Dimensions of Human Factors in Nuclear Power Safety

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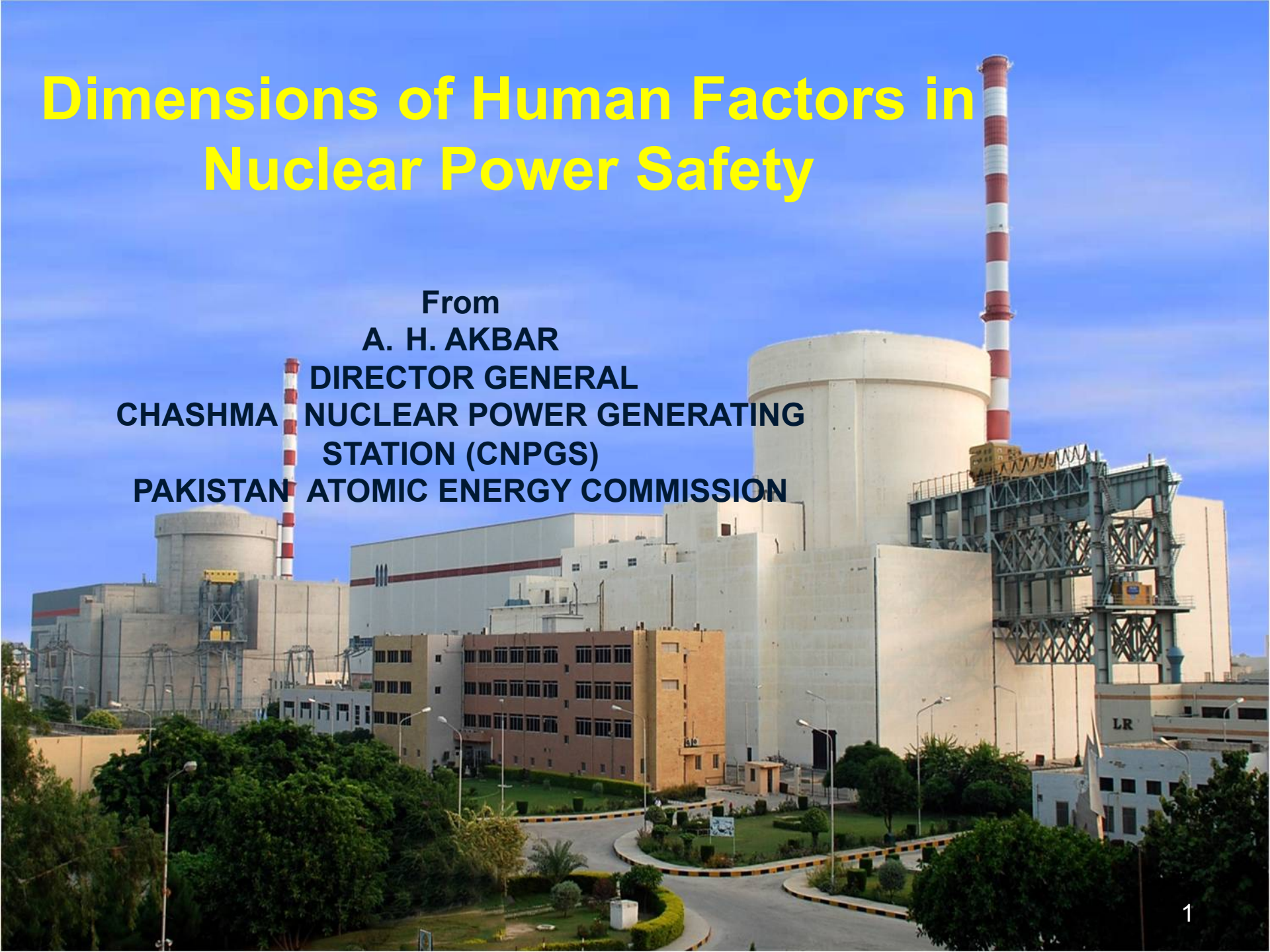
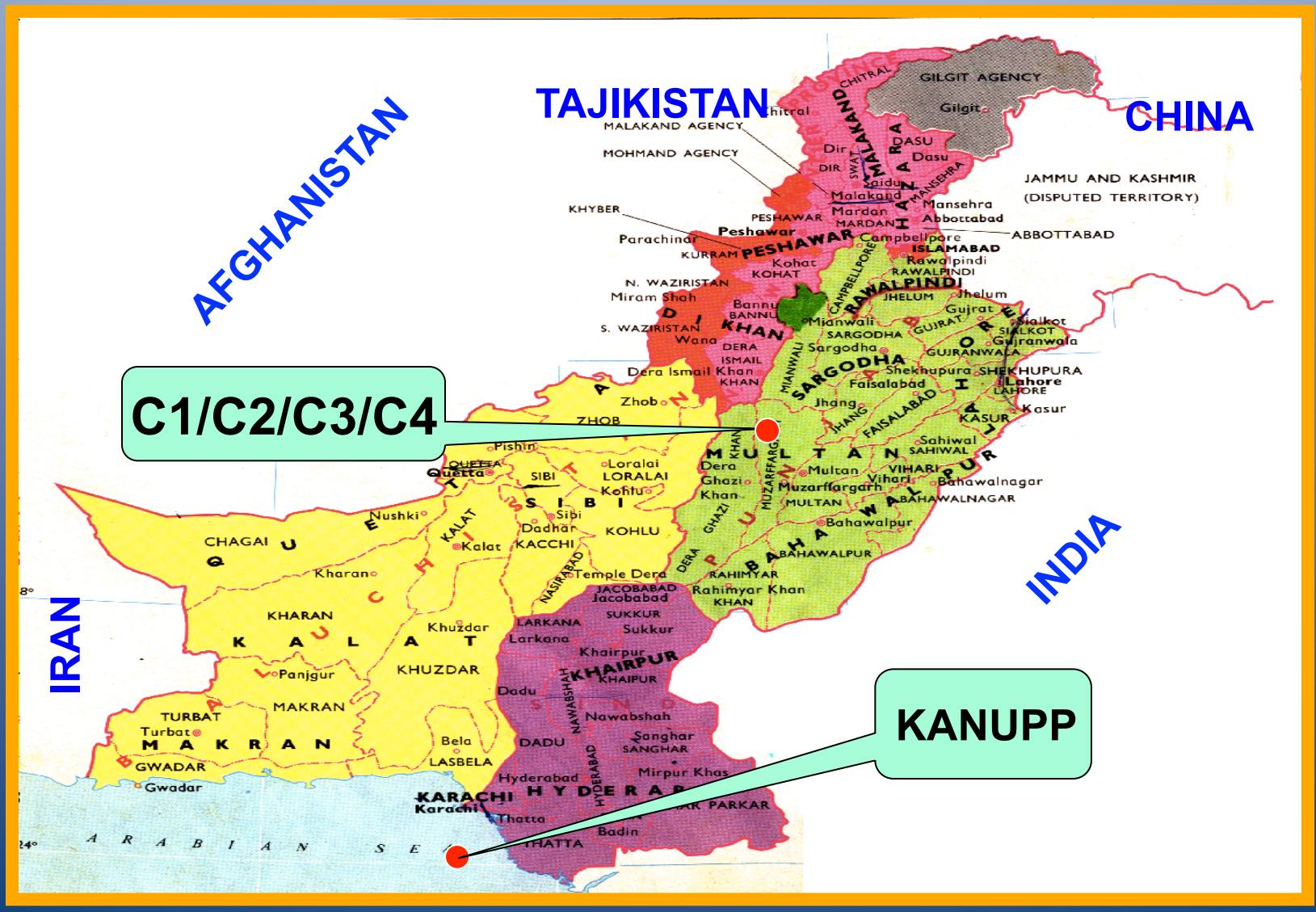
PAKISTAN ATOMIC ENERGY COMMISSION



