International Workshop: Kiev, The Ukraine

Use of Probabilistic Safety Analysis in Operation of Nuclear Power Plants and Regulatory Decision Making

Principles

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Topic Areas

- Principles
- Program
- Applications
- Reactor Oversight Program & Significance Determination Process

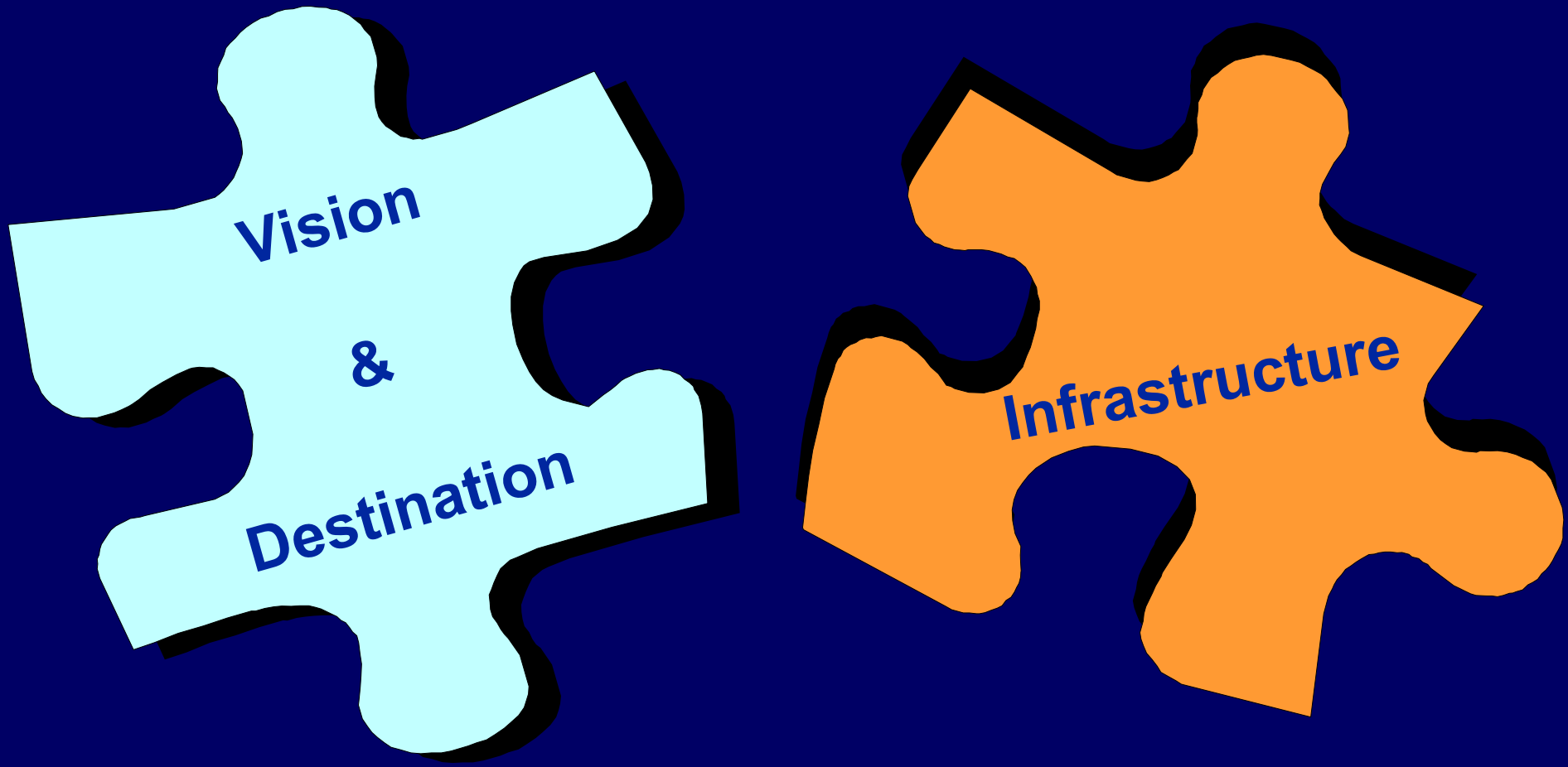
Principles of Navigation

- Destination
  - Fundamental Principle:
    - » If you don't know where you are going, you will almost certainly not get there!
- Chart
  - Identify Destination & Obstacles
  - Plot Successful Course to Destination
    - » Appropriate Tools and Infrastructure
- Navigate!
  - Plan, Execute, Evaluate, Feedback

Destination

- Maintain Public Health & Safety by . . .
- Applying Risk Information in Integrated Decisions
- Regulating Licensees Such That They
  - Manage Risk
  - Evaluate Risk
  - Operate Facilities Accordingly

