Document 3, The 6th Meeting,
Working Group on Voluntary Efforts and Continuous Improvement of Nuclear Safety,
Advisory Committee for Natural Resources and Energy

Development & Implementation of Risk Management for Nuclear Power Plants

Presented to
Working Group on Voluntary Efforts and Continuous Improvement of Nuclear Safety
Nuclear Energy Subcommittee
Advisory Committee for Natural Resources and Energy
(The 6th Meeting)

By
Rick Grantom
C. R. Grantom P.E. & Assoc. LLC

C. R. (Rick) Grantom P.E.

Mr. C.R. (Rick) Grantom has been in the nuclear industry since 1978 and in the field of Probabilistic Risk Assessment and Technical Risk Management for the past 30 years. Recently retiring to work as an independent consultant Mr. Grantom held managerial positions at the South Texas Project as Manager, Risk Management & Risk Management Projects. In those roles he was responsible for the development, application, implementation, and overall management of STP's Risk Management/PRA programs.

In the past Mr. Grantom has directly involved in all phases of risk informed applications for nuclear power plants including :

- **On-Line Maintenance (Plant Configuration Risk Management),**
- **Exemption from Special Treatment Requirements (Industry Pilot, Top Industry Practice Award)**
- **Risk Managed Technical Specifications, RITS 4B (Industry Pilot, Ralph B. Sylvia Best-of-the Best Top Industry Practice Award)**
- **Owner Controlled Surveillance Frequency Program, RITS 5B**

He is currently focused on developing new and innovative risk informed approach supporting closure of GSI-191, emergency containment sump performance.

Mr. Grantom is also the Co-Chairman of the ASME/ANS Joint Committee on Nuclear Risk Management, and an Ex-Officio member of the ASME Board on Nuclear Codes and Standard.

Mr. Grantom holds a B.S. Degree in Nuclear Engineering from Texas A&M University and is a registered Professional Nuclear Engineer in the State of Texas.

Key Topics

- Background & History
- Early recognition of the need for a Risk Management Program
- Use of Risk Insights in Risk Informed Applications
- Safety Culture Perspectives
- Implementing Risk Management Programs
- Organizational Aspects

Background & History

STP PRA History Part 1

- Questions from Owners during construction regarding the high cost were answered in part as being due to the third train.
- The STP ECCS has separate injection paths which is different from all other W PWRs, which are "headered".
- STP has 14 foot active fuel height versus 12
- The A/E for STP had not designed a nuclear plant
- *THE ORIGINAL PURPOSE OF THE STP PRA WAS TO SHOW THE THIRD TRAIN BENEFIT AND TO LOOK FOR "CURIOSITIES"*

STP PRA History Part 1, cont.

- STP PRA program officially commenced in 1984
- In June,1985 a Preliminary Scoping Study was presented to the NRC
- Highest risk contributors and areas of uncertainty was Electrical Auxiliary Building HVAC and RCP Seal LOCAs
- A second phase was authorized began in 1986 and finished in 1989.
- The second phase was reviewed by the NRC and a Safety Evaluation Report (SER) issued allowing STP to use the PRA for regulatory purposes.

STP PRA History Part II

- During the construction phase two immediate design changes were identified with the PRA: Containment purge isolation and CVCS letdown were changed from MOVs to AOVs for station blackout purposes. *Example of the beneficial use of PRA at construction and design phases.*
- From PRA Systems Analysis efforts, it was identified that the CVCS positive displacement pump (PDP) could be used for an alternate RCP seal injection method given loss of CCW. This was proceduralized due to the PRA. Also, the use of the TSC diesel generator to power the PDP given a loss of offsite power and failure of all diesel generators was also proceduralized. *Example of Defense-in-Depth capability identified through the systematic examination from PRA methods.*
- The Technical Specification Allowed Outage Times (AOTs) for ECCS components were extended from 3 days to 7 days. This was a significant enabler of improved reliability for ECCS equipment and provided increased operational flexibility to perform maintenance while at-power. *Example of PRAs ability to optimize system and equipment availability and reliability.*

STP PRA History Part II, cont.

- In 1994, regulatory concerns over plant management and maintenance backlog reached a point where a key safety component (TDAFW pump) had multiple surveillance test failures after maintenance had been performed. NRC shutdown STP for 13 months for a full scope regulatory Diagnostic Evaluation, most all the senior management was replaced. PRA was used to determine the priority and scope of equipment that would be "re-certified" as part of an NRC Confirmatory Action Plan. *Significant strategic point in the recognition, use and organizational acceptance of PRA by the new management team.*
- As a result of the Diagnostic and regulatory recommendations, Senior Executives authorized that a PRA or Risk Management strategic plan be developed to incorporate safety improvements and other optimizations into plant processes.
- Three key risk initiatives were identified: <u>Risk Managed Technical Specifications</u>, <u>Risk Significance Equipment Categorization </u>(i.e., graded Quality Assurance), and <u>Generation Risk Model</u>. (a brief discussion of these will be discussed later in this presentation.
- Thus, started STP's formal Risk Management Programs…

Early Successes

- PRA Risk Analysis allowed regulatory evaluations to occur to assess the safety risks leading to regulatory approval for the following
  - Extension of Tech Spec Allowed Outage Times for safety related cooling water and dependent systems (72 hours to 14 days)
  - One-time 113 day AOT extension for Emergency Diesel Generator
- Shutdown Risk safety improvements (recognition of risk for midloop operations, ensuring defense-in-depth)

Risk Informed Applications

- ***Moving risk analysis from analysts to others***
- ***Enabling others to improve decision-making***
- ***Incorporating safety improvements into station equipment, process, and culture***

On-Line Maintenance
(Configuration Risk Management)

What is the risk associated with removing a group of components from service?