Nuclear Power Plants in Pakistan

Nuclear Power Plants	Capacity (MWe)	Year of Commissioning
In Operation		
KANUPP	137	1972
CHASNUPP-1	325	2000
CHASNUPP-2	325	2011
Under-construction		
CHASNUPP-3	340	2016
CHASNUPP-4	340	2017
Target		
Installed Capacity	8,800	by 2030

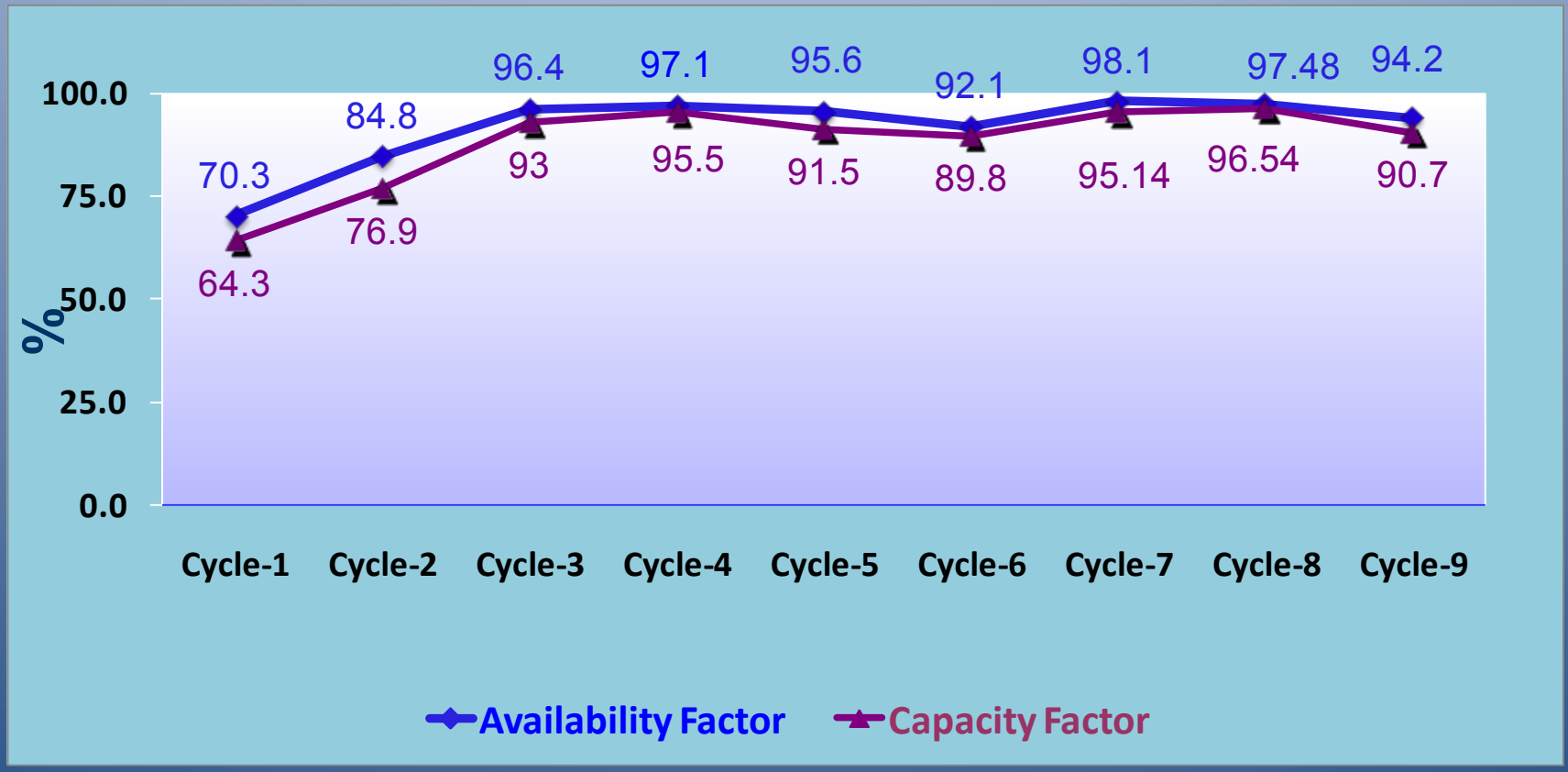
Location of NPPs



C-1 & C-2 Milestones

Milestone	C-1	C-2
Signing of Contract	Dec 31, 1991	May 04, 2004
First Concrete Pouring	Aug 01, 1993	Dec 28, 2005
Submission of FSAR	Apr 01, 1998	Nov 30, 2009
First Fuel Loading	Nov 22~28, 1999	Dec 22~30, 2010
First Criticality	May 03, 2000	Feb 22, 2011
Connection to Grid	June 13, 2000	Mar 14, 2011
Commercial Operation	Sep 15, 2000	May 18, 2011