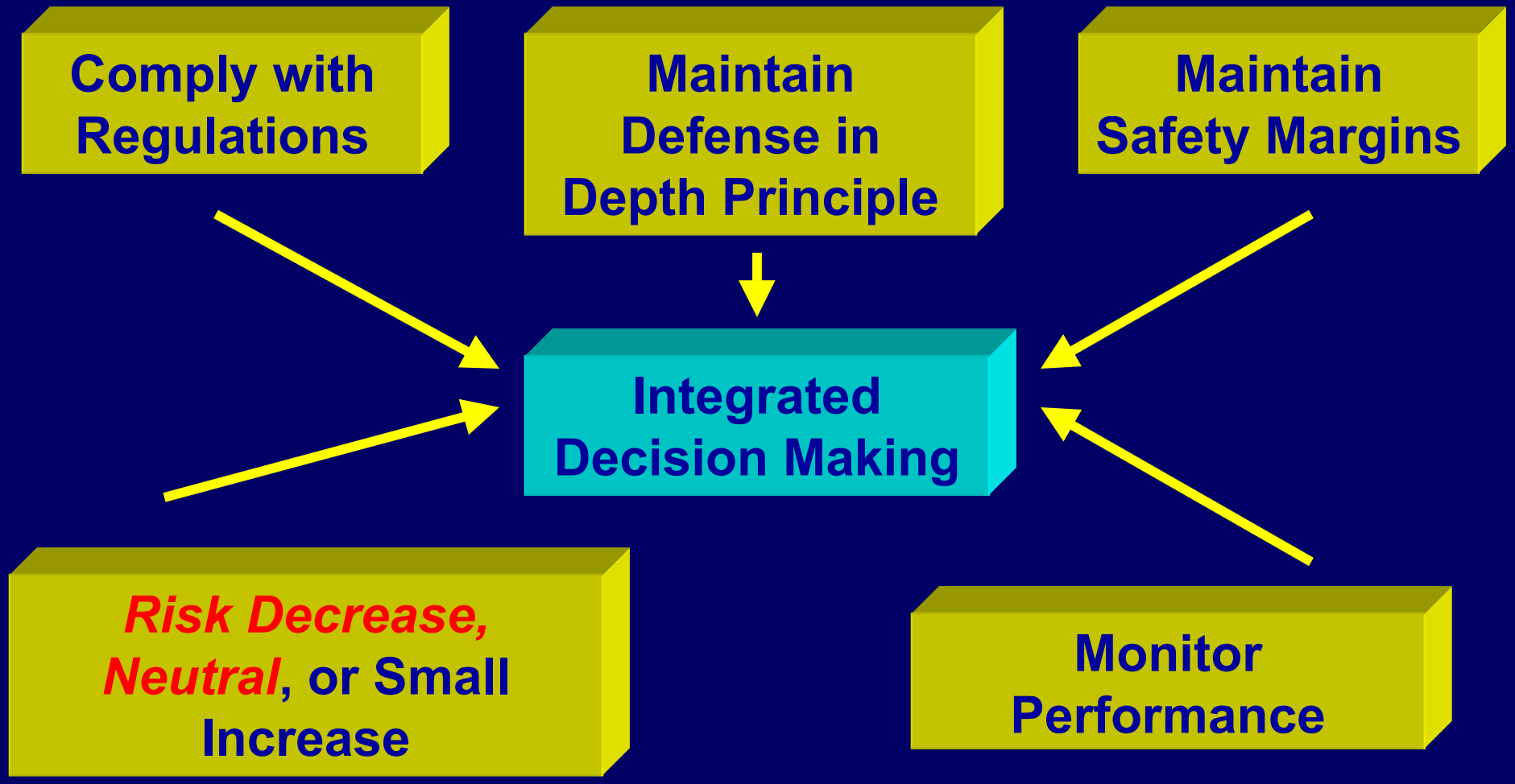
Navigate To Destination



Use of PSA

- Three time periods
  - "Crossing street"
- Good as new

Integrated Decision Making



Objectives

- Enhance Safety Decisions
  - Add risk-insights to engineering information
- Effective & Efficient Use of NRC Resources
  - Focus NRC actions & resources on most safety significant issues
- Reduce Unnecessary Industry Burden
  - Focus licensee actions & resources on most safety significant issues

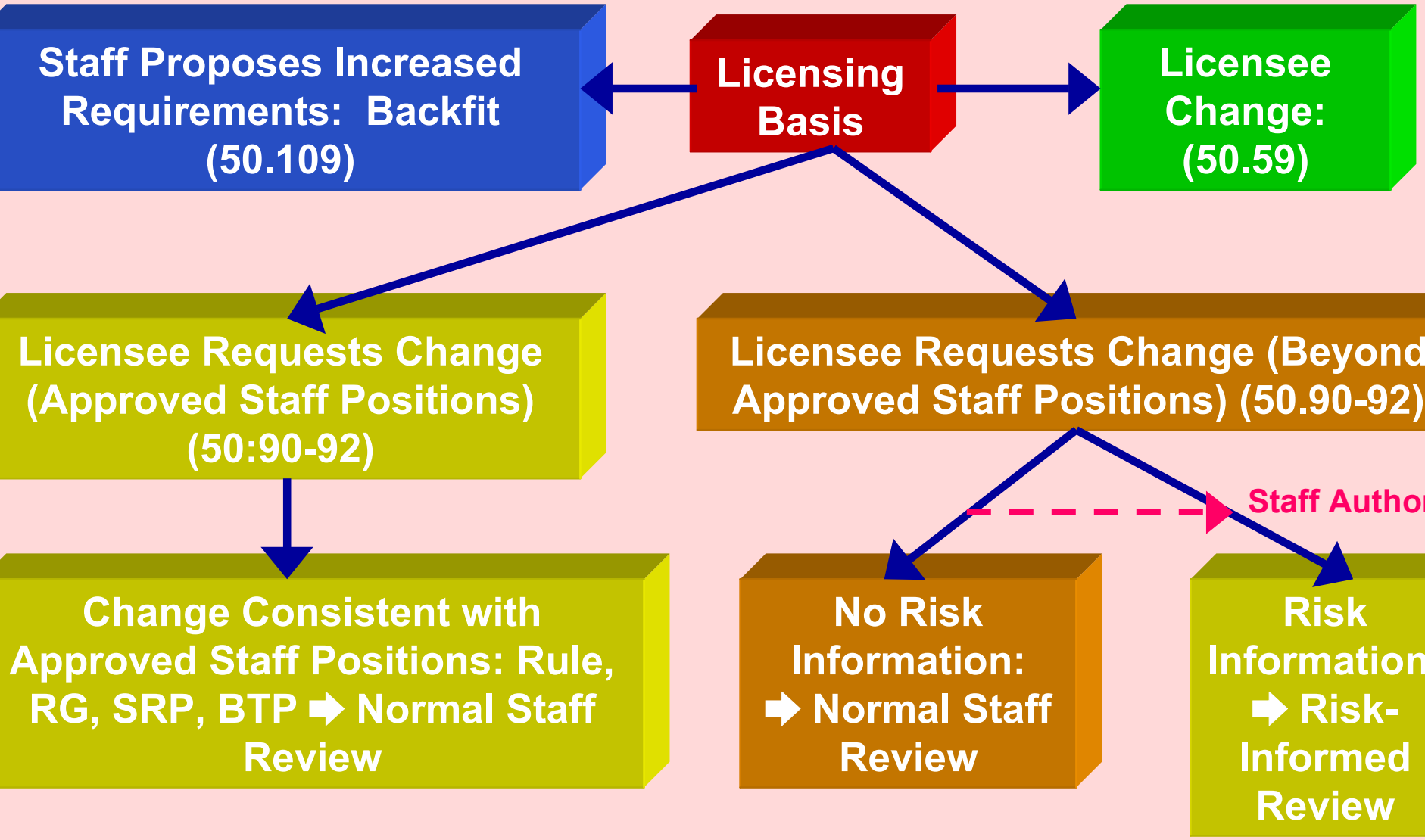
Risk-Informed (R-I) Initiatives

- Arenas
  - Licensing
  - Events Assessment
  - Oversight
  - Regulations
- Build Upon Current Infrastructure, Policies, Practices

Risk-informed Regulation

- Commission's Safety Goals
  - Quantitative Health Objectives
- PSA Policy Statement
- Regulatory Guides & Standard Review Plans
  - Risk measures
  - Decision logic

Decision Logic: Licensing Basis Changes



BALANCE

- Maintain Safety
- Increase Effectiveness & Efficiency
- Reduce *Unnecessary* Burden
- Increase Public Confidence

