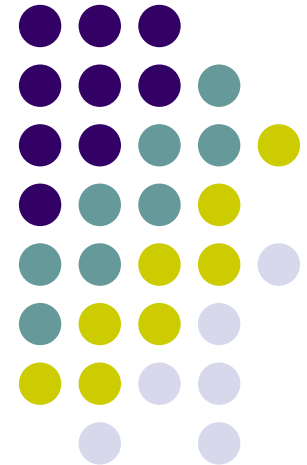


# ***INPO's Approach to Human Performance in the U.S. Commercial Nuclear Industry***

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**Tony Muschara**

Principal Program Manager – Hu  
Institute of Nuclear Power Operations



# INPO's Mission

***...to promote the highest levels of safety and reliability — to promote excellence — in the operation of nuclear electric generating plants.***



# Key Messages



- λ Work Preparation – Performance – Feedback is a **risk-management** process.
- λ Protect the plant from people by **aggressively** managing defenses.
- λ Performance improvement should be **systematic** and **systemic** in its approach.
- λ People must understand the **why's**, and demonstrate proficiency with Hu tools.

# ... Nuclear Safety...



## 1. Tremendous Power – reactivity management

- $\lambda$  Reactivity and power level controls
- $\lambda$  Rod control & drive reliability
- $\lambda$  Instrumentation reliability

## 2. Decay Heat Load – inventory and cooling

- $\lambda$  Reactor cavity and fuel pool
- $\lambda$  Secondary plant equipment reliability
- $\lambda$  Safety system reliability and controls
- $\lambda$  Plant materials integrity and design margins

## 3. Radioactive Material – barrier integrity

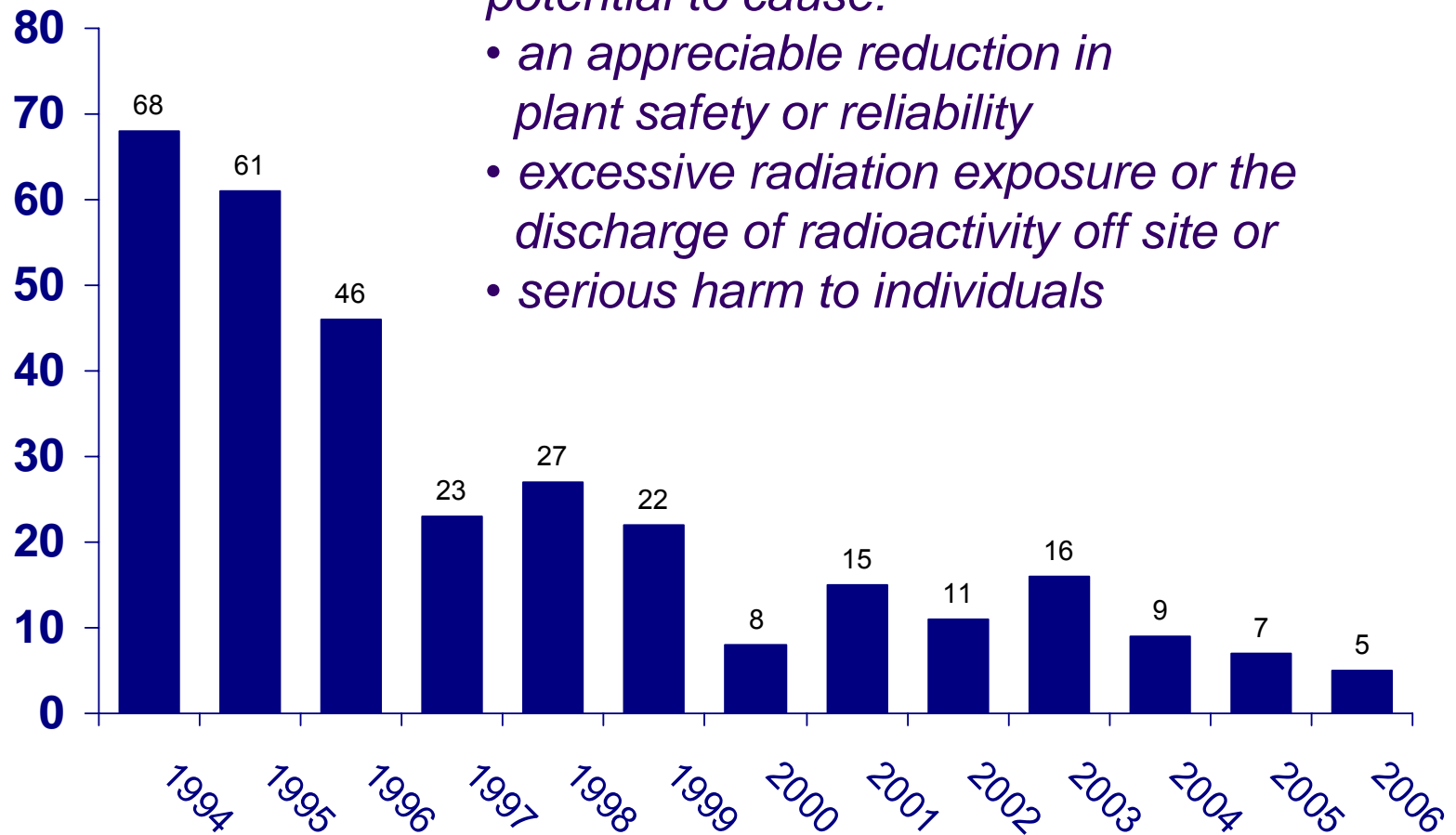
- $\lambda$  Containment integrity
- $\lambda$  Defect-free fuel
- $\lambda$  Primary systems integrity