C-1 Cycle Wise Performance



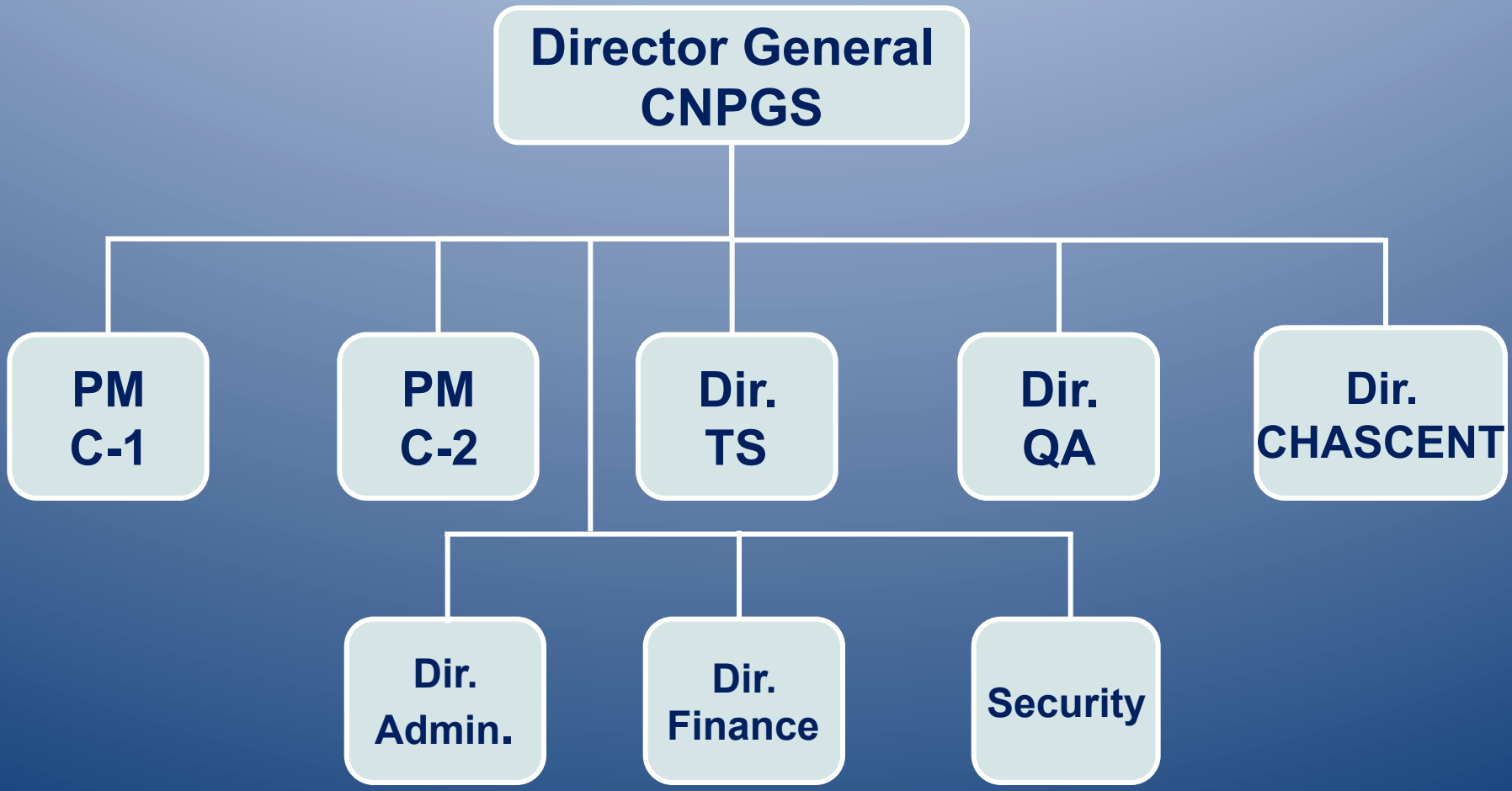
Longest Continuous Operation: 239 Days

C-2 Cycle-1 Performance