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Program

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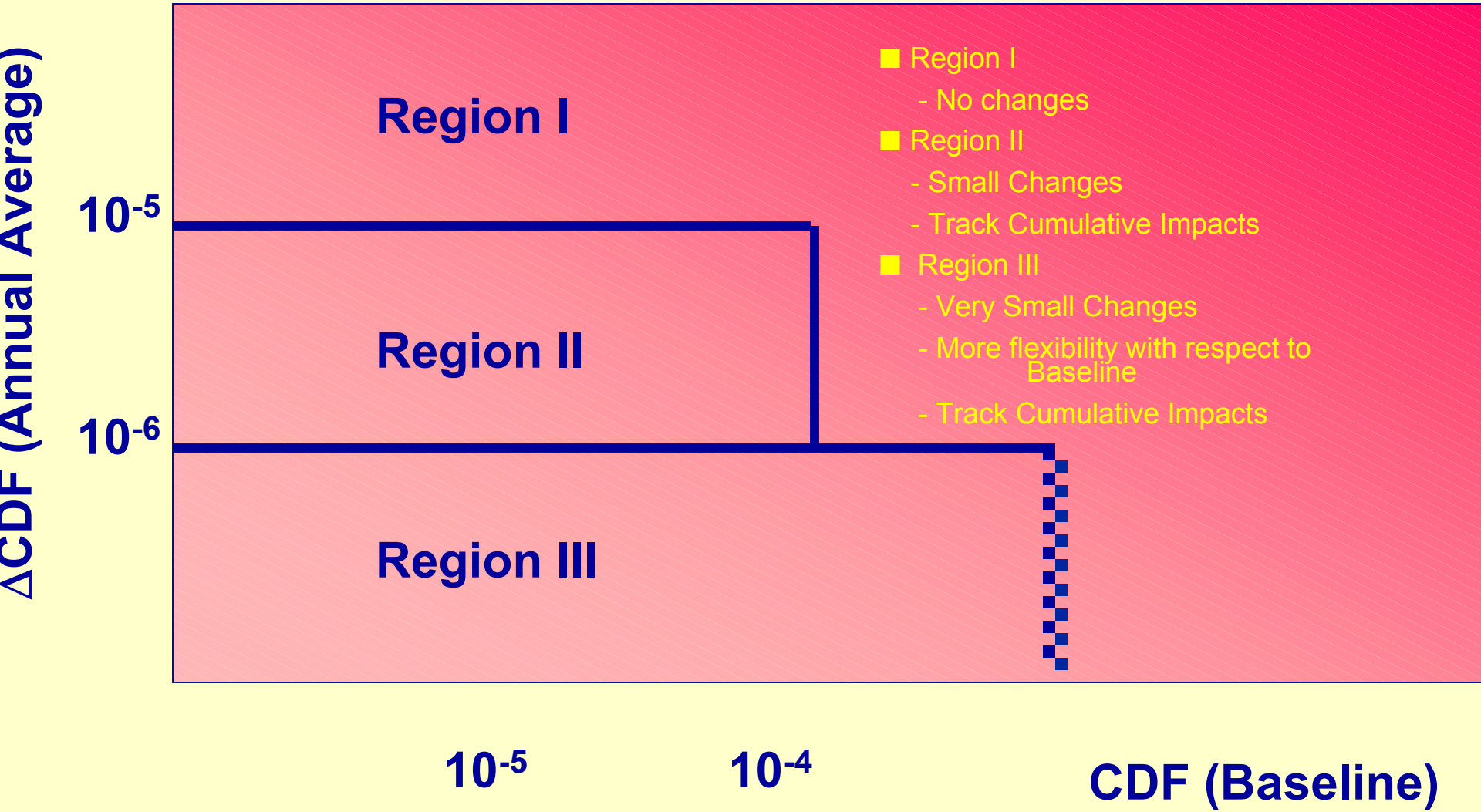
Safety Goals

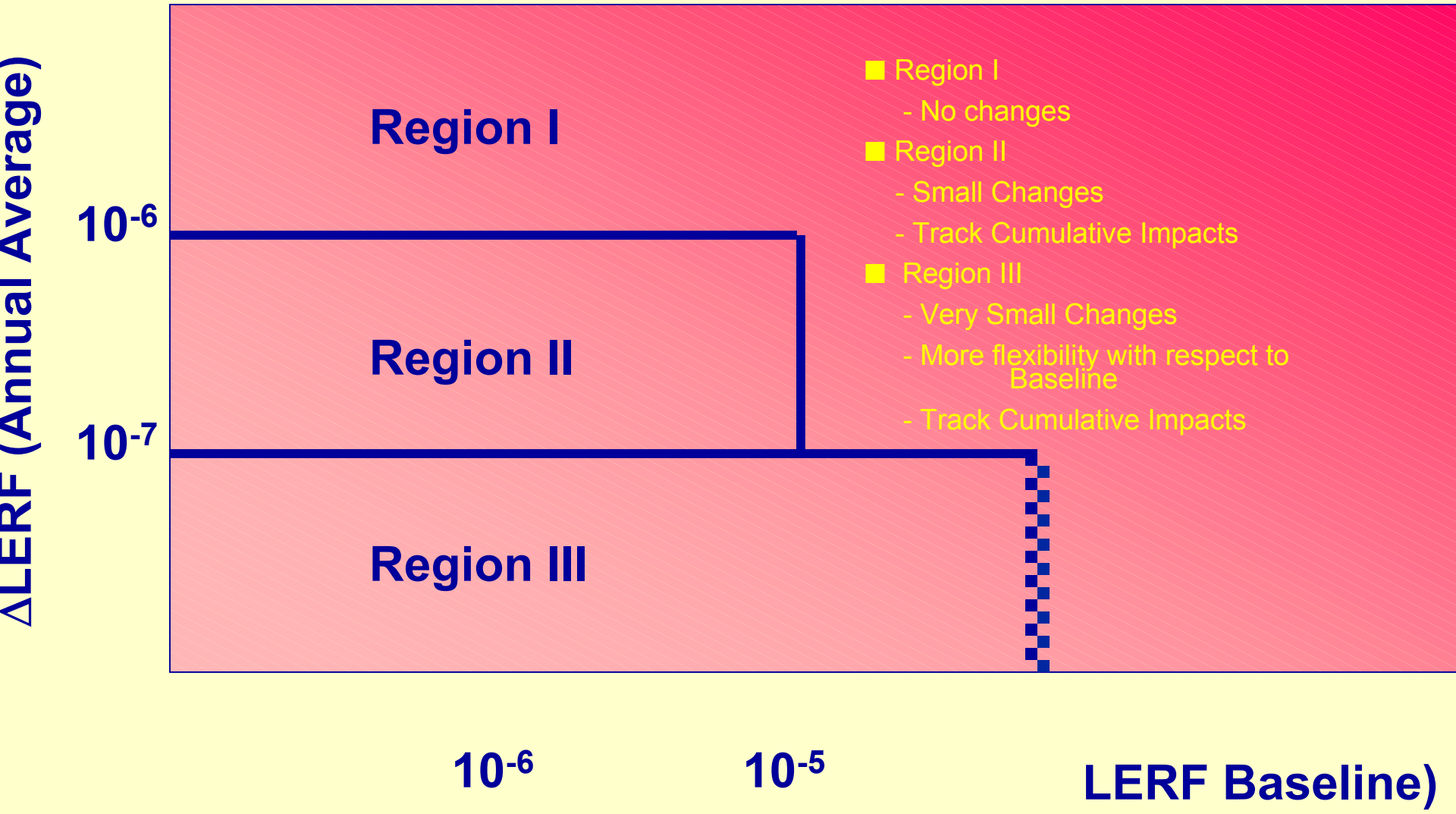
- Qualitative
  - Individual Consequences of Nuclear Plant Operation Bear No Significant Additional Risk
  - Societal Risks = Those from Other Forms Electrica Generation and Not a Significant Addition
- Quantitative
  - Risk of Prompt Fatalities within 1 mile = 0.1% Sum from Other Accidents
  - Risk of Cancer Fatalities within 10 miles = 0.1% Sum from All Other Causes
- No Fatality Acceptable