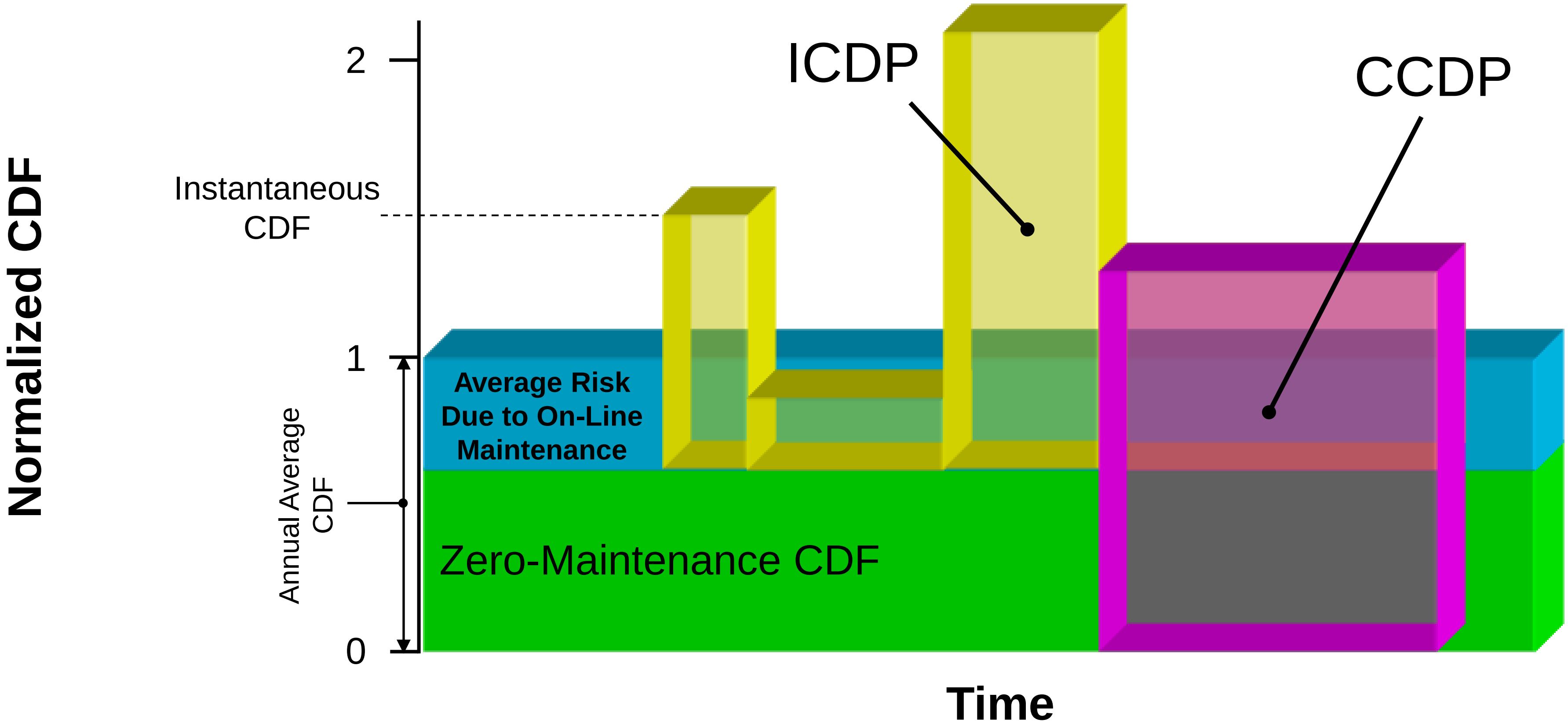
Configuration Risk Management (CRM)

- On-Line Maintenance programs require the capability to evaluate the change in risk from different plant configurations
- A plant configuration (i.e., **maintenance state**) is the set of equipment removed from service at any given time
- Configuration Risk can have both quantitative or qualitative considerations
- Quantitative is required for more advanced risk informed applications (e.g., Risk Managed Technical Specifications)

Configuration Risk Management (CRM)

- **How do plant operators know what is in the PRA and what is important for risk managing the station?**
  - **One Good Practice** is to provide **<u>CRM System Guidelines</u> for all systems modeled in the scope of the configuration risk management program** (i.e., on-line maintenance)
    - Identifies to Control Room Operating crews what equipment is modeled in the PRA, the basis for inclusion in the risk model, the associated PRA-modeled component failure modes, and plant specific CRMP designators
    - Controlled copies maintained in Control Rooms
    - PRA and System Engineers provide input for revisions to CRM guidelines for their assigned systems as needed

Anatomy of an On-Line Risk Profile



$$CDF_{\text{annual avg}} = CDF_{\text{Zero maint}} + CDF_{\text{Avg maint}}$$

$$CCDP = ICDP + CDP_{\text{Zero maint}}$$

CCDP – Conditional Core Damage Probability
CDF – Core Damage Frequency
CDP – Core Damage Probability
ICDP – Incremental Core Damage Probability

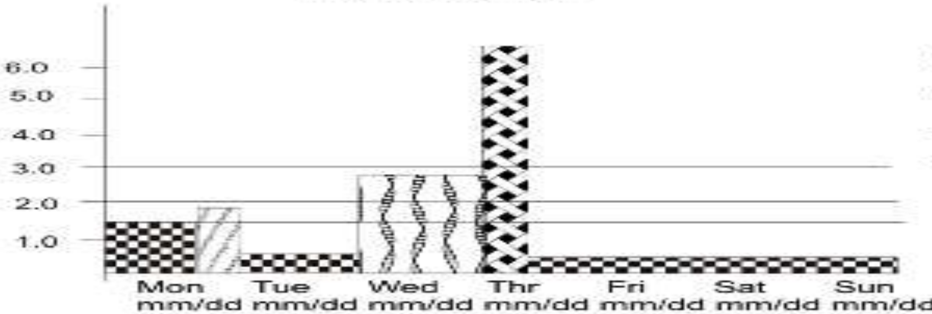
RA Seq. No:
PRA Model:
BOP Model:
Comments:

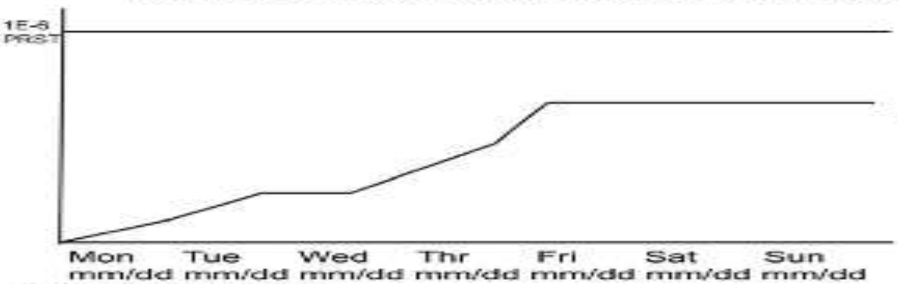
UNIT X RISK PROFILE

Date Printed

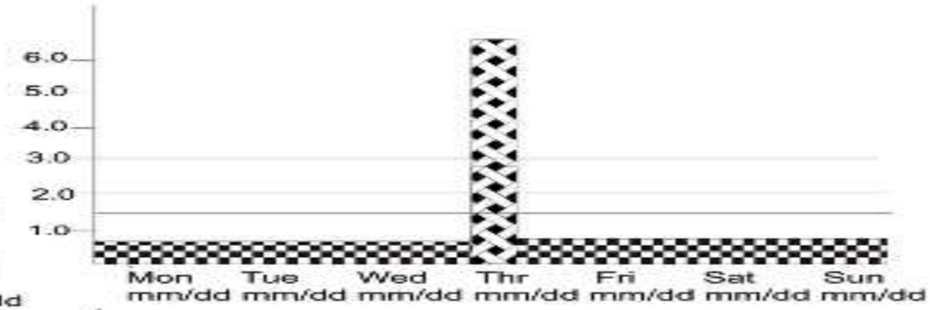
Unit X Risk Index for the Week of DD/MM	
Actual	1.05 White
Predicted	1.06 Yellow
Station RI	1.01 Green

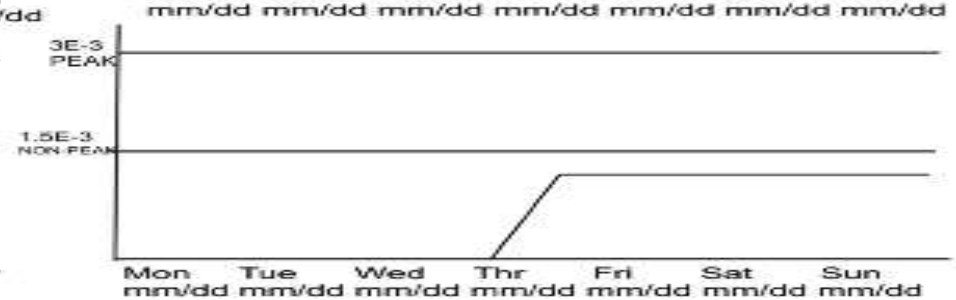
PRA PROFILE





BOP PROFILE





PRA MAINTENANCE

PRA Risk Function	Non-Functional Date	Functional Date
CVB	06/01/2010 03:00	06/02/2010 00:00
HHA	06/01/2010 03:00	06/01/2010 13:00
DFP3	06/01/2010 03:00	06/01/2010 15:00

