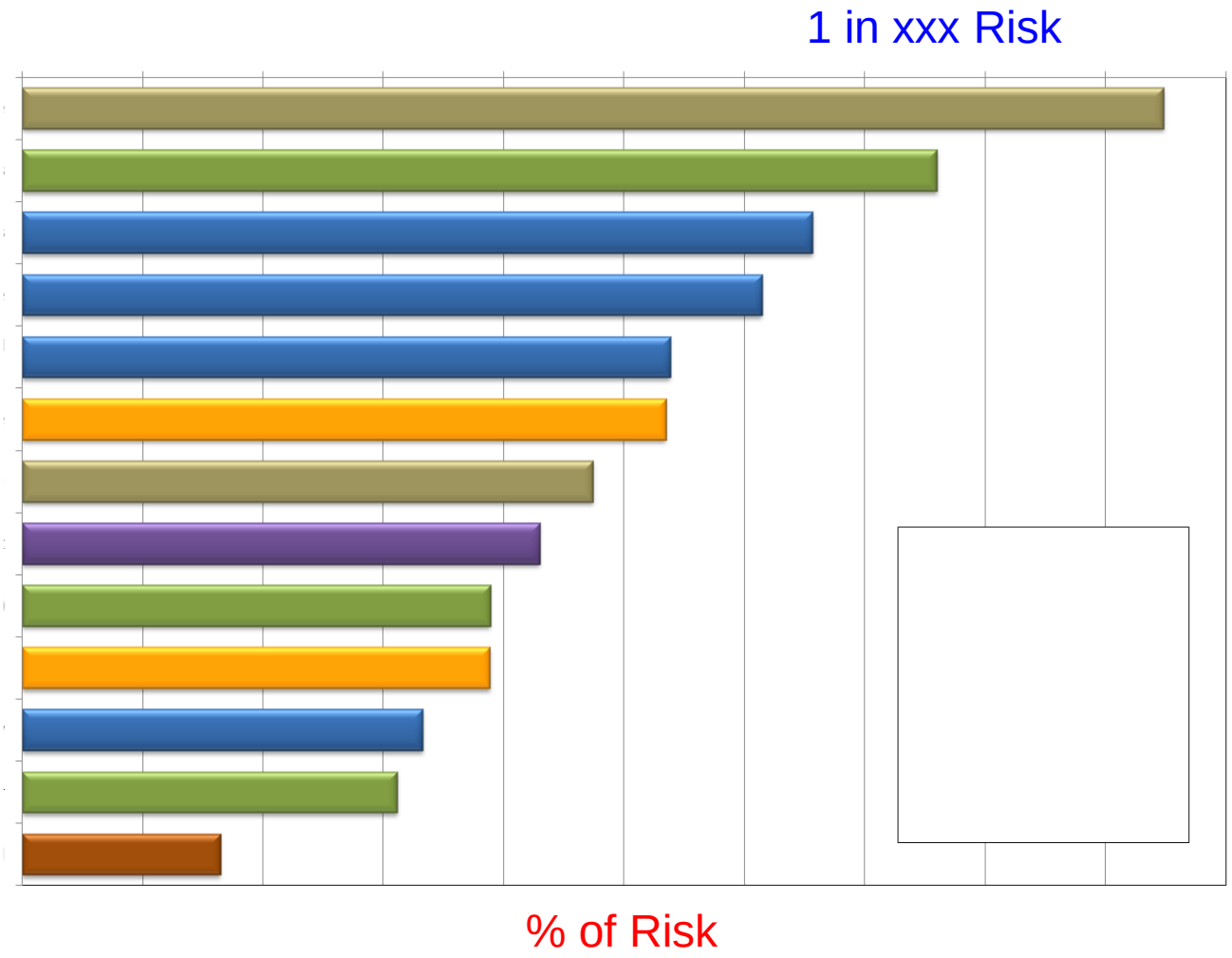
No Pie Charts,

They assume completeness and we know that we don't know it all.