Risk-Informed Guidance

	Regulatory Guides: Guidance to Licensees	Standard Review Plan: Guidance to NRC Staff
General	RG 1.174	SRP Chapt.19, Rev P
IST	RG 1.175	SRP Section 3.9.7
GQA	RG 1.176	GQA Inspection Guidance
TS	RG 1.177	SRP Section 16.1
ISI	RG 1.178	SRP Section 3.9.8



Acceptance Guidelines for Core Damage Frequency



Acceptance Guidelines for Large Early Release Frequency

Use of Risk Information in NRC and Industry Programs

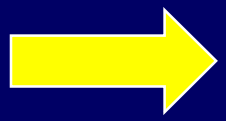
	RG 1.174 Low CDF and LERF	RG 1.174 High CDF and LERF	EPRI PSA Application Guide	EPRI Temporary Change	OL 803	Reactor Oversight Program SDP	Regulatory Analyses Guidelines	NEI 91-04 Severe Accident Guidelines	
10^{-3}	Not Normally Allowed	Not Normally Allowed	Unacceptable	Potentially Risk Significant	Substantial Risk Significance	**Red** Unacceptable	Proceed to Value Impact Analysis (PRIORITY)	Cost Effective Admin. Procedure, Hardware Change, treat in EOP, or include in SAMG	10^{-4}
10^{-4}									10^{-5}
10^{-5}			Further Evaluation Required			**Yellow** Required Regulatory Response	Proceed to Value Impact Analysis	Cost Effective EOP, Minor Hardware Change, or include in SAMG	10^{-6}
10^{-6}	Small Changes Acceptable with Management Attention			Assess Non-Quantifiable Factors	Low to Moderate Risk Significance	**White** Increase Regulatory Response	Management Decision Whether to Proceed to Value Impact Analysis	Include in SAMG	10^{-7}
10^{-7}	Very Small Changes Acceptable	Very Small Changes Acceptable	Non-Risk Significant	Non-Risk Significant	Very Low Risk Significance	**Green**	No Action	No Specific Action Required	10^{-8}

ΔLERF or LERF for single sequences (/yr)

PSA Quality: Anticipated Approac

Phase	Scope	Standard	Regulatory Guide(s)	App Priority
1	For App	No	Yes, Slide 15	Discuss
2	For App	Yes	Yes	
3	Full	Yes	Yes	
4	State of Art	Yes	Yes	
Proof of Concept	Full	As Available		High

PSA Quality

- High Quality PSA
  - Level 1 & 2; Internal & External Events
    - » Fire, Flood, Seismic
  - Power, Transition, Shutdown (All Modes)
  - Level 3 (additional goal)
- Meets *a* Standard
- Living, Maintained
- Higher Quality  Increased Flexibility

PSA Quality Verification

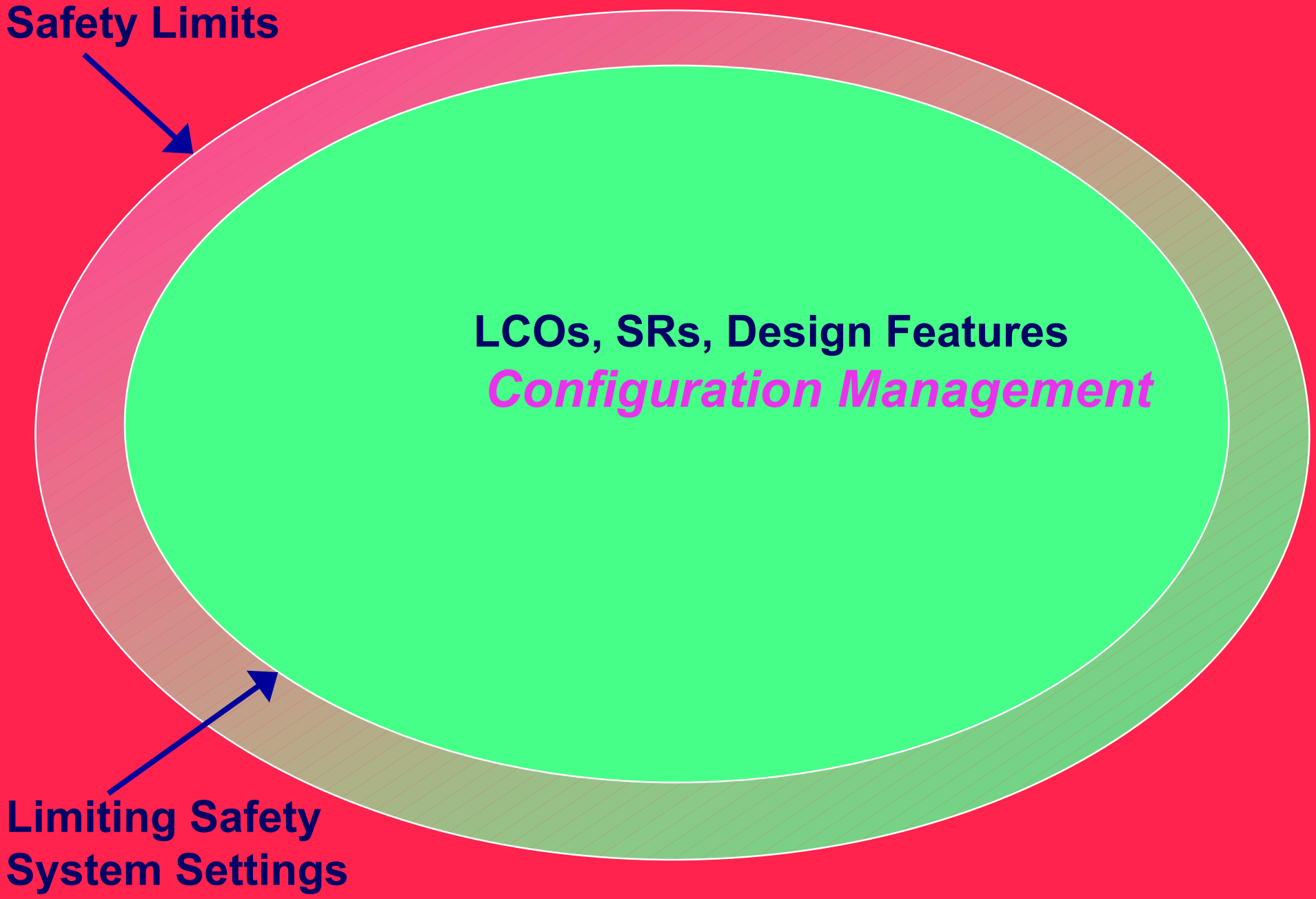
- Industry Certification
- Owners' Group Cross Comparison
- Standards
  - ASME: Level 1, Level 2, Internal Events
  - ANS: Shutdown, External Events
  - ANS: Fire Protection
- NRC Staff Assessment
- SDP Phase 2 Notebook & SPAR Benchmark