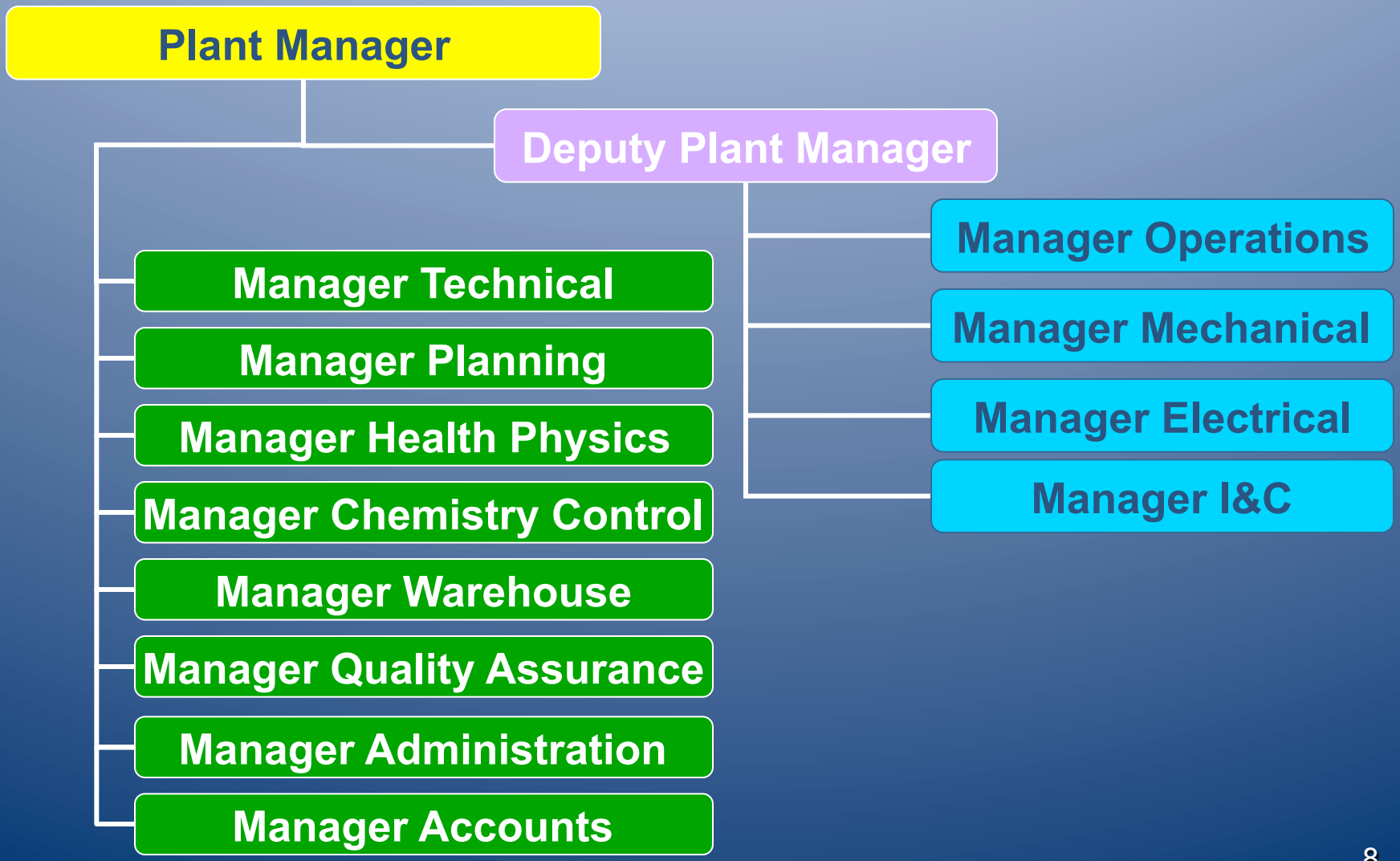
May 12, 2011 – Jan 20, 2013

Availability Factor	**86.7 %**
Capacity Factor	**79.3 %**
Longest Continuous Operation	**161.7 Days**

