



Safety Performance Measurement for Safety Enhancement at NASA

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Does Safety Tend to Be Taken for Granted?

- **NASA Safety Manual (NPR 8715.3) defines **safety** as freedom from conditions that can cause death, injury, occupational illness, damage to equipment or property, or damage to the environment.**
- **Thus, safety is generally not conspicuous. It is the degree of absence of safety that is noticed and measured.**
- **This is perhaps why safety may be taken for granted or even ignored until an accident or mishap occurs after which safety awareness suddenly increases.**



Metrics Are Needed to Measure Performance Improvement

“If you cannot measure it,
you cannot improve it.”

Lord Kelvin (1906)



NASA Core Values

- The NASA Core Values are:
 1. **Safety**
 2. **NASA Family**
 3. **Excellence**
 4. **Integrity**
- **The #1 NASA Core Value** is safety and health of the public, the NASA workforce and partners, and the high-value assets entrusted to us.



The Case for Safety Performance Measures

- We state that safety is the cornerstone upon which we build mission success. The degree of our commitment to safety in design and operational decisions must be measured, i.e., gauged through metrics.
- We need safety-related performance measures to convincingly make the case that our performance in protecting the safety of the public, NASA family, and in mission success is improving.
- Consider the following questions:
 - When and how are system safety analysis findings used in our decision-making (essence of CAIB Finding F7.4-4)
 - What is the safety impact of a proposed design or operational modifications?
 - What is the safety impact of the proposed relaxation of a requirement?



Occupational Safety Metrics

- We monitor and periodically report **occupational health and safety performance** of our workforce and contractors by quantifying adverse outcomes (metrics) using statistical data. These metrics are used to measure the adequacy of our performance in protecting the safety and health of NASA family (workforce and contractors).
- The reported metrics cover on a periodic basis
 - Deaths
 - Injuries
 - Property damage
 - Close calls
 - Lost time
 - Etc.