Licensee Program

- Formal Process
- Evaluate Circumstances, Configuration; make Decision
  - Criteria Levels
  - Expert Panel
  - Appropriate Management Decisions
  - Compensatory Measures
- Performance Indicator(s)

Operational Management

- Working with NSSS Owners Groups
- In Accordance with Current Rules
- Integrated Optimum Risk Locus
  - Power, Transition, End Mode
  - Compensatory Actions vs. AOTs
    - » Success Paths: Lower Risk
    - » Identify and Avoid High Risk Situations


Safety Limits
LCOs, SRs, Design Features
Configuration Management
Limiting Safety
System Settings

Risk-Informed (R-I) Control Room

- Operators
- Shift Technical Advisor
- PRA Staff
- Operations Management
- Inspectors

R-I Control Room Support

- Maintenance & Work Planning Staff
- Training Program
- Communication of PSA Insights
- PSA Information Access & Control

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Applications

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Practical Applications

- Operational Management
- Technical Specifications
- Maintenance Rule
- Inservice Inspection
- Inservice Testing
- Graded Quality Assurance

Practical Applications

- Risk-informing 10 CFR Part 50
- Reactor Oversight Program
  - Significance Determination Process
- NSSS Aging & Degradation
- Event Assessment
- Notices of Enforcement Discretion

Technical Specifications

- Three tier approach
  - Risk measures
  - Importance measures
  - Configuration Risk Management Program (CRMP) or Maintenance Rule (a)(4)

Example: San Onofre Emergency Diesel Generator

- AOT extension: 3 to 14 days
- Risk of maintenance at power < at shutdown
- ΔCDF decrease of 1.6 E-5/year
- Vulnerability: reactor cavity seal not seismically designed
- TD AFW pumps operable, EDG maintenance
- CRMP

Maintenance Rule

- 10 CFR 50.65 (a)(4)
- Evaluate risk significance of proposed maintenance configurations
- Regulatory efficiency: subsume CRMP

Inservice Inspection

- Focus: Piping Segments with EITHER . . .
  - Important Degradation Mechanisms OR
  - High Failure Consequences
- 40 Units at 30 Sites Have Adopted
- 14 Units at 10 Sites Under Review
- Changes Location and Number of Welds
- Changes Inspection Methods: WOG, EPRI

Inservice Inspection Benefits

- Essentially Risk Neutral
- Conserve fiscal resources
- Reduce personnel radiation exposure

Inservice Testing

- Categorize pumps & valves
  - High safety significance (HSSC)
    - » Could include non-code components
  - Low safety significance (LSSC)
- Adjust test frequency to risk
  - Include some compensatory measures
  - Staggered testing reduces CCF
- Evaluate (integrated) risk measures
- Adopted: 2 Units Full Scope; 1 Partial
- In Review: 1 Unit Full Scope; 1 Partial