# Significant Events – USA



*An event that caused or had the potential to cause:*

- an appreciable reduction in plant safety or reliability*
- excessive radiation exposure or the discharge of radioactivity off site or*
- serious harm to individuals*

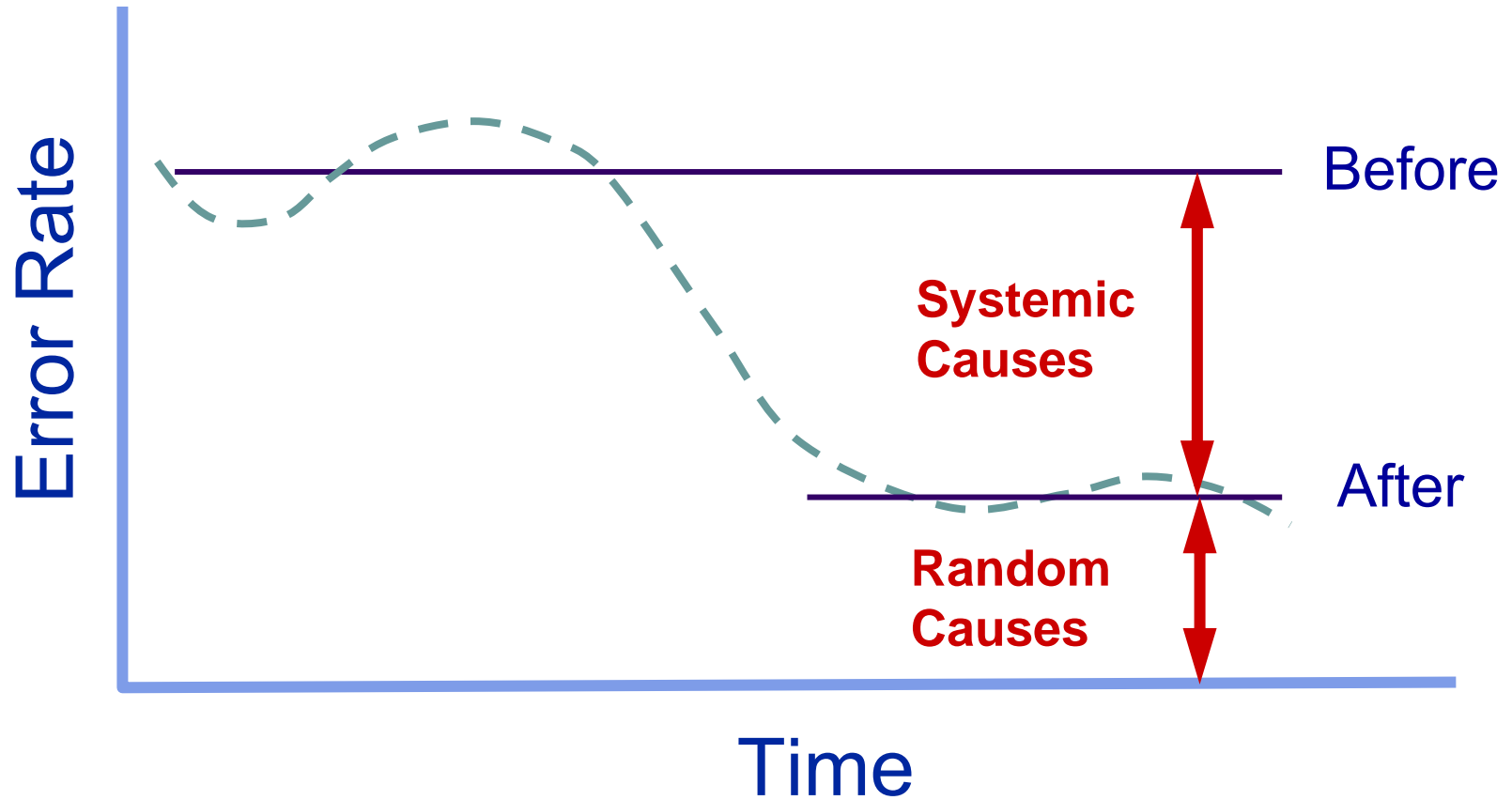
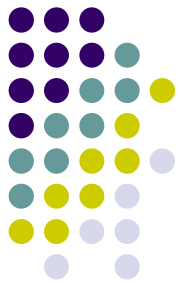


# *What is Managed?*



- λ Assets: people, plant, and property
- λ Hazard: human error
- λ Exposure: “People *touching* equipment”
- λ Risk: probability and consequences
- λ Event: ▼ frequency and ▼ severity
- λ Controls:
  - λ **error rate** (frequency) → reduce active errors
  - λ **defense-in-depth** (severity) → reduce latent conditions