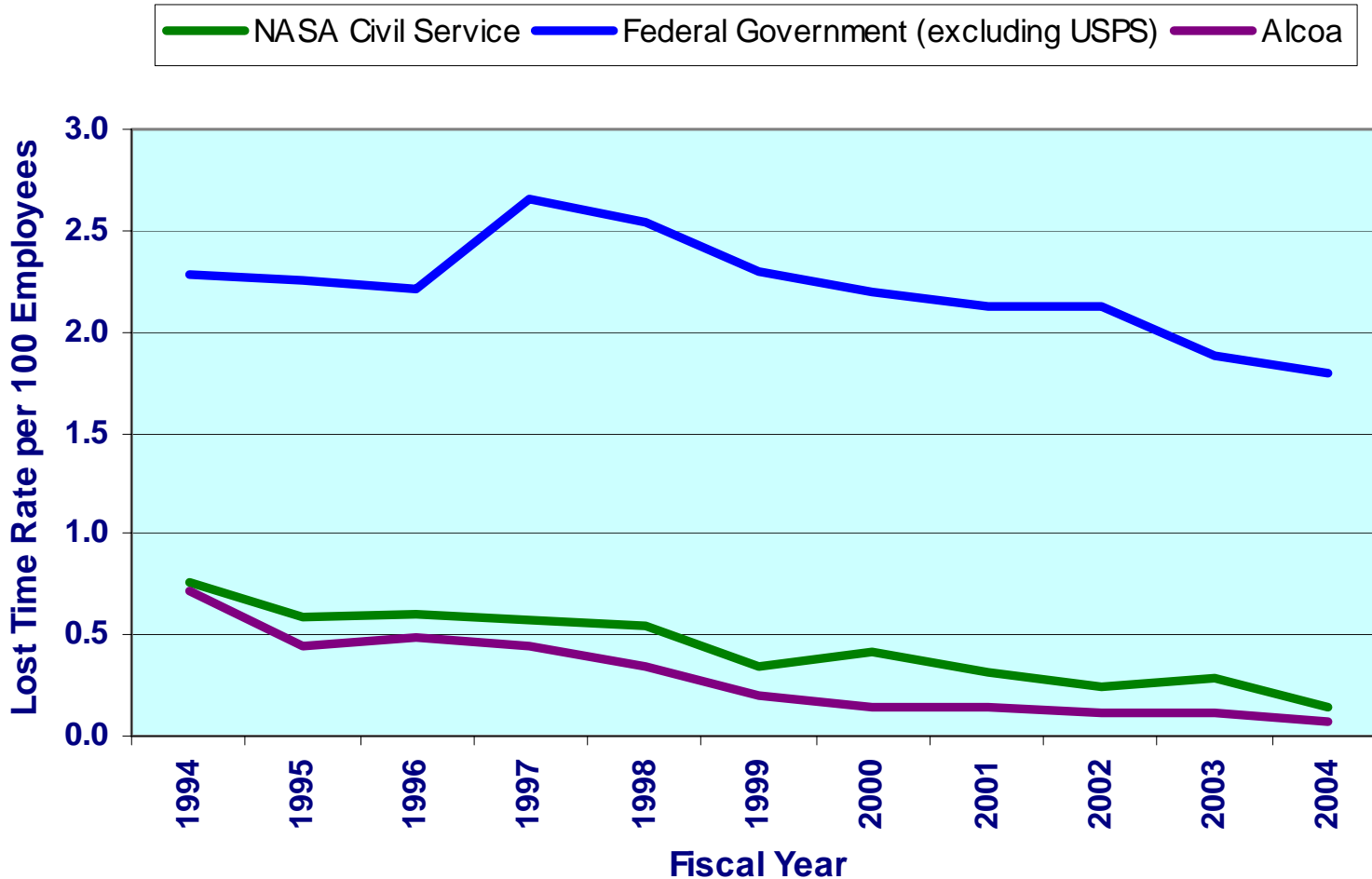


Types of Mishaps and Injuries (NPR 8621.1)

	Damage Level	Injury
Type A	\$1,000,000 or more/Crewed aircraft hull loss/ Aircraft departure from controlled flight	Fatality/ permanent total disability/ Inpatient care of 3 or more persons within 30 days of mishap
Type B	At least \$250,000 but less than \$1,000,000	Permanent partial disability / inpatient care of 1-2 persons within 30 days of mishap
Type C	At least \$25,000 but less than \$250,000	Nonfatal injury or illness causing days away from work, restricted duty, or job transfer
Type D	At least \$1,000 but less than \$25,000	Nonfatal OSHA recordable injury and/or illness that is not a type C mishap
Close Call	Less than \$1,000 or employee concern for a potential mishap	Minor injury/ first aid or condition for a potential mishap



Example of Lost Time Rate Comparison: NASA vs. Federal Government and Industry Leader





Safety Performance in All NASA Activities

- What about safety performance measures for the rest of the NASA activities, programs, missions?
- We have reliability performance measures for design and operation (e.g., double fault tolerance).
- We do not have systematic and comprehensive ways to directly measure safety performance in the design and operation phases of our missions.
- We perform FMEA, hazard, and other safety analyses for systems and programs but the results of these analyses do not readily reveal whether safety is improving, getting worse or staying the same unless the analyses are explicitly performed for comparison “before and after” a change.



Performance Indicators and Measures

Definitions:

- A **performance indicator** is a basic parameter (described qualitatively or quantitatively) that is perceived to have potential relationship to a given figure of merit, e.g., safety, economic value, mission duration, etc.
- A **safety performance indicator** is therefore a basic parameter (qualitative or quantitative) that has a potential relationship to safety.
- **Performance measure** is the measure (metric) of a performance indicator.



Safety Is not Reliability

- **Reliability and safety are related to each other, but one is not subset of the other.**
- **Safety enhancement can be achieved through a number of measures including**
 - **Engineered safety systems**
 - **Safety margins**
 - **Inherent (natural) safety barriers or design features.**
- **Reliability of engineered safety systems is a necessary ingredient for safety and thus it can be seen as a safety performance measure.**
- **Reliability of non-safety related systems may not necessarily be related to safety. Something can fail without impacting safety.**



KPP Are Performance Indicators

NPR 7120.5C defines key performance parameters (KPP) as those capabilities or characteristics (typically engineering based or related to safety or operational performance) considered most essential for the project, system, or advanced technology development to be reevaluated or terminated.

Thus, treating public and mission safety as performance indicators is consistent with draft NPR 7120.5C which requires that we monitor the technical and programmatic performance of our missions using metrics called Key Performance Parameters (KPP).



Risk-based Approach to Safety Performance Measures

- Risk assessment provides logic and qualitative and/or quantitative bases for analyzing scenarios that can lead to mishaps and accidents and for subdividing them down into system and component contributions to these mishaps or accidents.
- Therefore a risk assessment approach provides a convenient platform for identifying, structuring, and evaluating safety performance measures at different stages of design or operation.
- Also, risk assessment provides a convenient basis for linking safety performance with reliability performance. The quantitative risk assessment can be developed into a “safety and risk monitor” typically implemented as a “living quantitative risk assessment” model.