BOP MAINTENANCE

BOP Risk Function	Non-Functional Date	Functional Date
MFWP11/21	06/04/2010 02:00	06/04/2010 12:00

PRA MAINTENANCE STATES

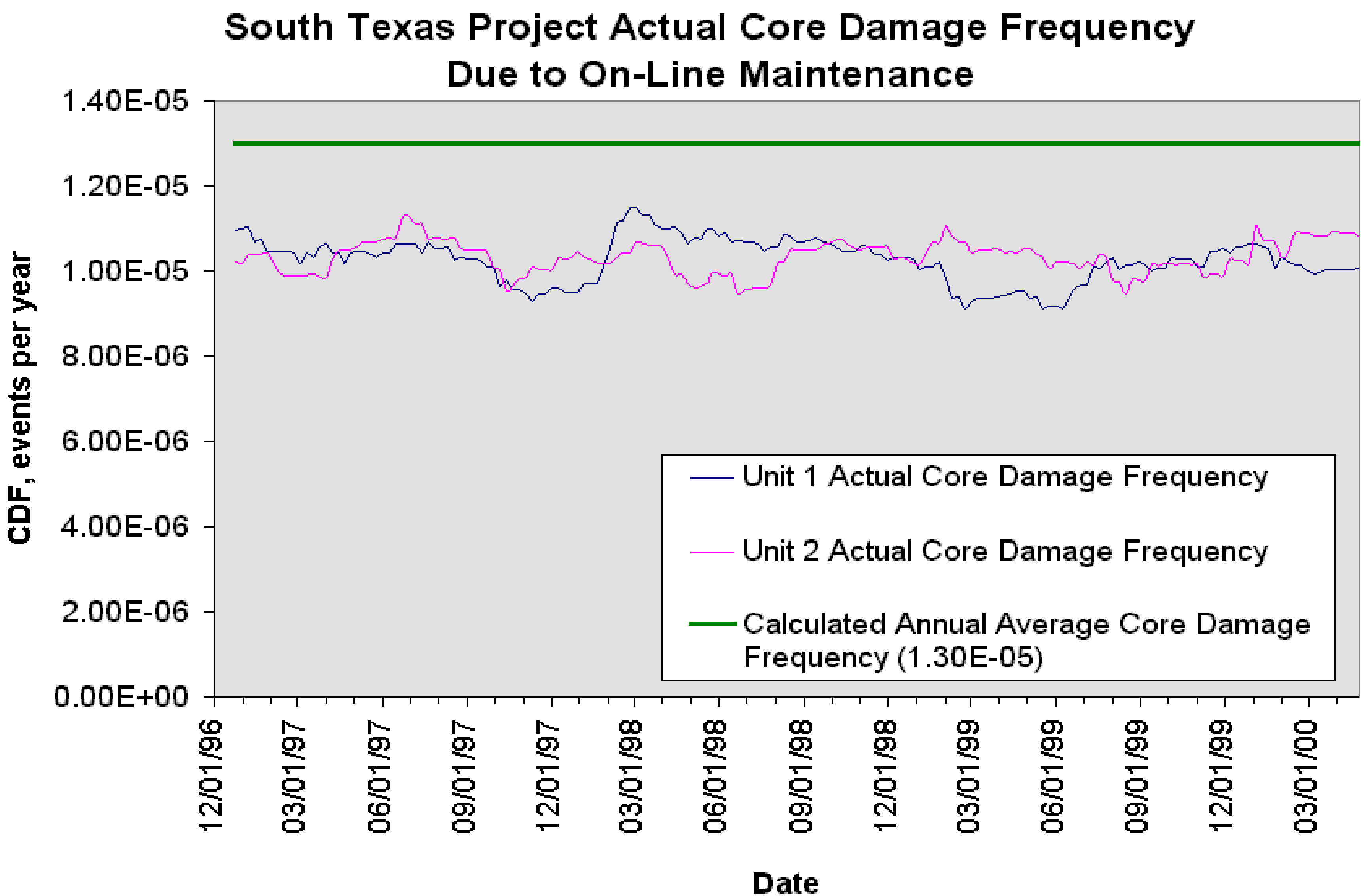
PRAMS	Start Time	Duration (hr)	CDF	ICDP	Color
CVB DFP3 HHA	06/01/2010 03:00	10	2.58E-06	2.37E-08	RED
CVB DFP3	06/01/2010 13:00	2	5.14E-06	2.41E-11	YELLOW
CVB	06/01/2010 15:00	9	5.13E-06	9.44E-11	WHITE
NO CRM EQUIPMENT NON-FUNCTIONAL	06/02/2010 00:00	50	5.03E-06	0.00E+00	GREEN
NO CRM EQUIPMENT NON-FUNCTIONAL	06/04/2010 02:00	10	5.03E-06	0.00E+00	GREEN
NO CRM EQUIPMENT NON-FUNCTIONAL	06/04/2010 12:00	40	5.03E-06	0.00E+00	GREEN

ICDP-WEEK 2.38E-08

BOP MAINTENANCE STATES

BOPMS	Start Time	Duration (hr)	TF	ITF	Color
NO BOP EQUIPMENT NON-FUNCTIONAL	06/01/2010 03:00	10	0.35433	0.00E+00	GREEN
NO BOP EQUIPMENT NON-FUNCTIONAL	06/01/2010 13:00	2	0.35433	0.00E+00	GREEN
NO BOP EQUIPMENT NON-FUNCTIONAL	06/01/2010 15:00	9	0.35433	0.00E+00	GREEN
NO BOP EQUIPMENT NON-FUNCTIONAL	06/02/2010 00:00	50	0.35433	0.00E+00	GREEN
MFWP11/21	06/04/2010 02:00	10	0.51227	1.58E-01	YELLOW
NO BOP EQUIPMENT NON-FUNCTIONAL	06/04/2010 12:00	40	0.35433	0.00E+00	GREEN

ITP-WEEK 1.58E-01


South Texas Project Actual Core Damage Frequency
Due to On-Line Maintenance
CDF, events per year
1.40E-05
1.20E-05
1.00E-05
8.00E-06
6.00E-06
4.00E-06
2.00E-06
0.00E+00
12/01/96
03/01/97
06/01/97
09/01/97
12/01/97
03/01/98
06/01/98
09/01/98
12/01/98
03/01/99
06/01/99
09/01/99
12/01/99
03/01/00
Date
Unit 1 Actual Core Damage Frequency
Unit 2 Actual Core Damage Frequency
Calculated Annual Average Core Damage Frequency (1.30E-05)

Risk Significance Categorization

What is the risk significance of a component?

How should it be treated?