# Error Rate Reduction



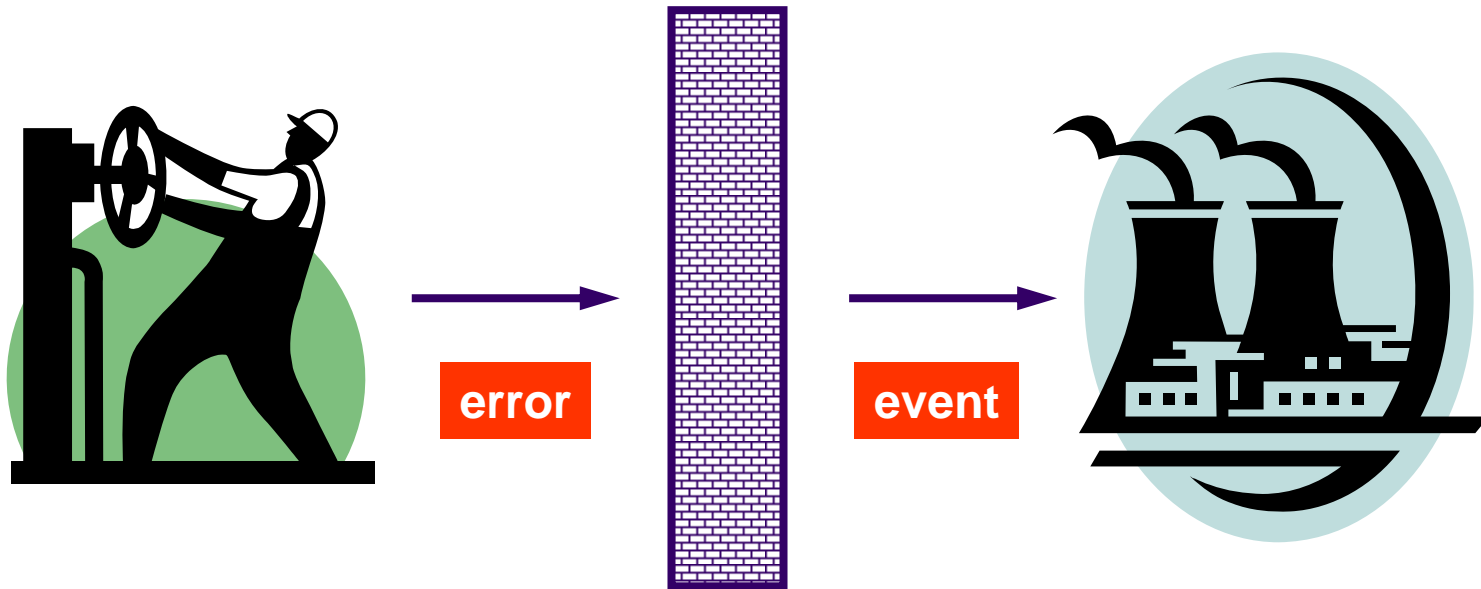
# Hazard – Barrier – Asset



**Hazard:**  
Human – “touching”

**Barrier(s):**  
Less than Adequate  
or Missing

**Asset:**  
Object to Protect



Where's the **risk**?!