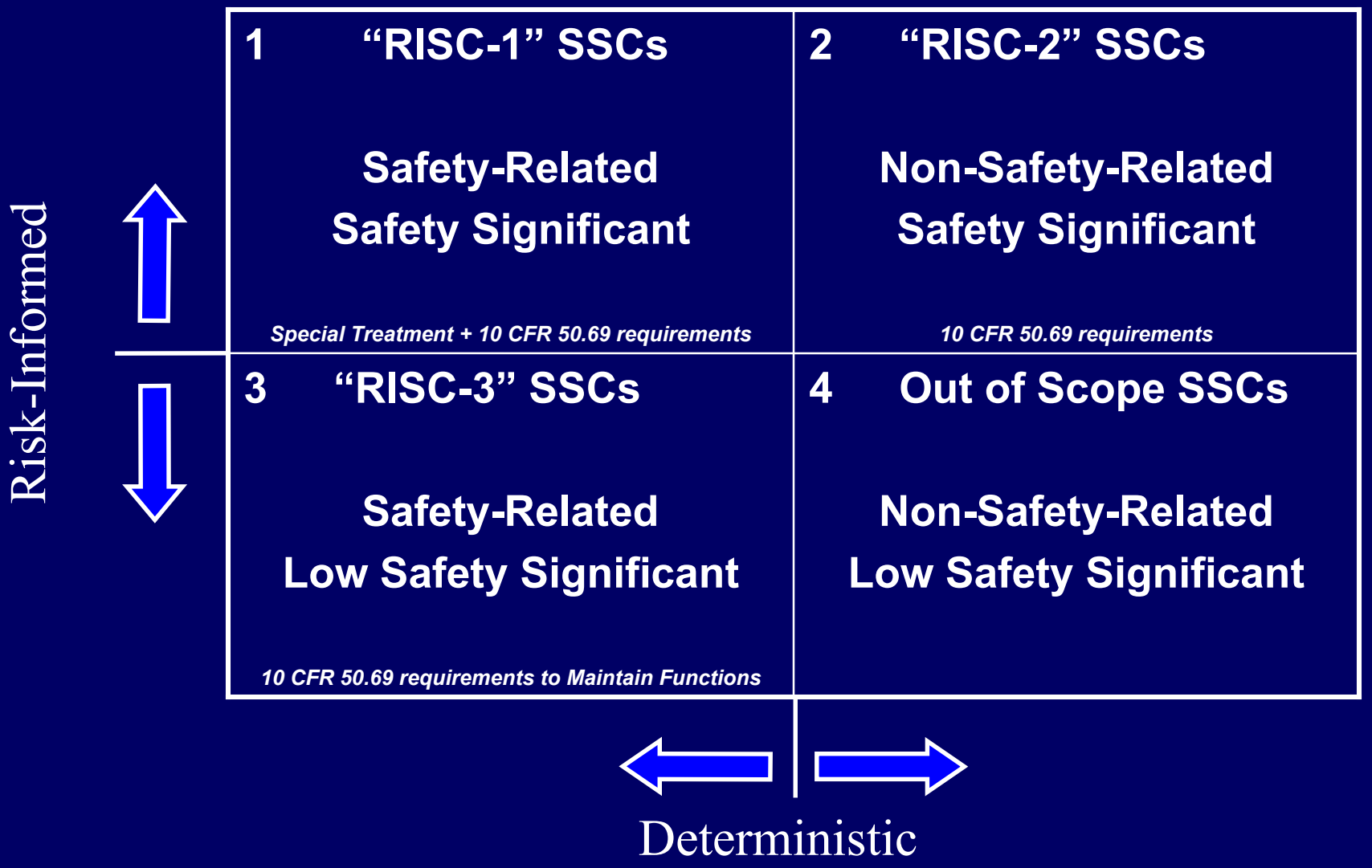
Inservice Testing Benefits

- Focus on more safety significant issues
- Reduce operator burden
- Reduce off-normal configurations
- Conserve fiscal resources
- Commence peak full scope program
  - Quantitative: <10E-6/ year CDF increase
  - Qualitative: risk neutral
    - » Added risk-important components to program
    - » Fewer tests & fewer realignment errors

Graded Quality Assurance

- **South Texas project**
  - **Less QA effort for 15 of 18 criteria**
  - **Implement equipment monitoring**
  - **Risk neutral**
- **Other regulations complicated implementation**
  - To be resolved in RIP 50 technical requirements phase

Categorization of Structures, Systems, and Components



Risk Informing 10 CFR 50 (RIP50)

- Continue with applications
- Special treatment requirements
  - Proposed rule and appendix
    - » Four quartiles
- Technical requirements
  - Containment Combustible Gas Control
  - Large Break LOCA
  - Future?

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Reactor Oversight Program (ROP) Significance Determination Process (SDP)

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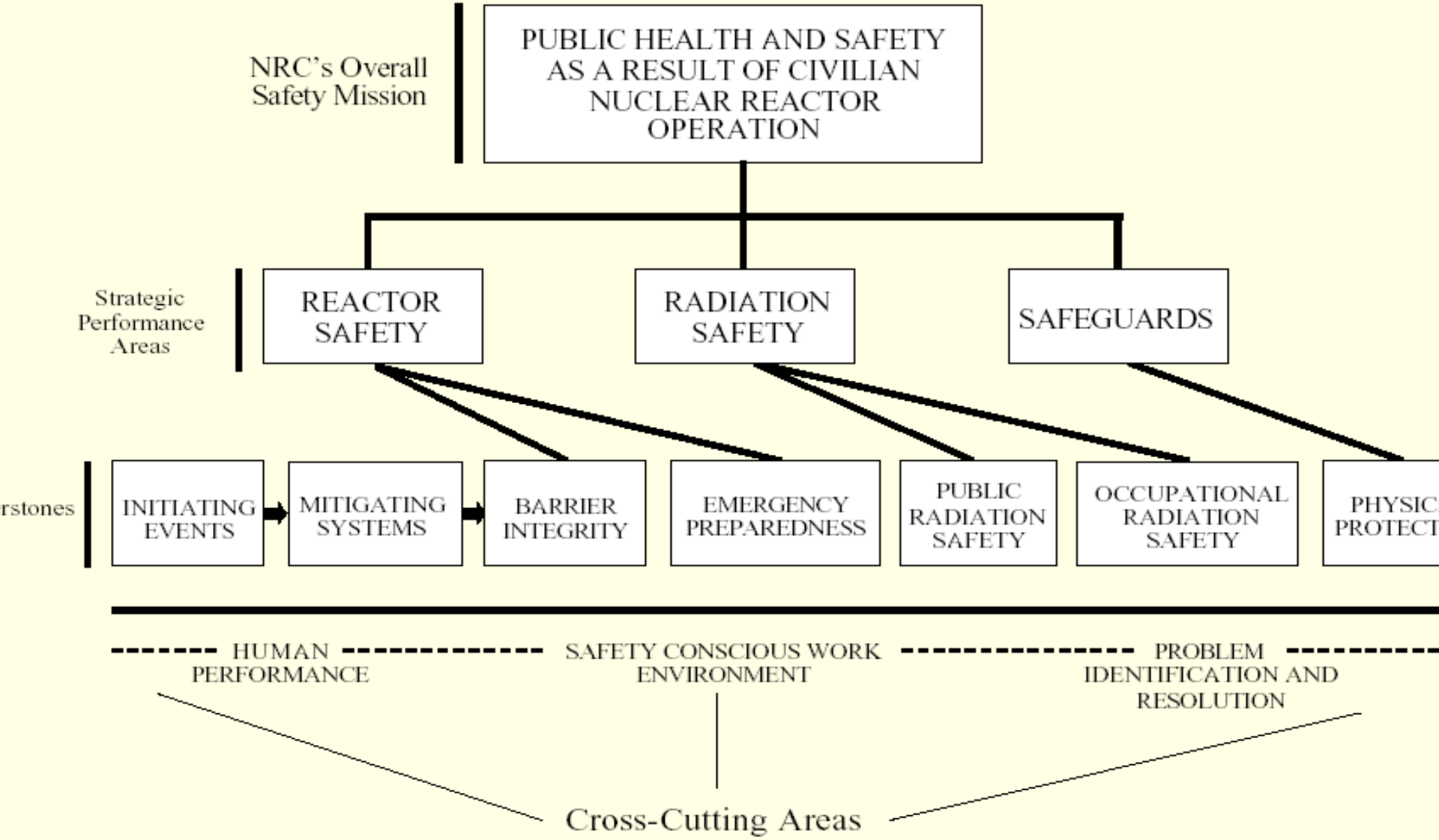
ROP and SDP Program

- NRC Inspection Manual Chapters
  - 0305, ROP Program
  - 0307, ROP Self-Assessment Program
  - 0308, ROP Basis
  - 0350, Plants Shutdown ? Performance Problems
  - 0608, Performance Indicator Program
  - 0609, SDP (Also Attachments & Appendices)
  - 0612, Power Reactor Inspection Reports
- http://www.nrc.gov/reading-rm/doc-collections/insp-manual/manualchapters.htm