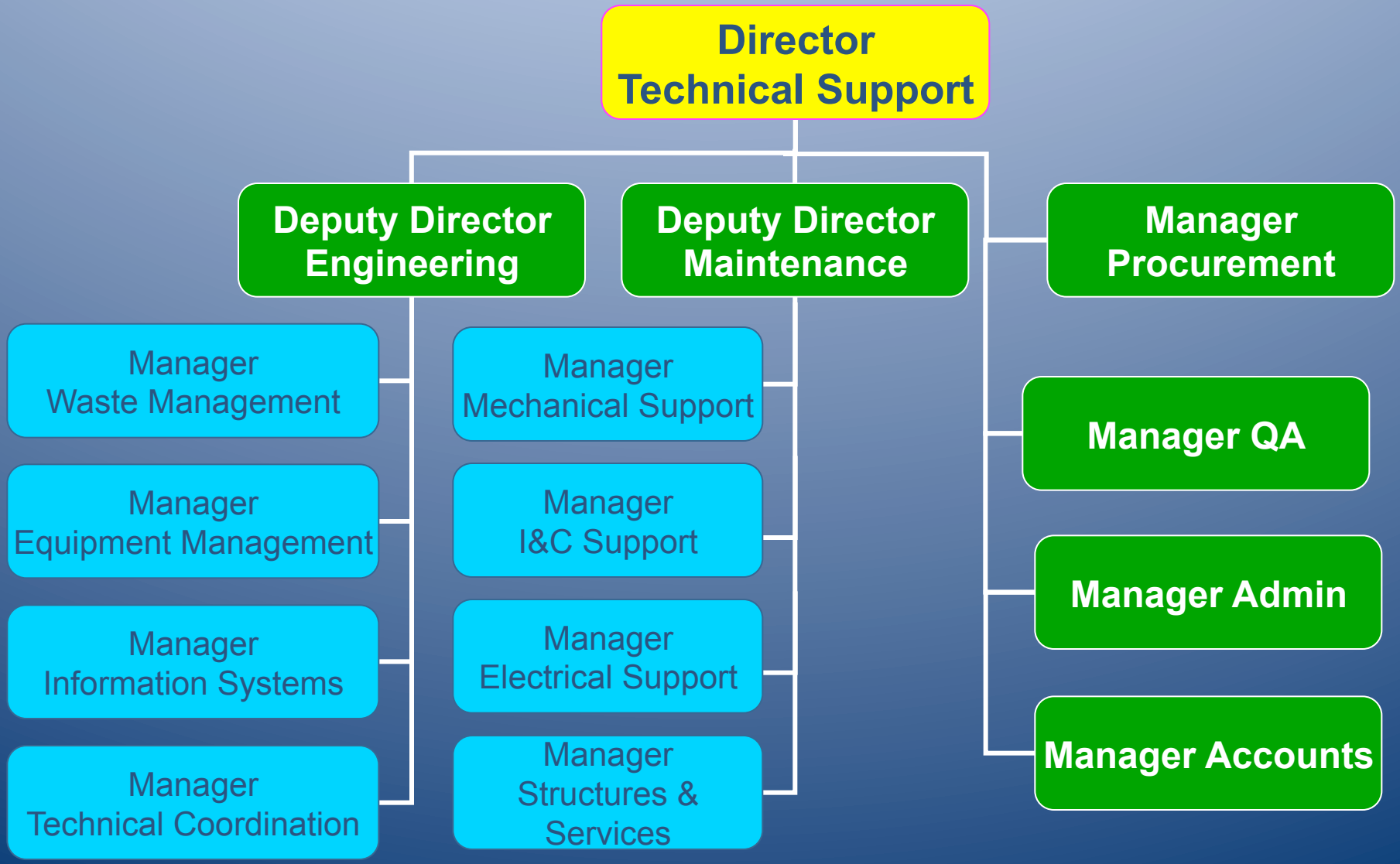
CNPGS Organization



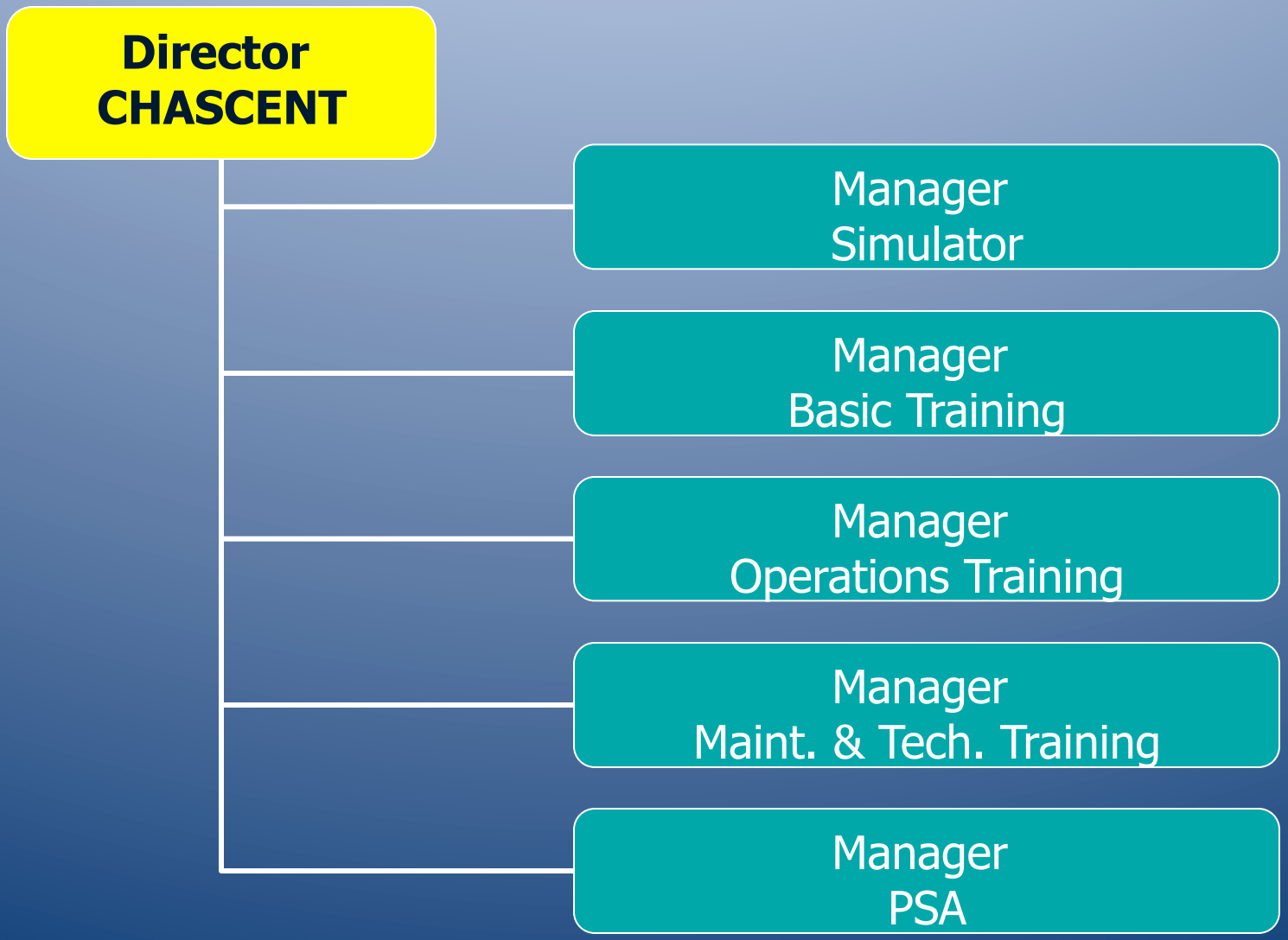
Plant Organization - CNPGS



Directorate of Technical Support - CNPGS



CHASNUPP Centre of Nuclear Training - CNPGS



Operational Safety

- Periodic Safety Review (PSR) for unit C-1
- Corporate and Plant Safety Policy
- Technical Specifications requirements
- Operating Experience Feedback
- Management oversight
- Regulatory Oversight
- Support from Reactor vendor, Designer available
- Third Party Inspections
- Self-assessment program
- IAEA Pre-OSART and OSART missions, WANO Peer Reviews / Follow-ups / TSMs at C-1

Operational Safety

- WANO-TC Pre-startup Peer Review / Follow-up and TSM for C-2 in Human Performance improvement and organization for multi-unit sites
- Corrective Action Program (CAP)
- Safety Performance Indicators Program
- Ageing Management Program
- Equipment Condition Monitoring Program

Regulatory Oversight
Pakistan Nuclear Regulatory Authority (PNRA)

- Regulations
- Operating License Conditions
- Operating License Re-Validation
- Approval of Modifications affecting safety
- Participation in selected activities
- Surveillance
- Formal Audits / inspections
- Review of Mandatory Reports
- Evaluation of Emergency Preparedness Plan (EPP) exercises.
- Approval of FSAR, EPP, QAP, PSP, PSA etc.

Operational Safety - Corporate Oversight

Pakistan Atomic Energy Commission (PAEC) has always given importance to the axis of nuclear safety.

- Safety & QA Directorates at corporate Level
- Inspections in the area of nuclear safety, radiological safety, industrial safety, and physical protection
- QA audits
- Corporate Peer Review
- Safety enhancement improvements under Fukushima Response and Action Plan (FRAP C-12).

Human Factors (HF) for Nuclear Power Safety

Aims of Presentation…..

Raise awareness of need to address human factors risks related to design, maintenance and operation of safety-related systems

- **We all know Human Factors have much to offer nuclear safety**
- **Environment where the persons works**
- **The equipment interface and functionality**
- **The design of Systems and Procedures**
- **The organization of work**
- **The reliability and capability of the personnel**