# Strategic Approach to Hu



$$R_e + M_d \rightarrow \emptyset E$$

*Reducing  
error*

*and*

*Managing  
defenses*

*leads  
to*

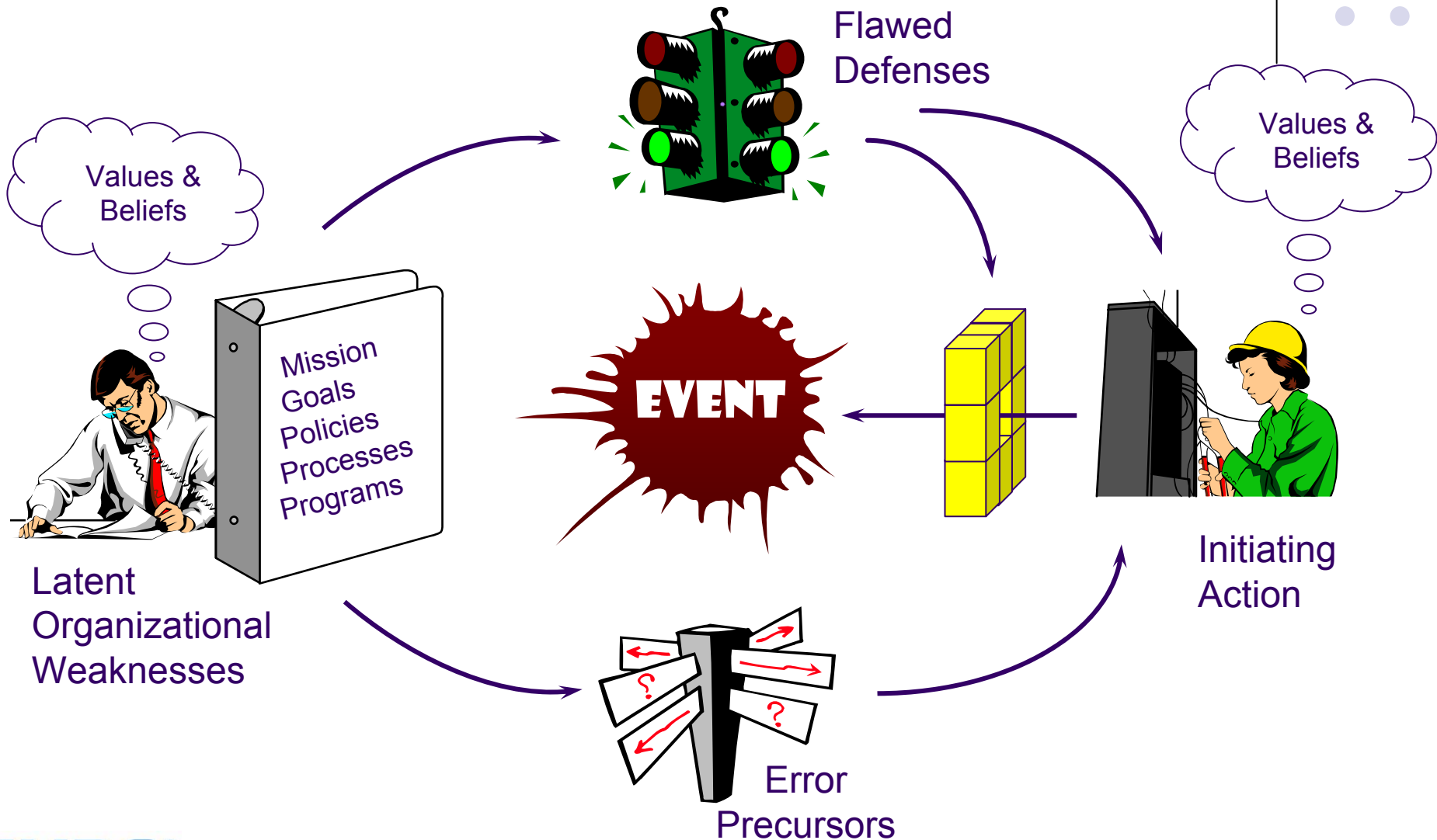
**ZERO  
Events**



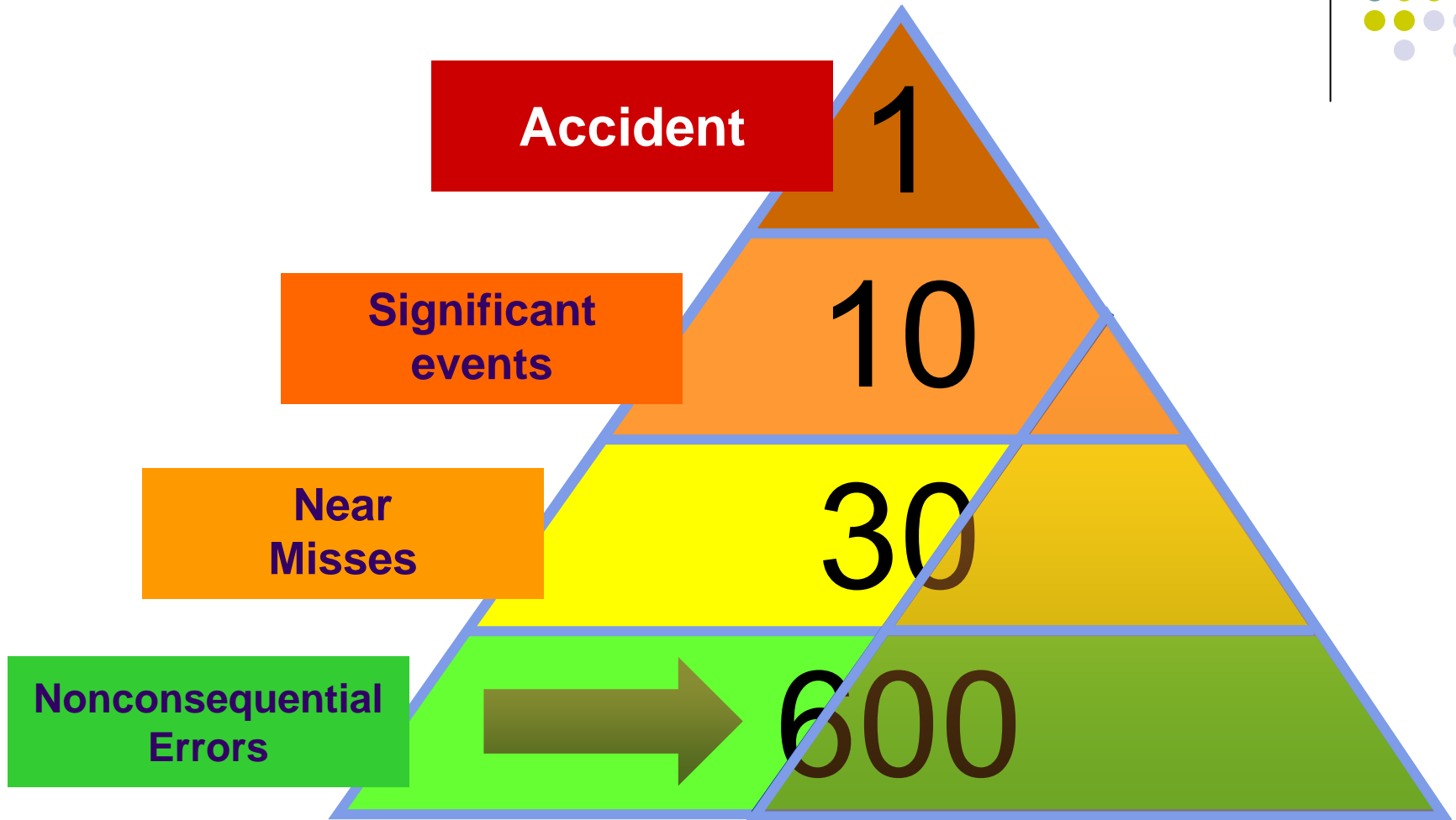
Identify  
Analyze  
Correct



# Anatomy of an Event



# Severity Pyramid



Source: Frank Bird, Jr., *Practical Loss Control Leadership*, Det Norske Veritas (formerly International Loss Control Institute), 1969.

# *Risk-based Approach\**



- $\lambda$  Human and equipment risk are not the same.
- $\lambda$  Process of assigning controls for work activities uses a *graded approach*.
- $\lambda$  Controls are *proportionate* to the risk or potential consequence.

\* IAEA, *Management of Operational Safety in Nuclear Power Plants* – a report by the International Safety Advisory Group, final draft, 1999.

# *Positive Control*



**What is intended to happen  
is what happens  
and that is all that happens**

# Critical Step



**Critical Step** – a procedure step, series of steps, or action that if done improperly *will cause irreversible harm* to equipment or people, or significantly impact plant operation



# “S-A-F-E-R”

## Task Preview



<b>S</b>	<b><u>S</u>ummarize</b> <i>critical steps</i>
<b>A</b>	<b><u>A</u>nticipate</b> <i>errors or mistakes at each critical step</i>
<b>F</b>	<b><u>F</u>oresee</b> <i>probable and worst-case consequences</i>
<b>E</b>	<b><u>E</u>valuate</b> <i>defenses, barriers, contingencies, &amp; abort criteria</i>
<b>R</b>	<b><u>R</u>eview</b> <i>experience relevant to the task</i>