50.69 Categorization

RISC-1 Safety-Related Safety Significant	RISC-2 Non Safety-Related Safety Significant
RISC-3 Safety-Related Low Safety Significant	RISC-4 Non Safety-Related Low Safety Significant

Risk Informed
Technical Specifications
(RITS)

RITS 4B
Risk Managed
Technical Specifications
(RMTS)

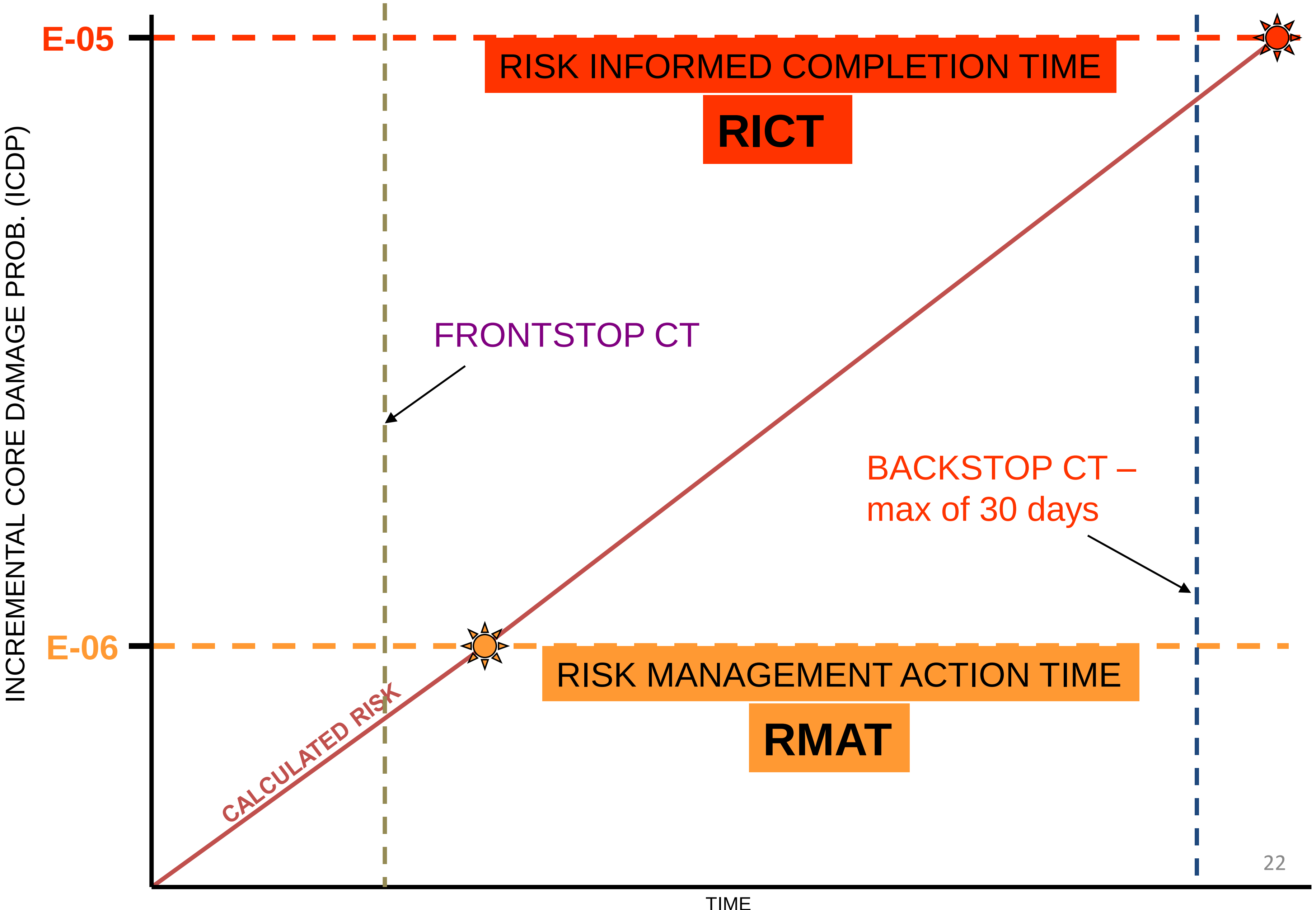
RMTS

RMTS allows:

- A licensee to calculate allowed outage times for Tech Spec Equipment based on configuration risk

RMTS provides:

- **Improved safety** through application of risk insights
  - Greater insights into safety significant equipment impacts, facilitate management/supervisory oversight actions
- **Increased operational flexibility**
  - Risk-informed allowed outage times are based on risk significance of equipment out of service
- **Increased maintenance flexibility for equipment reliability improvements**
- **Fewer Tech Spec LCO challenges**


E-05
RISK INFORMED COMPLETION TIME
RICT
FRONTSTOP CT
BACKSTOP CT –
max of 30 days
E-06
RISK MANAGEMENT ACTION TIME
RMAT
CALCULATED RISK
INCREMENTAL CORE DAMAGE PROB. (ICDP)
TIME

RMTS Applicable Scope

- Selected instrumentation
- Pressurizer PORVs
- Accumulators
- ECCS
- RHR
- RWST
- Containment Isolation Valves
- Containment Spray
- Containment Fan Coolers
- Batteries
- ESF Buses
- AFW
- MSIVs
- Atmospheric Steam Relief
- Control Room Makeup and Cleanup Filtration (cooling function)
- Component Cooling Water
- Essential Cooling Water
- Essential Chilled Water
- SDGs and Off-site circuits

RMTS Timeline

- March 18, 2003: Letter of intent
- December 27, 2003: Request for RG 1.200 fee waiver
- August 2, 2004: Broad-Scope Risk-Informed Technical Specification Amendment Request
- October 28, 2004: Technical Adequacy of the South Texas Project Probabilistic Risk Assessment (RG 1.200)
- February 10, 2006; April 26, 2006; February 28, 2007: Response to NRC Requests for Additional Information on STPNOC Proposed Risk-Informed Technical Specifications
- June 6, 2006 and December 28, 2006: Revised Broad Scope Risk-Informed Technical Specification Amendment Request
- May 9, 2007: Response to Request for Additional Information on Risk-Informed Technical Specification Amendment Request
- May 17, 2007: Supplement to Revised Broad Scope Risk-Informed Technical Specification Amendment Request