Two Types of Performance Measures

- **High-level** safety performance measures are those that **directly impact safety**. These are the “end states” in a quantitative risk assessment.
 - Examples: Loss of crew, loss of vehicle, loss of module
- **Low-level** safety performance measures are described in terms of fundamental events or conditions that are thought to **ultimately impact safety**.
 - Examples: system or component unreliabilities



Safety Relevant Performance Measures

- **Examples of safety relevant performance measures include rate measures (number of events per reporting time period) of the following occurrences:**
 - **Initiating events (internal or external)**
 - **Component unavailability or multiple related unavailabilities**
 - **Safety function unavailability**
 - **Safety system unavailability**
 - **Personnel errors**
 - **Other significant events or collectively significant related occurrences**



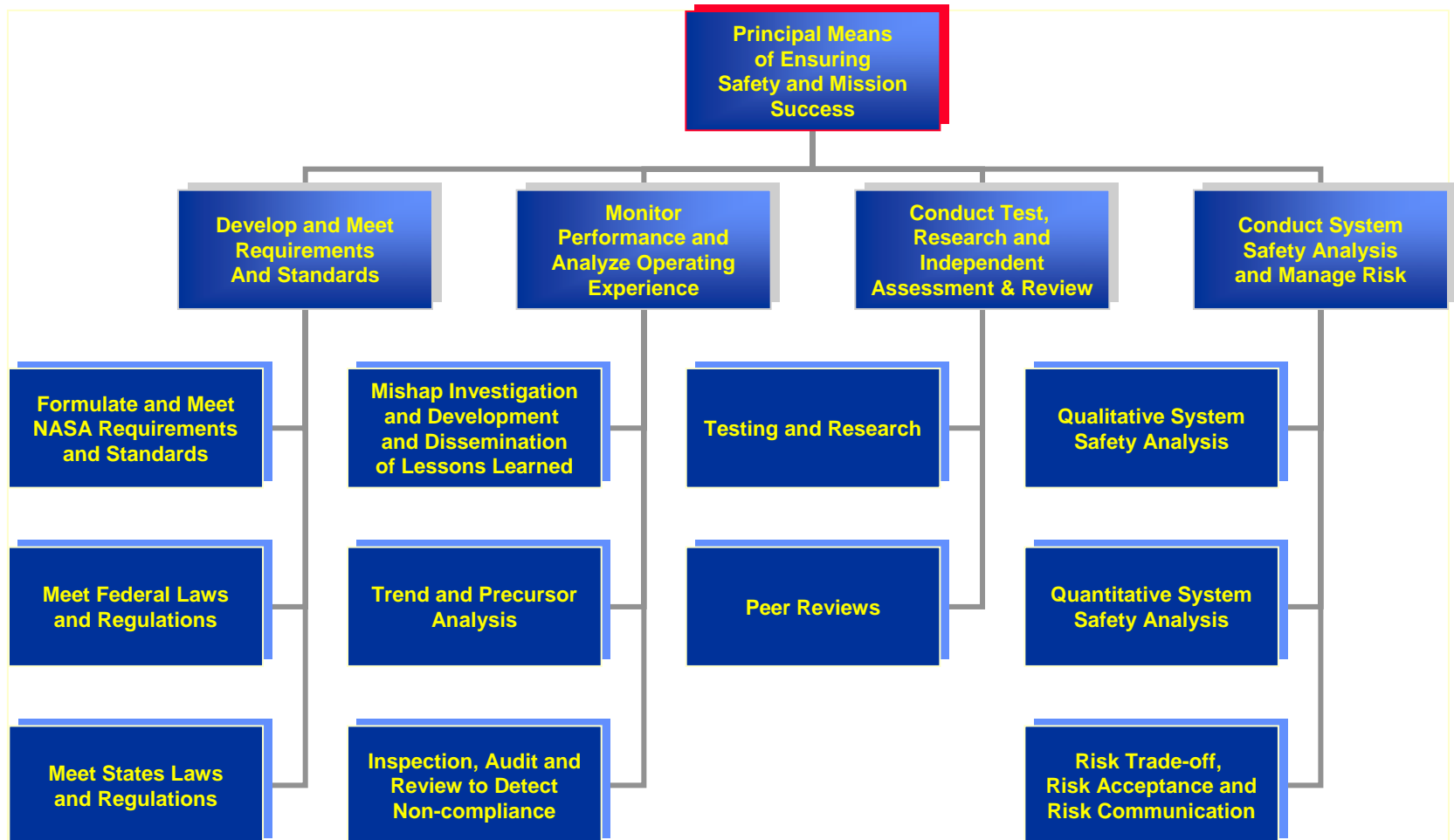
Hierarchic Categorization of Performance Measures