# *Managing Defenses*



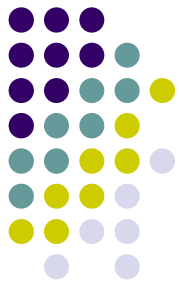
- 1. Identify** unsafe condition(s)
- 2. Analyze** its cause(s) and extent of condition
- 3. Correct** the condition(s)



# ***Work Execution***

## ***“touching” equipment***

**$R_e$**



### $\lambda$ **Work Preparation**

$\lambda$  planning, walkdowns, task assignments and prejob briefings (task preview)

### $\lambda$ **Work Performance**

$\lambda$  uneasiness, situation awareness, Hu tools, teamwork and supervision

### $\lambda$ **Work Feedback**

$\lambda$  reporting and observations

# Post-Job Reviews



- λ Can't afford not to debrief – information fed back into the company processes
- λ Too narrowly focused on “things done wrong”
- λ Nameless and rankless – it's what's right
- λ Compared with pre-job briefing (critical steps)
- λ Causal analysis: what – how – why
- λ Written feedback – lessons learned (step-by-step fixes)

# Defenses



## $\lambda$ Engineered Controls

- $\lambda$  equipment reliability, software & hardware configuration, human-machine interface

## $\lambda$ Administrative Controls

- $\lambda$  procedures, training, processes, policies, expectations and standards

## $\lambda$ Cultural Controls

- $\lambda$  assumptions, values, beliefs, attitudes, work group norms, and leadership

## $\lambda$ Oversight Controls

- $\lambda$  accountability, performance improvement

# Defense-in-Depth



Functions	Engineered Controls	Admin Controls	Cultural Controls	Oversight Controls
Inform	Beacon	Sign	Pay attention to sign	Supervision
Detect & Warn				
Protect				
Recover				
Contain				
Escape				