RITS 5B
Owner Controlled Surveillance Frequency Control Program

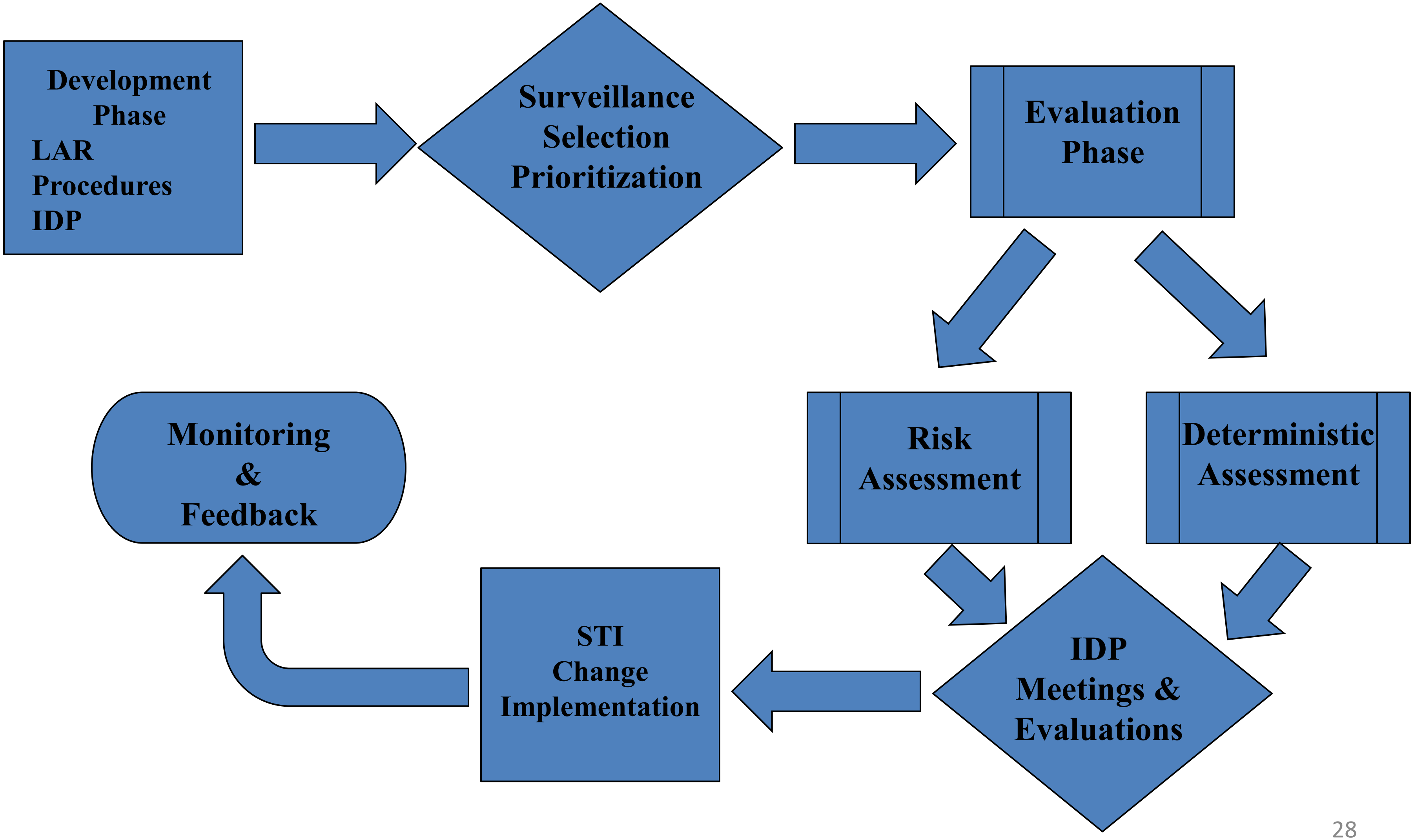
Risk-Informed Surveillance Test Intervals

- **Establishes a process to extend surveillance test intervals (STIs) based on probabilistic and deterministic insight**
- **Places STIs under the licensee's control** – the ST frequencies are moved from Tech Specs and placed into a licensee controlled document (e.g., Surv. Frequency Control Document)
  - Licensee can adjust surveillance test frequency intervals with a documented risk informed technical basis
- **Voluntary** – requires regulatory approval
- Licensee implementation **requires** an **independent decision making panel** (IDP)

RITS 5(b) Benefits

- Safety Benefit
  - By reducing the number of surveillance performances, the amount of time the Station is exposed to higher risk conditions is reduced
  - Testing is focused more on safety significant equipment
- Operational Benefit
  - Reductions in equipment manipulations – less wear-and-tear
  - Reductions in radiological exposures for plant personnel
  - Places the ownership for determining surveillance test intervals onto the licensee, where it belongs

RITS 5(b) Task Flow



Risk Management
&
Safety Culture

How did the risk informed applications support Safety Culture?

Important Considerations

- Facilitative Leadership Styles
  - People are encouraged and rewarded for identifying problems
  - People are encouraged to identify nuclear safety issues
- Problem Identification & Resolution Programs are used by all levels of personnel to identify issues and concerns

Promotion & Advocacy

- Risk Management is a top down initiative
- Led by Executive Management (Vision/Mission/Policy)
  – Regularly communicates and advocates the importance of risk management to ensure safe reliable operation
  – Regularly communicates and advocates the importance of using risk insights to improve safety
  – Holds regular meetings to discuss risk management performance and issues
  – Ensures training and gaps in knowledge are addressed at all levels

Role of Risk Informed Applications

- Risk Informed Applications support Safety Culture and Safety Conscious Work Environment by providing tools and aids to help personnel use risk insights and identify risk significant conditions
- Key Risk Informed Initiatives are Risk Significance Categorization

Role of Senior Leaders

- Risk Management is a decision-making tool for senior leaders (Enterprise Level or minimal level)
- Align management on Risk Management Mission and Vision (Safety is first priority; Reliability and Cost-Efficiencies)
  - What risk contributors do you want to manage?
  - Organizational Structure (Manager/Supervisors/Staff)
- Establish roles, responsibilities, and expectations
- Establish a risk management strategic plan
- Establish expectation for a learning organization (within and outside Risk Management organization) in risk concepts and practices

Role of Regulator

- Strong oversight and commitment to analyze risks through PRA and risk management methods
- Encourages safety improvement through risk insights
- Uses current risk insights but requires PRAs to meet Standards
- Uses risk insights for audits and inspections
- US NRC risk informed regulatory programs and risk informed regulation are important

Essential Plant Functions

- Electric Power – 4.16KV ESF Bus, CR HVAC, Batteries, Lights, Access, Communications etc.
- Instrumentation & Monitoring
- Instrument Air
- Ultimate Heat Sink/Cooling Water – Remove Decay Heat (RCS, SFP)
- Makeup Water (RCS, SFP)

Essential Human Functions

- Shelter
- Food
- Water
- Communications

Organizational Interfaces/Priorities

Operations – Procedures, RX Cooldown, Restore 4.16KV Bus

ERO – Offsite interface

Risk Management – Analyses, Insights, Compensatory Measures, Contingencies

Engineering – Analysis, Mods, Facilities Design, Equipment Specs, etc.

Others…..

Nuclear Units 1&2 Island

Boundary Conditions:

- Extreme Flood/Loss of Impoundment
- Both units in Station Blackout
- No offsite or onsite power for 7 days
- No crew change
- No access to station

Coping Equipment

- Portable Battery Chargers
- Portable DGs
- Portable Diesel Pumps (B5B like)
- Fans, Hoses
- Heavy Equipment (clear paths, etc.)

Offsite Notification/Support

- Federal/State Notification/Support
- Disaster Response Protocol

What needs to be done along this timeline by on-shift crews & station organizations during the first 24 hours?
Constraints – 8 hour Battery Coping period
Risk Perspective – Succeed/Fail each action path to create an event tree of outcomes & appropriate contingency actions