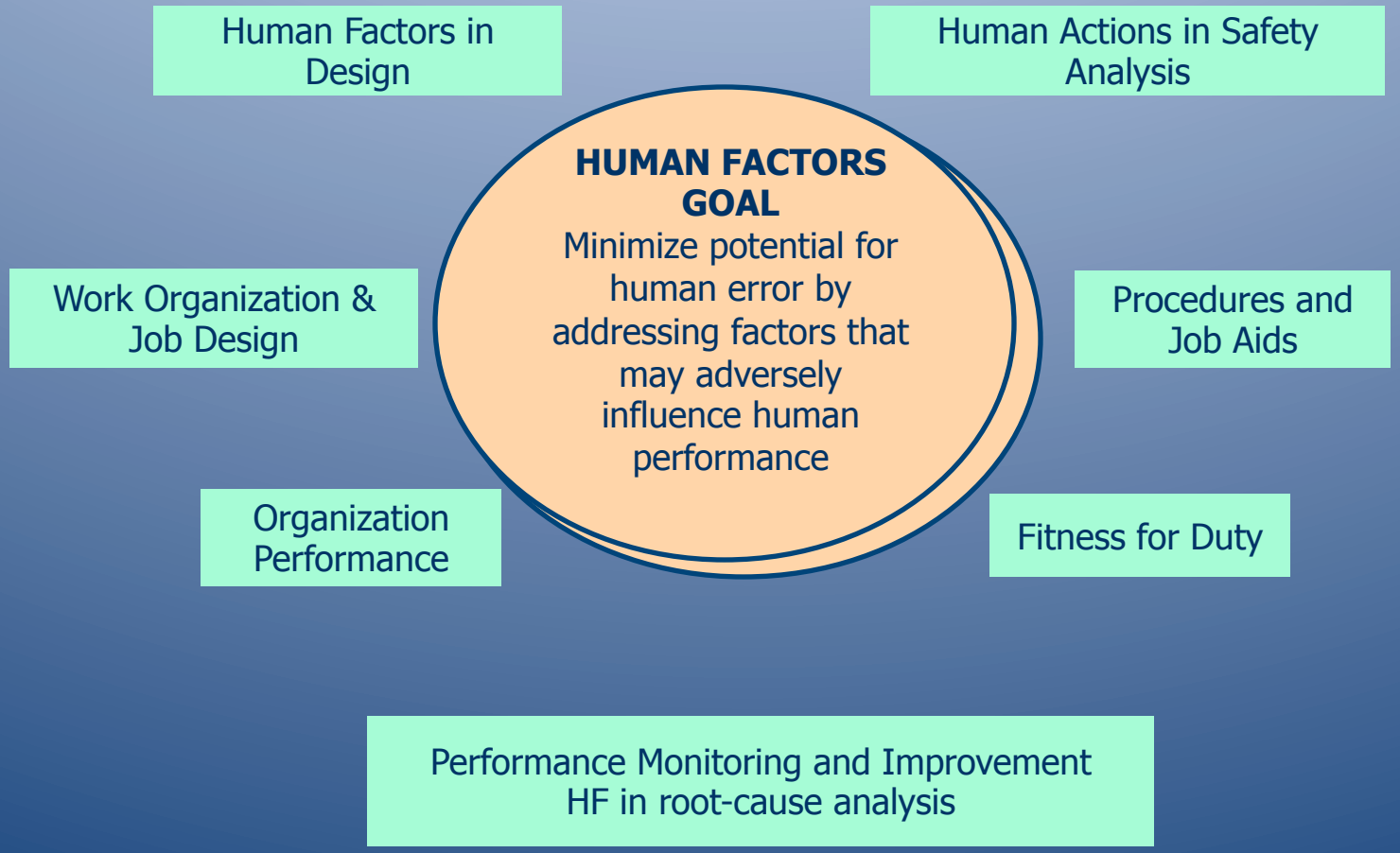
Foreword

- The incidents at Three Mile Island and Chernobyl are much cited, and a recent accident at Fukushima has seemingly reinforced this concern, caused to a large extent by human errors.
- Success of the nuclear industry from safety point of view has large credit to the international exchange of experience.
- IAEA has played a crucial role in this spread of nuclear safety.
- The nuclear industry is regarded as the Gold Standard in human factors but there is a little room of complacency.

Foreword

- This paper addresses the human aspects of nuclear power. The purpose of this paper is to bring together established human factors approaches and effective application of these socio-technical challenges being faced in nuclear power industry.
- Being regulatory requirement, Chashma Nuclear Power Generating Station (CNPGS) conforms to the requirement of Human Factors Engineering (HFE).