PM event types can be categorized in a hierarchic fashion like the following one:

- Type 1: **Initiating** event; or changes in a known way of an initiating event frequency;
- Type 2: **Functional** unavailability; **system** unavailability; **train** unavailability; or changes, in a known way, of the failure rate of the safety function, system or train (directly, without being attributable to a change in component failure rates);
- Type 3: **Component** unavailability; or changes, in a known way, of a component failure rate; and
- Type 4: **Correlation** with a change in a failure rate (of a safety component, train, system, or function) or with an initiating event frequency. Effects of safety culture are in this category.

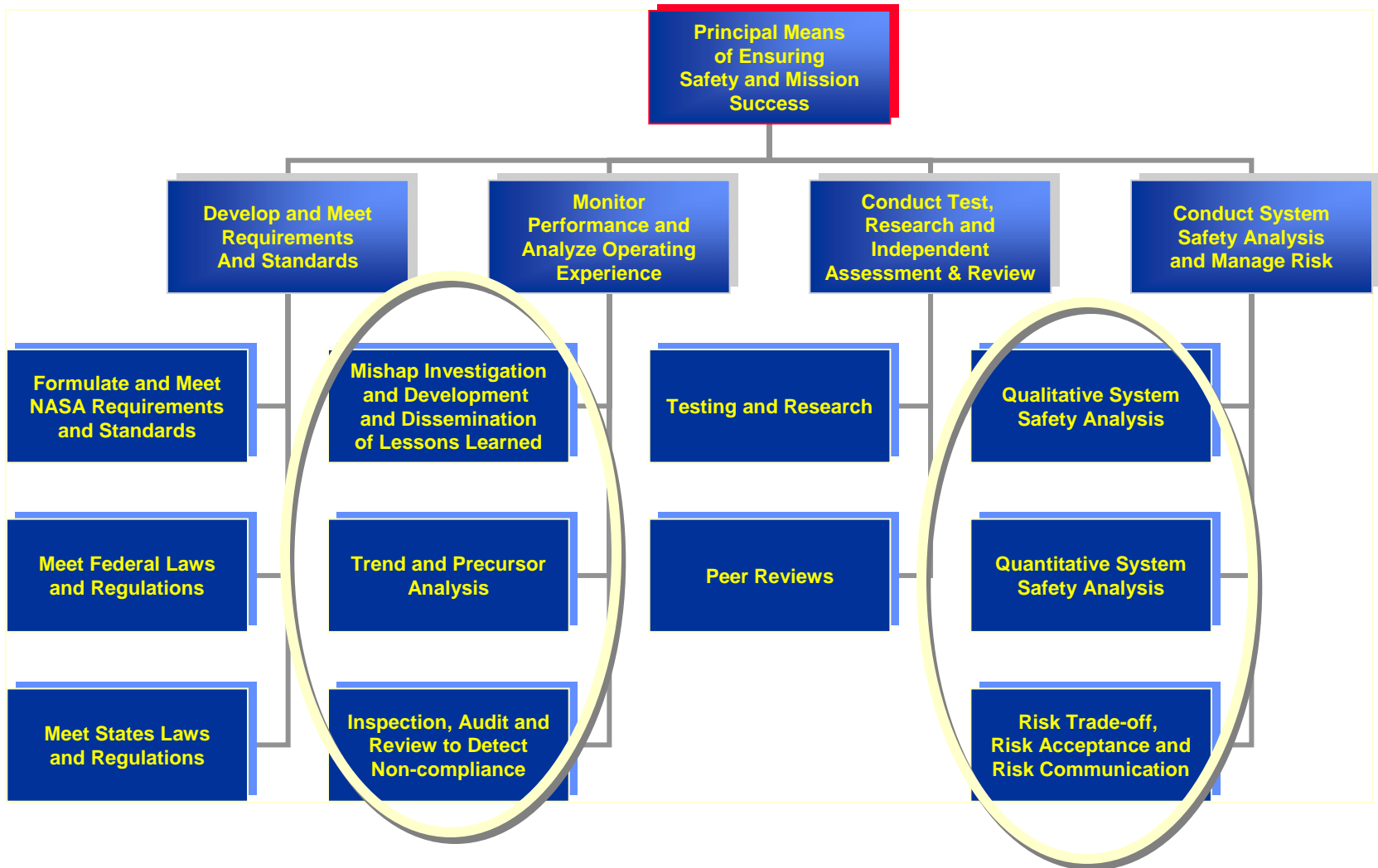


Framework for the Development of Performance Measures to Ensure Safety and Mission Success