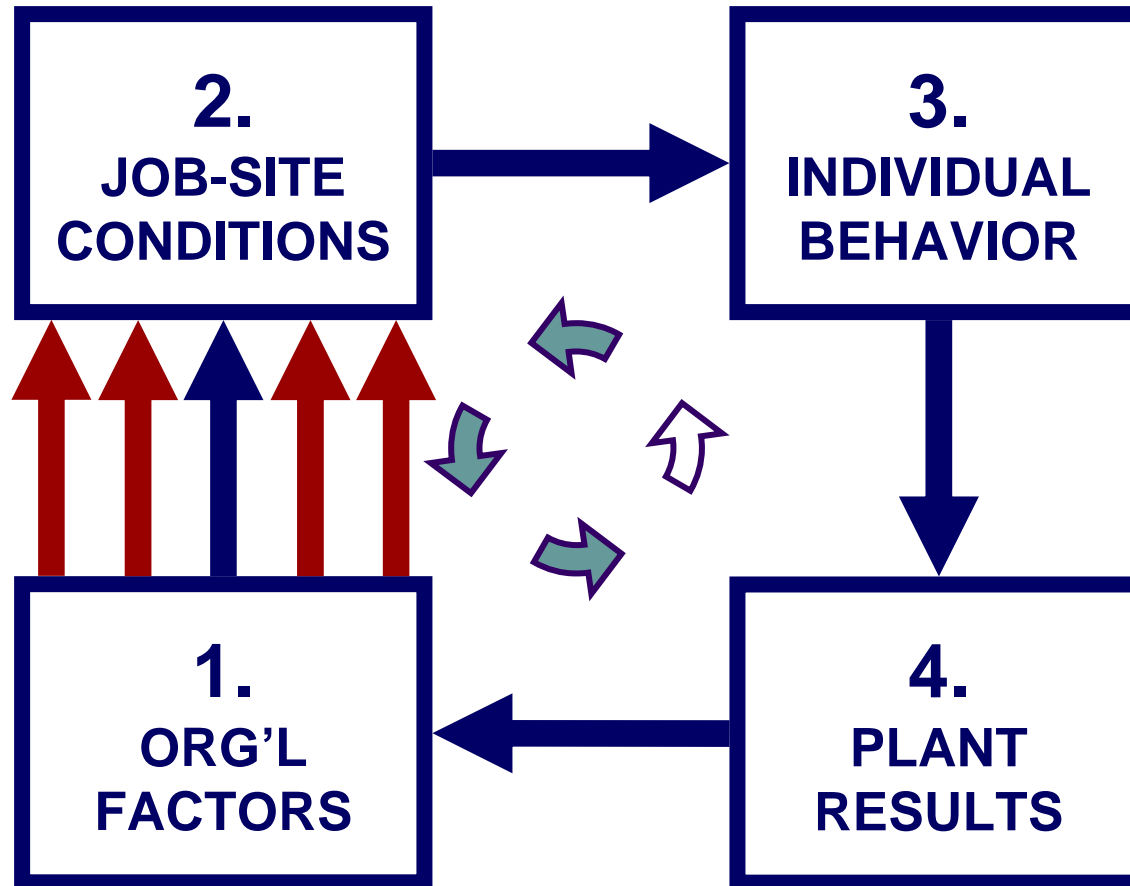
# *Organizational Factors*



1. Mission
2. Organizational structure
3. Clear direction
4. Work management
5. Administrative controls
6. Hazard control processes
7. Training & qualification
8. Engineering processes

9. Performance improvement processes
10. Technology
11. Human resources
12. Conservative decision making
13. Communication
14. Managerial/supervisory practices

# Performance Model



# Behavior Engineering Model - Nuclear (BEM-N)



	<b>Direction to Act</b>	<b>Opportunity to Act</b>	<b>Willingness to Act</b>
<b>Environmental Factors</b>	Task- or Job- related Information	Resources and Environment	Incentives and Disincentives
<b>Individual Factors</b>	Knowledge and Skills	Capacity and Readiness	Personal Motives

Source: Adapted with permission of the International Society for Performance Improvement, [www.ispi.org](http://www.ispi.org).

# BEM-N\*



	<b>Job/Task-related Information</b>	<b>Resources and Job Environment</b>	<b>Incentives and Disincentives</b>
<b>Environmental Factors</b>	<ol style="list-style-type: none"> <li>1. Job or task goals, desired results, roles and responsibilities, and criteria for success are clearly identified.</li> <li>2. The risk importance of the job or task and critical steps, if any, have been denoted and communicated as such.</li> <li>3. Clear expectations and standards for the conduct of work exist and have been communicated.</li> <li>4. The usability, accuracy, and availability of procedures support error-free performance.</li> <li>5. Relevant feedback on previous job or task performance, including opportunities for development, has been given to the individual (if applicable).</li> </ol>	<ol style="list-style-type: none"> <li>1. Tools, material, clothing, furniture, facilities, systems, and equipment accommodate human limitations and are available and accessible.</li> <li>2. Other individuals or organizations are available for support, if needed.</li> <li>3. Adequate time is allotted, and other work conditions that could hinder performance are eliminated or minimized.</li> <li>4. The values, attitudes, and beliefs of the person's immediate work group about hazards in the workplace support safe practices.</li> </ol>	<ol style="list-style-type: none"> <li>1. Financial and non-financial rewards and disincentives are contingent on performance.</li> <li>2. Competing incentives for poor performance are eliminated.</li> <li>3. The job or task provides opportunities for success and career advancement, meets employee needs, and result in identifiable pieces of work traceable to the individual.</li> <li>4. People are treated with honesty, fairness and respect regardless of position in the organization.</li> <li>5. Work group standards are consistent with the above.</li> </ol>
	<b>Knowledge and Skill</b>	<b>Capacity and Readiness</b>	<b>Motives</b>
<b>Individual Factors</b>	<ol style="list-style-type: none"> <li>1. Individual is qualified for the job or task and possesses the knowledge, skills, experience, and proficiency necessary to perform the task successfully.</li> <li>2. Individual understands the job or task objective(s), critical steps, and potential consequences if performed improperly.</li> <li>3. Individual understands the roles and responsibilities of others.</li> </ol>	<ol style="list-style-type: none"> <li>1. Individual possesses the intelligence, sociability, aptitude, size, strength, and dexterity to perform the job or task successfully.</li> <li>2. Individual is available for work, undistracted, and fit for duty.</li> </ol>	<ol style="list-style-type: none"> <li>1. Individual cares about performing the job or task well.</li> <li>2. Individual possesses a healthy work ethic and is willing to do what is right regardless of what others would do.</li> <li>3. Individual feels that the job or task is meaningful and attainable, progress is recognizable, and the task generates a personal sense of accomplishment.</li> </ol>