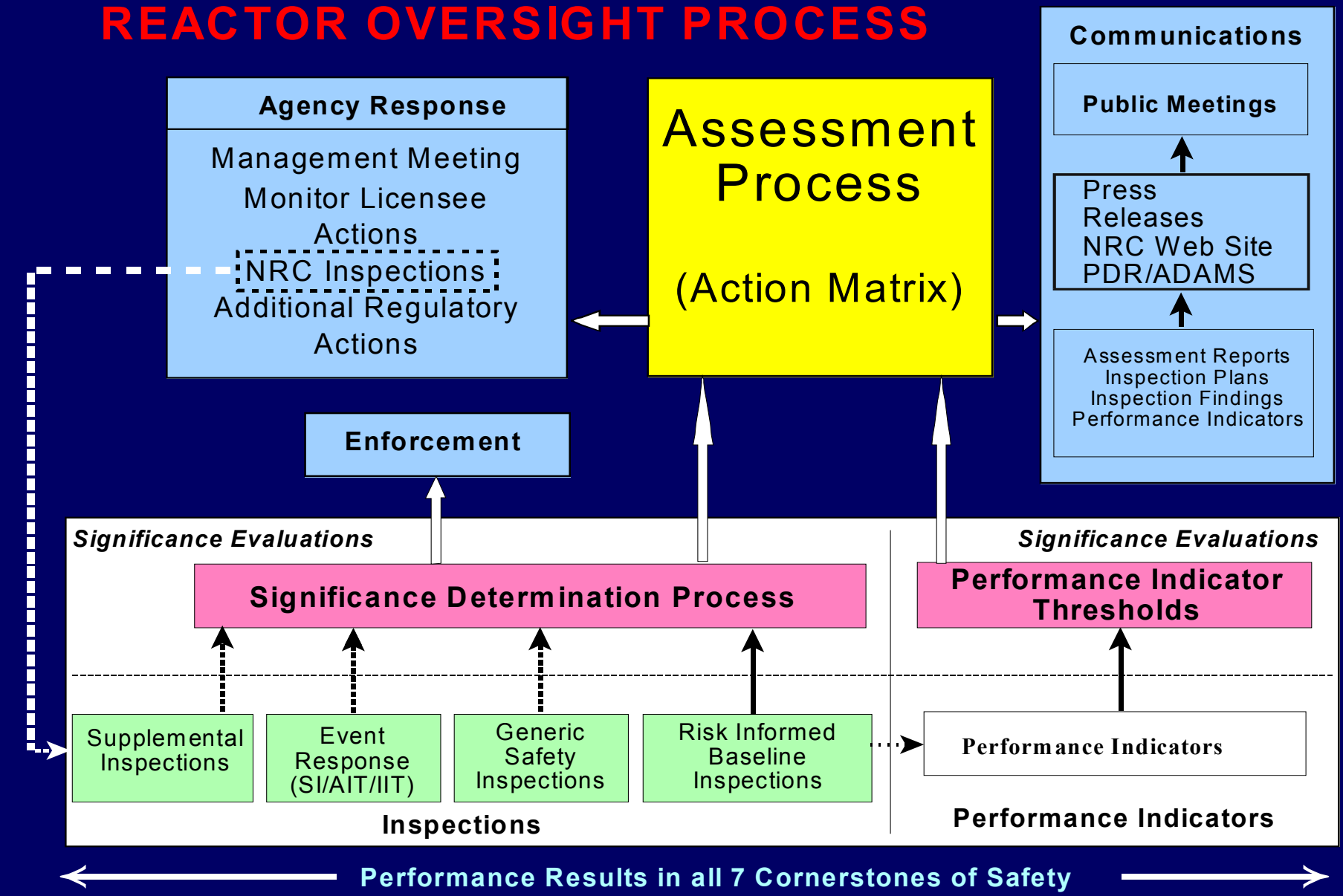
Performance Goals

- Maintain a Low Frequency of Events that could lead to a Nuclear Reactor Accident
- Zero Significant Radiation Exposures resulting from Civilian Nuclear Reactors
- No Increase in the Number of Offsite Releases of Radioactive Material from Civilian Nuclear Reactors that Exceed 10 CFR Part 20 Limits
- No Substantiated Breakdown of Physical Protection that Significantly Weakens Protection against Radiological Sabotage, or Theft or Diversion of Special Nuclear Materials