Two Areas to Focus on for Safety Performance Measures





Challenge

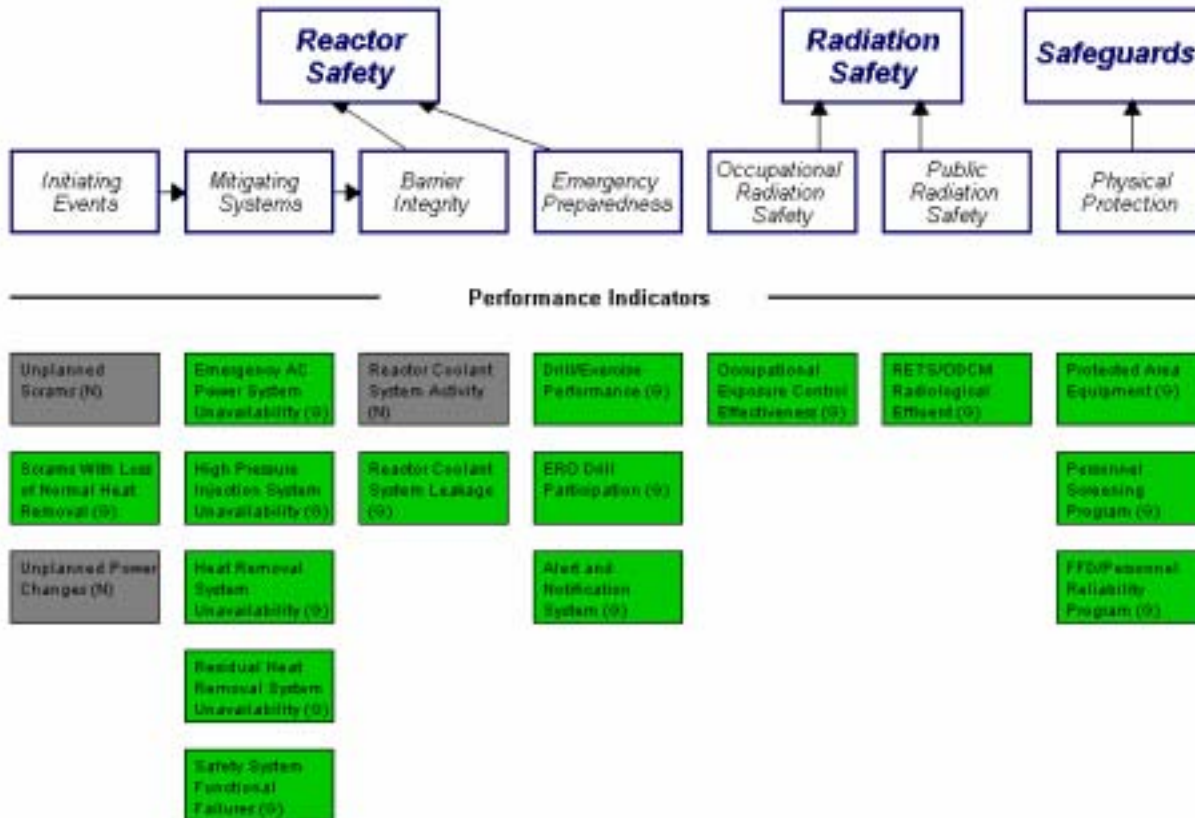
- **The challenge for NASA is to**
 - **Develop risk-based performance measures (RBPM) for NASA programs and missions in all relevant life cycles;**
 - **Screen and retain only those RBPM for which concrete correlations with safety changes (i.e., safety increase or decrease) exist;**
 - **Categorize the RBPM as shown before;**
 - **Evaluate the RBPM;**
 - **Monitor RBPM and RBPM trends to measure safety improvement.**



Backups



Example: How US NRC measures a utility's performance in safety



Safety Cornerstones

Performance Measures (Metrics)

Scram: Shutdown

ERO: Emergency Response Organization

RETS: Radiological Effluent Technical Specifications

ODCM: Offsite Dose Calculation Manual