\* Source: Adapted with permission of the International Society for Performance Improvement, [www.ispi.org](http://www.ispi.org). Content derived from Tom Gilbert's *Human Competence, Engineering Worthy Performance*, 1996, p.88.



# *Safety Culture Principles\**



1. Everyone is personally responsible for nuclear safety.
2. Leaders demonstrate commitment to safety.
3. Trust permeates the organization.
4. Decision-making reflects safety first.
5. Nuclear technology is recognized as special and unique.
6. A questioning attitude is cultivated.
7. Organizational learning is embraced.
8. Nuclear safety undergoes constant examination.

\* INPO, *Principles for a Strong Nuclear Safety Culture*, November 2004.

# *Safety Culture?*



In August 2005, two instrument control technicians disconnected the wrong electrical leads during a surveillance test on a steam generator blowdown flow channel, resulting in the blowdown bypass valve opening. The technicians could not locate the terminal board specified in the procedure and did not stop to call their supervisor. The technicians decided to lift leads from another point, resulting in a loss of power to the flow circuit. The change in blowdown flow caused a minimal change in reactor power.

# OR.3 Human Performance



“Station personnel select and apply appropriate error prevention techniques commensurate with the importance of assigned tasks to minimize the frequency and consequences of events.”

λ Organizational Factors

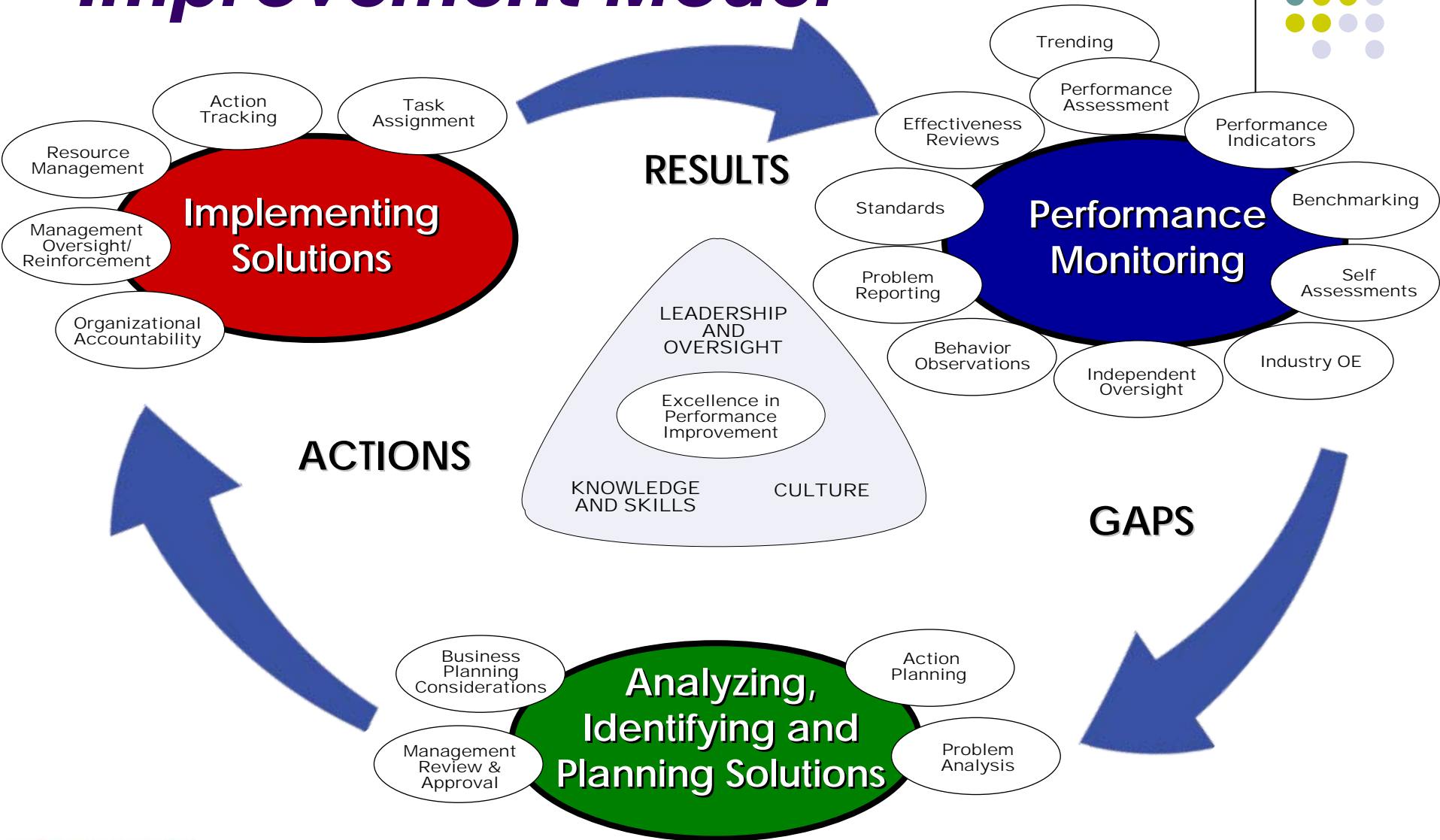
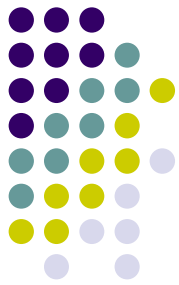
λ Job-Site Conditions