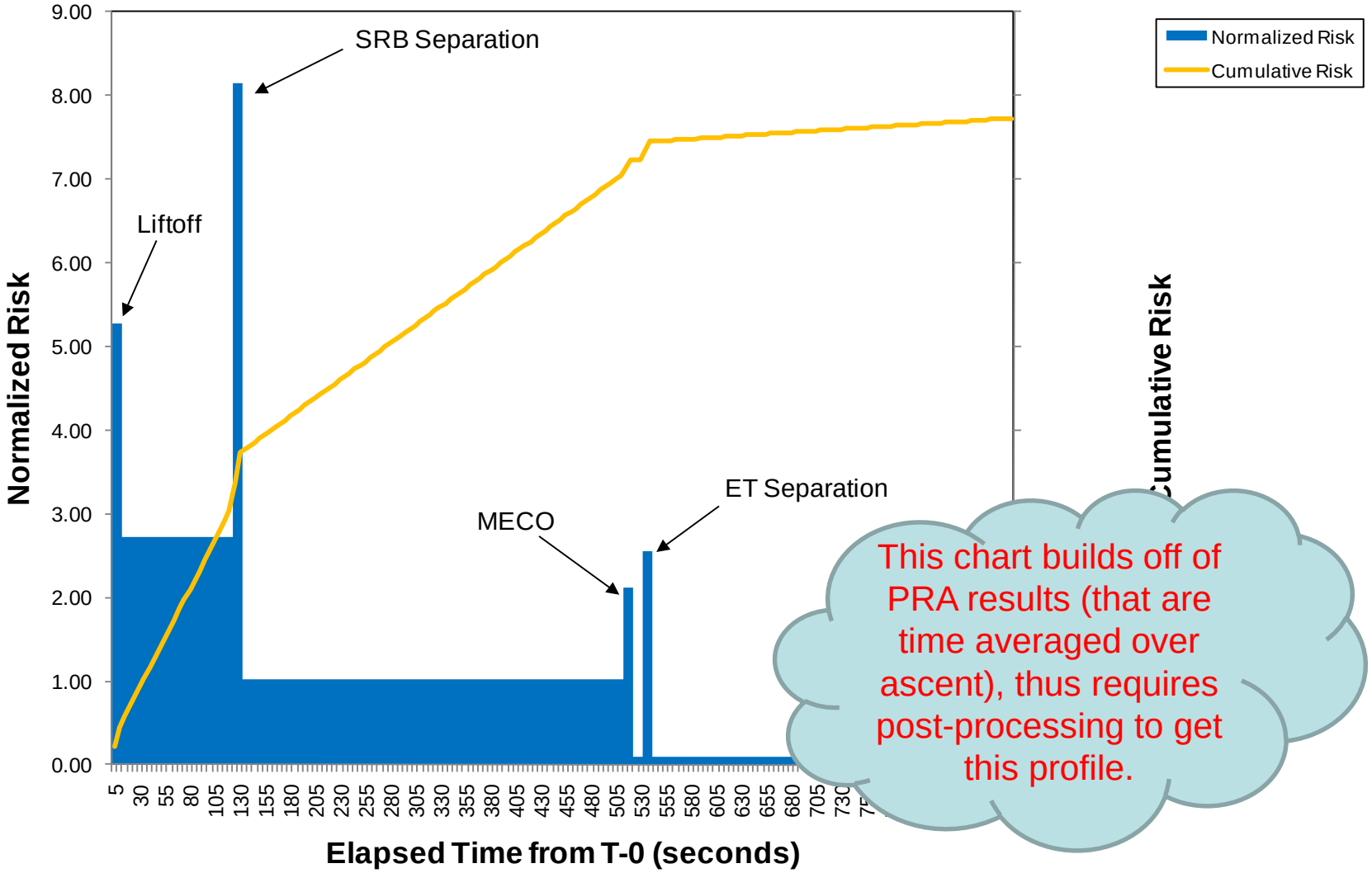


Notional Risk Drivers via Pareto
(e.g. Top 80% of Calculated Risk)

A Pareto chart like this can be made for each project, mission phase, etc.



Notional Ascent Risk Profile (not a direct output of PRA)



This chart builds off of PRA results (that are time averaged over ascent), thus requires post-processing to get this profile.