T=0 T=8 T=24 T=48 T=72 Day 4 Day 5 Day 6 Day 7

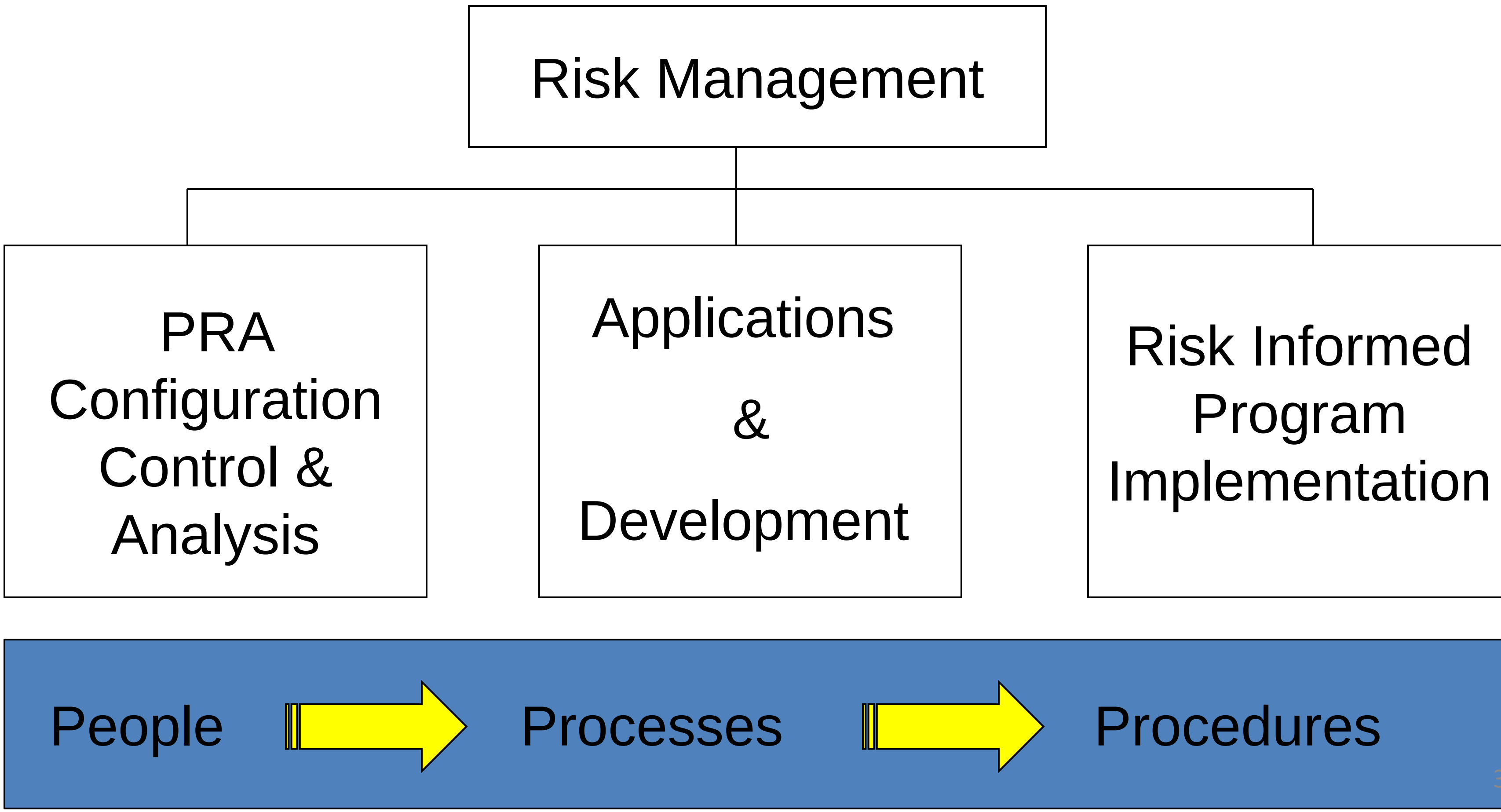
Priorities: Establish RCS Cooldown, Restore 4.16KV Assess Damage, Recharge Batteries, etc.

Implementing Risk Informed Applications

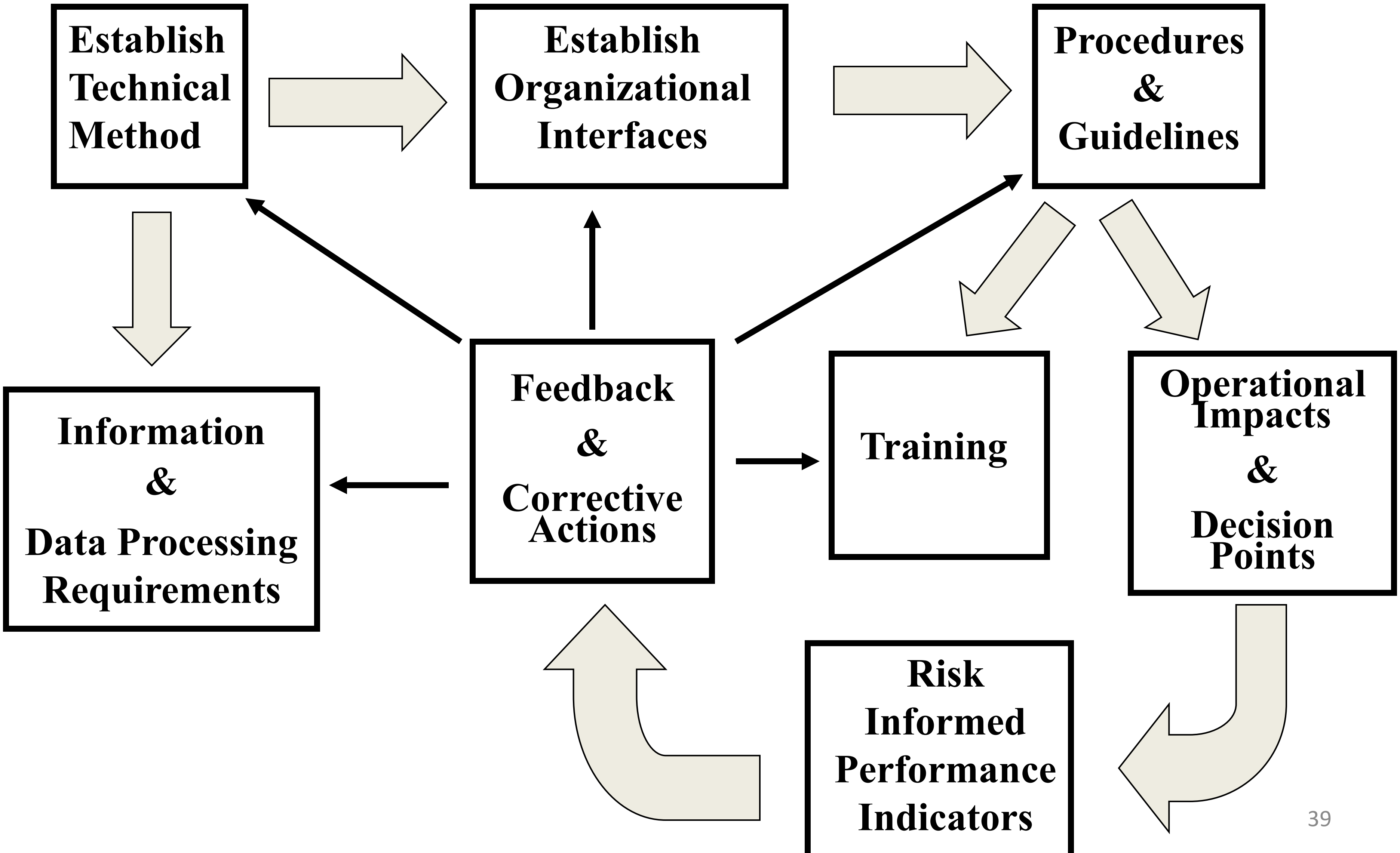
Key Implementation Process Elements

- Establishing Technical Methods
- Establishing Organizational Interfaces
- Information Requirements & Data Processing
- Translation to Procedures & Guidelines
- Operational Impacts and Decision Points
- Training
- Risk Informed Performance Indicators
- Feedback & Corrective Actions