λ Individual Behaviors

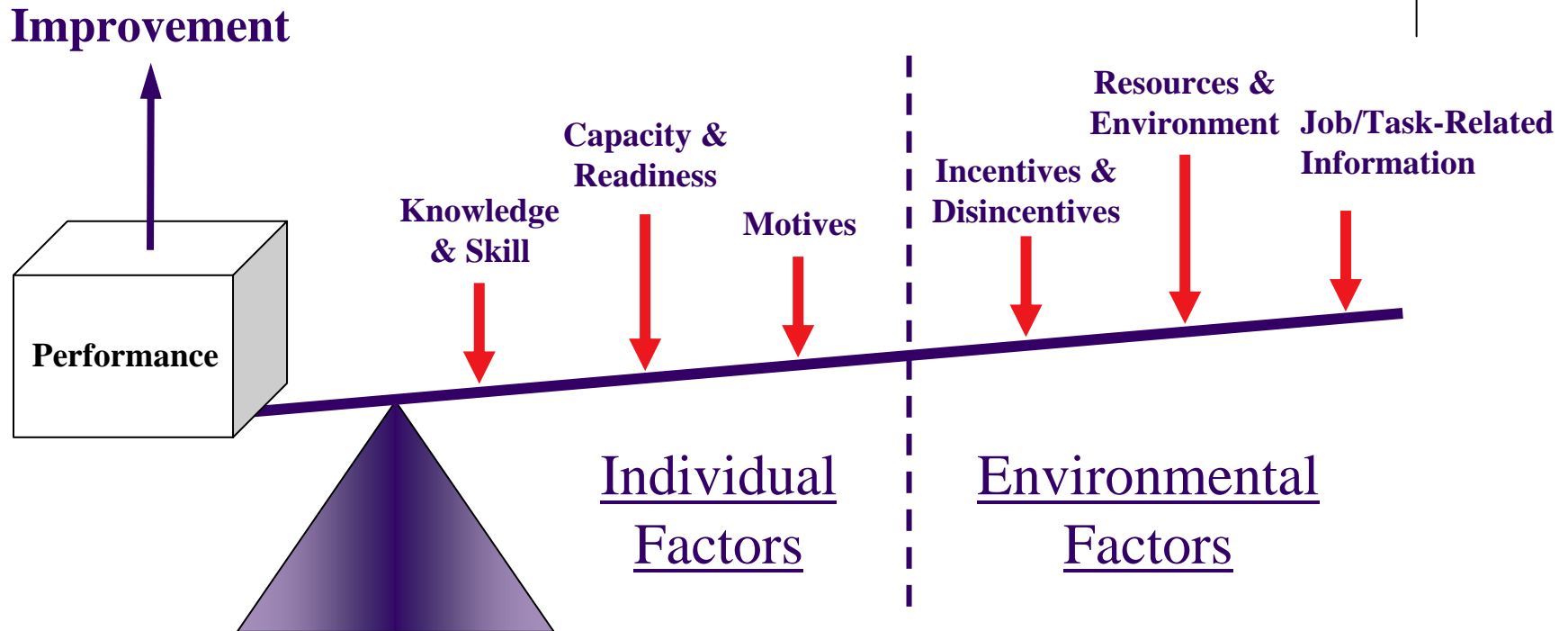
**$R_e$**

**$M_d$**

# INPO Performance Improvement Model



# Leverage – Corrective Actions



**Less ← Leverage to Affect Performance → More**

**More ← Cost of Corrective Actions → Less**

(Reprinted with permission of the International Society for Performance Improvement, [www.ispi.org](http://www.ispi.org).)

# *Delivery of Hu Training*



- λ Embed in line training programs
- λ Accomplish vs. Avoid
- λ Competence vs. Control
- λ 'Real-world' examples
- λ Ask 'Why?' frequently
- λ On-the-job training (OJT)
- λ Dynamic Learning Activities (DLAs)

# Strategic Approach to Hu



$$R_e + M_d \rightarrow \emptyset E$$

*Reducing  
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**ZERO  
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Identify  
Analyze  
Correct