Exhibit 1: REGULATORY FRAMEWORK



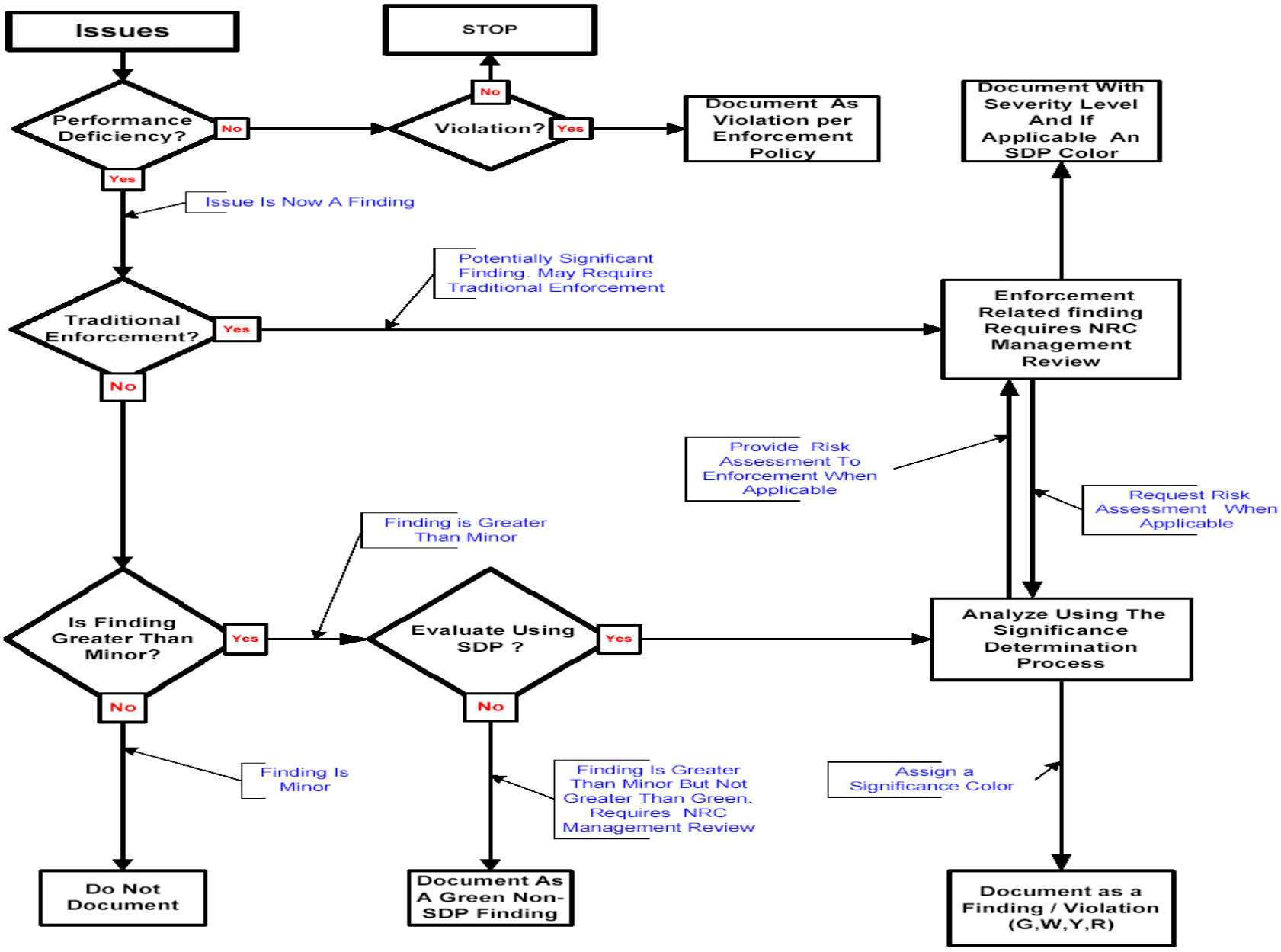
REACTOR OVERSIGHT PROCESS



ignificance Determination Process

- Supports reactor oversight program
- Determine safety significance:
  - Inspection Findings (Performance Deficiencies)
  - Performance Indicators
  - Risk Guidelines Comparable to Other R-I Activities
    - » RG 1.174 Guidelines
- Four levels

Issue Disposition Screening



Risk-Informed Significance Levels

Color	Δ CDF (/yr)	Δ LERF (/yr)	Description
Red	= E-4	= E-5	Unacceptable
Yellow	< E-4	< E-5	Required Regulatory Response
White	< E-5	< E-6	Increased Regulatory Response
Green	< E-6	< E-7	Licensee Response Corrective Action Program

Inspection Findings

- Inspection
  - Performance Deficiency
    - » SDP
- SERP
  - Preliminary “Color”
- Licensee Interface
- Final “Color”
- Assessments: Quarterly, Semi-Annually, Annually
  - Roll Up for Each Cornerstone
  - “Color” Inspection “Windows”
- Action Matrix
  - Determine Regulatory Action

Performance Indicators (PIs)

- 18 PIs
- Risk-Informed
  - Initiating Events
  - Mitigating Systems
  - Risk-Informed Thresholds
- Non Risk-Informed
  - Other Cornerstones
  - Traditional Engineering Thresholds
- Future: Mitigating System Performance Index (MSPI)
- Assessments: Quarterly, Semi-Annually, Annually
  - Roll Up for Each Cornerstone
  - “Color” Inspection “Windows”
- Action Matrix
  - Determine Regulatory Action

Assessment				
vel of eview	**Frequency Timing**	**Participants (* Chair)**	**Desired Outcome**	**Communication**
ntinuous	Continuous	Senior Resident Inspector (SRI)*, Resident Inspector (RI), regional inspectors, senior reactor analysts (SRAs)	Performance awareness	None required Notify licensee by an Assessment Follow-Up letter only if thresholds crossed
arterly	Once per quarter 5 weeks after end of quarter	DRP: Branch Chief (BC)*, Project Engineer, SRI, RI	Input and verify PI and PIM data Detect early trends	Update data set Notify licensee by an Assessment Follow-Up letter only if thresholds crossed
d-Cycle	At mid-cycle 6 weeks after end of second quarter	DRS or DRP Division Director (DD)*, DRP and DRS BCs	Detect trends Plan inspection	Mid-Cycle letter with an inspection plan through the next 12 months
d-of-Cycle	At end-of-cycle 6 weeks after end of assessment cycle	DRS or DRP DD, Regional Administrator (RA)*, NRR representative, BCs, principal inspectors, SRAs	Assessment of plant performance Oversight and coordination of regional actions	Annual Assessment Letter w an inspection plan through th next 12 months
ency tion	Review Annually 2 weeks after end of cycle review	EDO*, Director of NRR, RAs, DRS/DRP DDs, Inspection Program Branch, OE, OI, other HQ offices as appropriate	Oversight and coordination of agency-level actions	Commission briefing, followe by public meetings with individual licensees to discus assessment results

	Licensee Response Column	Regulatory Response Column	Degraded Cornerstone Column	Multiple Degraded Cornerstone Column	Unacceptable Performance Colu
	All Assessment Inputs (Performance Indicators (PIs) and Inspection Findings) Green. Cornerstone Objectives Fully Met.	One or Two White Inputs (in different cornerstones) in a Strategic Performance Area. Cornerstone Objectives Fully Met.	One Degraded Cornerstone (2 White Inputs or 1 Yellow Input) or any 3 White Inputs in a Strategic Performance Area. Cornerstone Objectives Met with Moderate Degradation in Safety Performance.	Repetitive Degraded Cornerstone, Multiple Degraded Cornerstones, Multiple Yellow Inputs, or 1 Red Input. Cornerstone Objectives Met with Longstanding Issues or Significant Degradation in Safety Performance.	Overall Unacceptable Performance. Plants Not Permitted to Operate Within this Bar Unacceptable Margin to Safety.
Regulatory Performance Meeting	None	Branch Chief (BC) or Division Director (DD) Meet with Licensee	DD or Regional Administrator (RA) Meet with Licensee	RA (or EDO) Meet with Senior Licensee Management	Commission meeting w Senior Licensee Management
Licensee Action	Licensee Corrective Action	Licensee root cause evaluation and corrective action with NRC Oversight	Licensee cumulative Root Cause Evaluation with NRC Oversight	Licensee Performance Improvement Plan with NRC Oversight	
NRC Inspection	Risk-Informed Baseline Inspection Program	Baseline and Supplemental Inspection Procedure 95001	Baseline and Supplemental Inspection Procedure 95002	Baseline and Supplemental Inspection Procedure 95003	
Regulatory Actions[1]	None	Supplemental Inspection only	Supplemental Inspection only	-10 CFR 2.204 DFI -10 CFR 50.54(f) Letter - CAL/Order	Order to Modify, Suspend, or Revoke Licensed Activities
Assessment Letters	BC or DD review/sign Assessment Report (w/ Inspection Plan)	DD review/sign Assessment Report (w/ Inspection Plan)	RA review/sign Assessment Report w/ Inspection Plan)	RA review/sign Assessment Report (w/ Inspection Plan)	
Annual Public Meeting	SRI or BC Meet with Licensee	BC or DD Meet with Licensee	RA (or designee) Discuss Performance with Licensee	EDO Discuss Performance with Senior Licensee Management	
Commission Involvement	None	None	None	Plant discussed at AARM	Commission Meeting w Senior Licensee Management

Increasing Safety Significance ?

Significance Determination Process

- Operation
- Shutdown
- Fire Protection
- Maintenance
- Containment
- NSSS Aging & Degradation

Конец