Key Organizational Functions



*** General Overall Process Flow ***

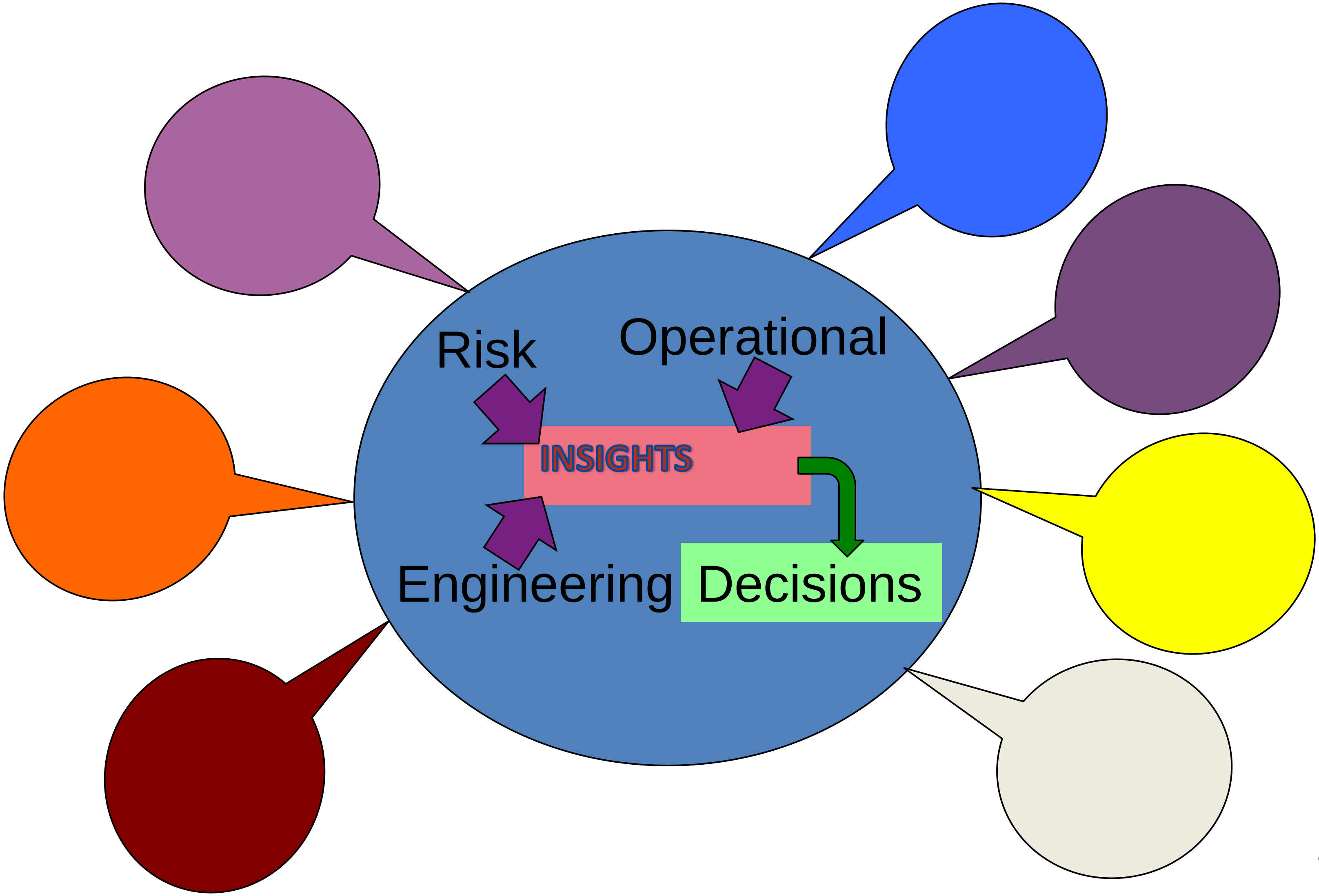


Establishing Organizational Interfaces

- **Who** is responsible for:
  - **Generating/delivering** information & data (maintain, update, archive)
  - **Developing/Performing** the required analyses
  - Process **Initiation** & **Maintenance** (e.g., Procedures & guidelines
  - **Developing/Delivering** Training
  - Station **Owner**/Management **Sponsor**
- **What** are they are responsible for:
  - Scope
  - Decision points, decision criteria
  - Effectiveness
- **When** do they take action(s)
- **Where** do they document (process, changes…)
- **How** do they monitor performance

Establishing Organizational Interfaces

Independent Decision-Making Panel (IDP)



Establishing Organizational Interfaces

- **Independent Decision-Making Panel (IDP)**
  - Key organizational and governance mechanism for risk informed applications
  - Multi-disciplinary group of experienced nuclear professionals
    - Operations, Risk Mgt/PRA, Engineering (Design, System), Licensing, QA, etc.
  - Procedurally controlled
  - Specially trained in use of risk insights and information
  - Decision-making body for running risk management programs
  - Generally responsible for administering program requirements and technical decisions related to implemented risk informed applications

Risk Informed Performance Indicators

- **System/Component Reliability (textbook definition)**
- **System/Component Availability (textbook definition)**
- Cumulative Actual vs. Planned Risk (weekly, quarterly, yearly)
  - Incremental Core Damage Probability
  - Incremental Large Early Release Probability
- Risk Index (Ratio of Actual Risk and Average Annual Risk)
  - Rolling 52 Week Average of Actual Risk/Planned Risk
- Maintenance Rule, MSPI
- High Risk Significant Equipment time to ROP/SDP thresholds
- ***Others?***

Key Take-Aways

- **Understand** and **be familiar** with risk informed applications
- **Establish** a site wide **communication** plan
  - Clear and written expectations for risk informed applications
  - Establish clear roles & responsibilities for supervisors/managers (points of contact)
- Establish and **use IDP** structures to implement risk informed programs (member selection is important)
- **Establish** management team **accountability** for implementing and monitoring risk informed programs & require periodic reporting to them
- **Use Risk Informed Performance Indicators** to ensure expectations are being met and to monitor safety/risk levels

Key Take-Aways

- **Applications** & **Implementation** effectiveness are **key** functions
  - Should be **repeatable** for developing more comprehensive risk management programs (build off of successes)
  - Consider cross organizational aspects of Risk Management Function
  - Consider corresponding effectiveness of Risk Management Organization
- **Use of risk** technology is **increasing** (i.e., more is coming
  - Fukushima impact for beyond design basis events,
  - Further regulatory migration to risk informed regulations)
  - NUREG-2150, Proposed Risk Informed Regulatory Framework

Organizational Issues & Considerations for Achieving Best Practices in Risk Management & PRA

How to establish risk management programs

Risk Management Organizational Issues & Considerations

- **Scope of Responsibilities** *(Who is responsible for Risk Management activities?)*
- **Areas of Influence** *(What do you want the Risk Management program to do?)*
- **Internal PRA Configuration Control Procedures and Processes**
- **Risk Informed Procedures & Processes** *(Risk Informed Applications, Decision-Making, etc.)*
- **Internal Governance Bodies** *(Management Oversight, Expert Panel)*
- **Risk Informed Performance Indicators** *(Equipment Availability and Reliability, daily/yearly station risk levels, investment-safety effectiveness, etc.)*
- **Resource Allocations** *(Change management, expectations, organizational impacts)*
- **Training** *(initial, organization specific, refresher, lessons learned)*

Scope of Responsibilities

- **SENIOR LEADERS**
  - Define and Document Risk Management mission, vision, and strategic direction
    - Broad Scope: many organizational functions targeted to for incorporation and integration of risk management analyses and programs (sometimes referred to as "Enterprise level")
    - Focused Scope: selected organizational functions targeted for incorporation and integration of risk management analyses and programs
    - Establish how risk management functions will be conducted and governed
    - Establish policies

Scope of Responsibilities (cont.)

- **Middle Management**
  - Implement Senior Leader expectations with respect to Risk Management
  - Establish risk management programs and processes
  - Manage programs and effectiveness
  - Monitor performance; translate operational and financial parameters into risk informed performance indicators
  - Establish corrective action and feedback mechanisms
  - Continuously learn/improve programs and processes

Scope of Responsibilities (cont.)

- **Support Organizations**
  - Maintain risk informed programs
  - Perform implementation activities (evaluate, analyze, assess, perform, train)
  - Obtain and trend pertinent risk-performance data
  - Training
  - Continuously improve

Governance Bodies

Independent Decision-Making Panels

- Working Groups (multi-disciplined)
- Expert Panels (multi-disciplined)

Management Oversight

- Station Management Team
  - Management Expectations
  - Management Improvement Areas
  - Management Sponsored Enhancements

Risk Informed Performance Indicators

- Station Level Indicators (Daily/yearly Core Damage Risk, Daily/yearly Plant Trip Risk)
- System Level Indicators (Unavailability/Unreliability)
- Component Level Indicators (Risk Significant Equipment reliability and availability levels)
- Customized Indicators (Most frequent event/cause CAP code for high risk significant components, Maintenance costs for risk significant & non-risk significant components)

Resource Allocation

Key Risk Management Functional Areas

- PRA Configuration Control & Analysis (Maintain/Enhance PRA, perform risk analyses, # of models/sites/units) (3-4 FTEs under current requirements, ~2 FTEs per model)
- Risk Informed Applications (quantitative & qualitative)
  - Specially risk trained individuals not necessarily practitioners)
  - Depending on the level/number of implemented applications (on average 1/2 FTE per application)
- Organizational Interfaces (vertically/horizontally, deploying/receiving products)
  - recommend assigned organizational points-of-contact with special training and special responsibility improve risk insights in their respective organizations

Visibility/Exposure of Risk Management Organization

- At the station - What station meetings are risk personnel invited to attend or required to attend?
- Role of centralized risk organizations

Resource Allocation

The above when considered as a whole should indicate the size a Risk Management organization should be and associated managerial/supervisory levels.

For a Risk Management group responsible for PRA configuration control, applications and implementation; recommend Manager and reporting Supervisors (one for PRA Configuration Control & Analysis and one for Risk Informed Applications/Implementation)

Key Take-Aways

- **Risk Management is a Discipline** like Operations, Engineering, Training, or Maintenance
- There **must be active ownership and engagement** by senior leaders to ensure ongoing effectiveness.
- Risk Management programs can **influence**, **change**, **help direct** the missions of other organizations
- It should be considered to be the mechanism where station exposures can be evaluated to **determine priorities** and **raise awareness**
- It is a **"living" program** and must have adequate resources to be effective
- It is a important tool for Senior Leaders to **manage** the **impact** of operational and financial events and to **strategically direct** organizations towards operational and financial excellence

NUREG 2150, Executive Summary

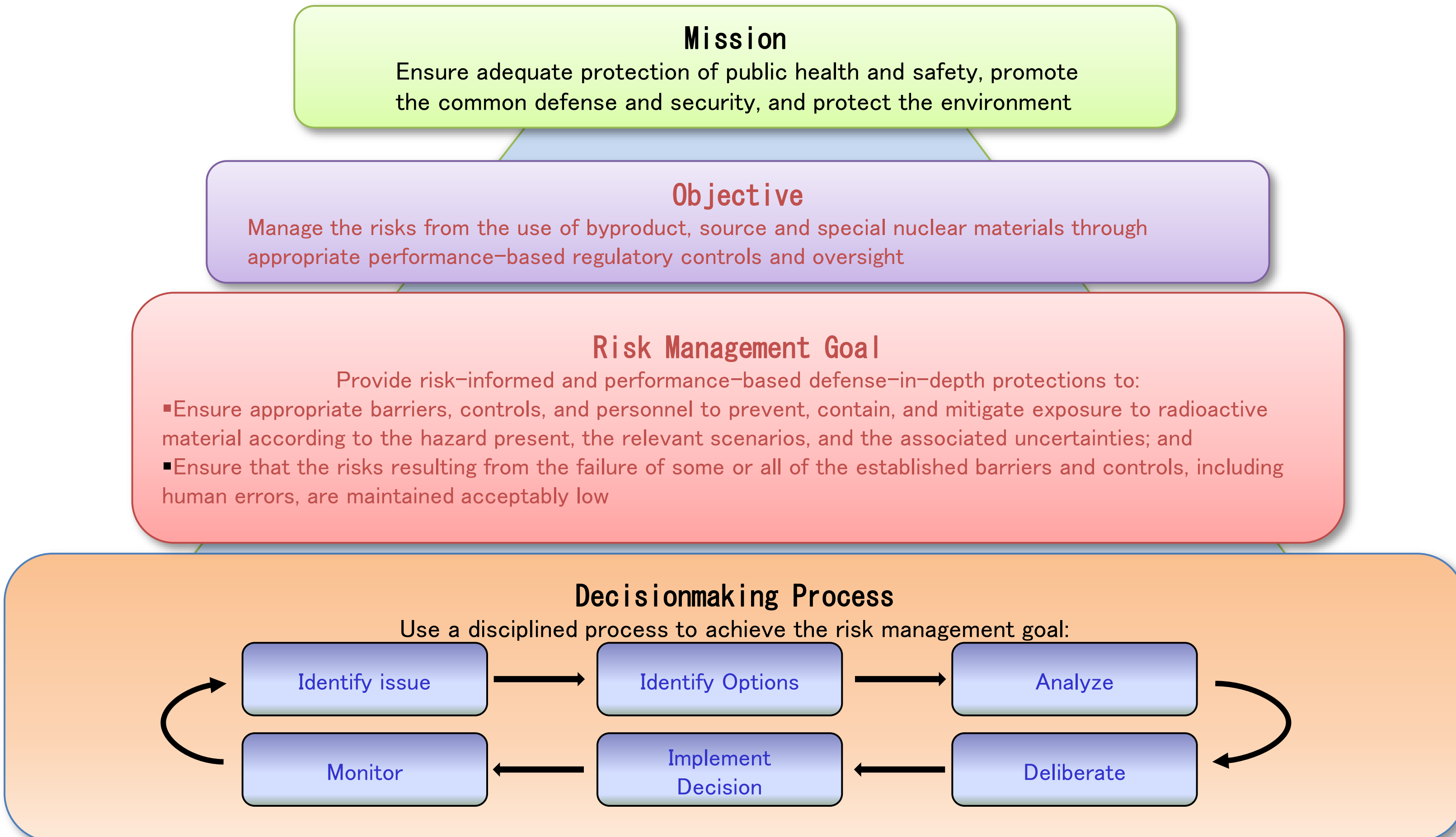


Figure ES-1 A Proposed Risk Management Regulatory Framework