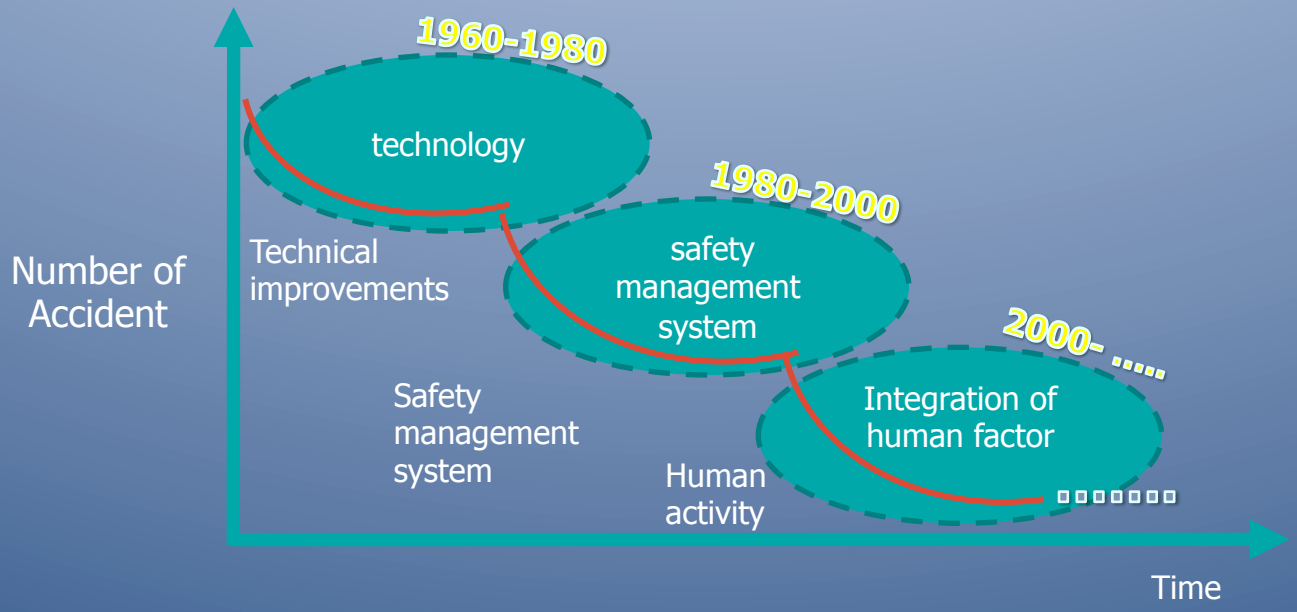
Human Factors Review Areas



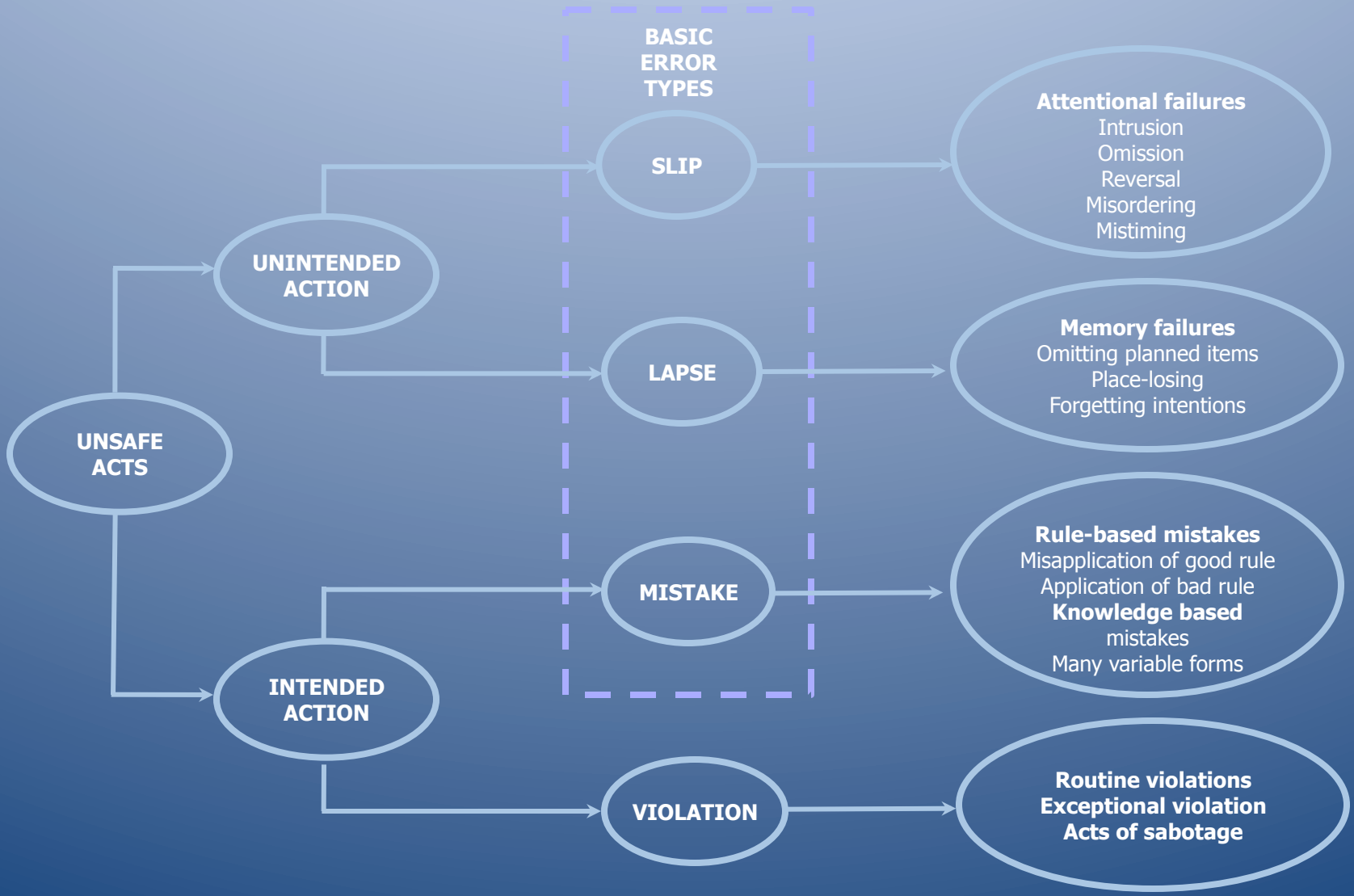
Why adopt a human factors approach to nuclear safety?

- As technology become more reliable, so human failure becomes the prevalent cause of nuclear incidents
- Do we point the finger at technology not keeping up its promises or do we point the blame at human error and complacency?
- Although the approach to human factors has matured considerably, yet, pockets of over-emphasis on technology without recognizing the human contribution to risk, do still exist

Human factor and Safety

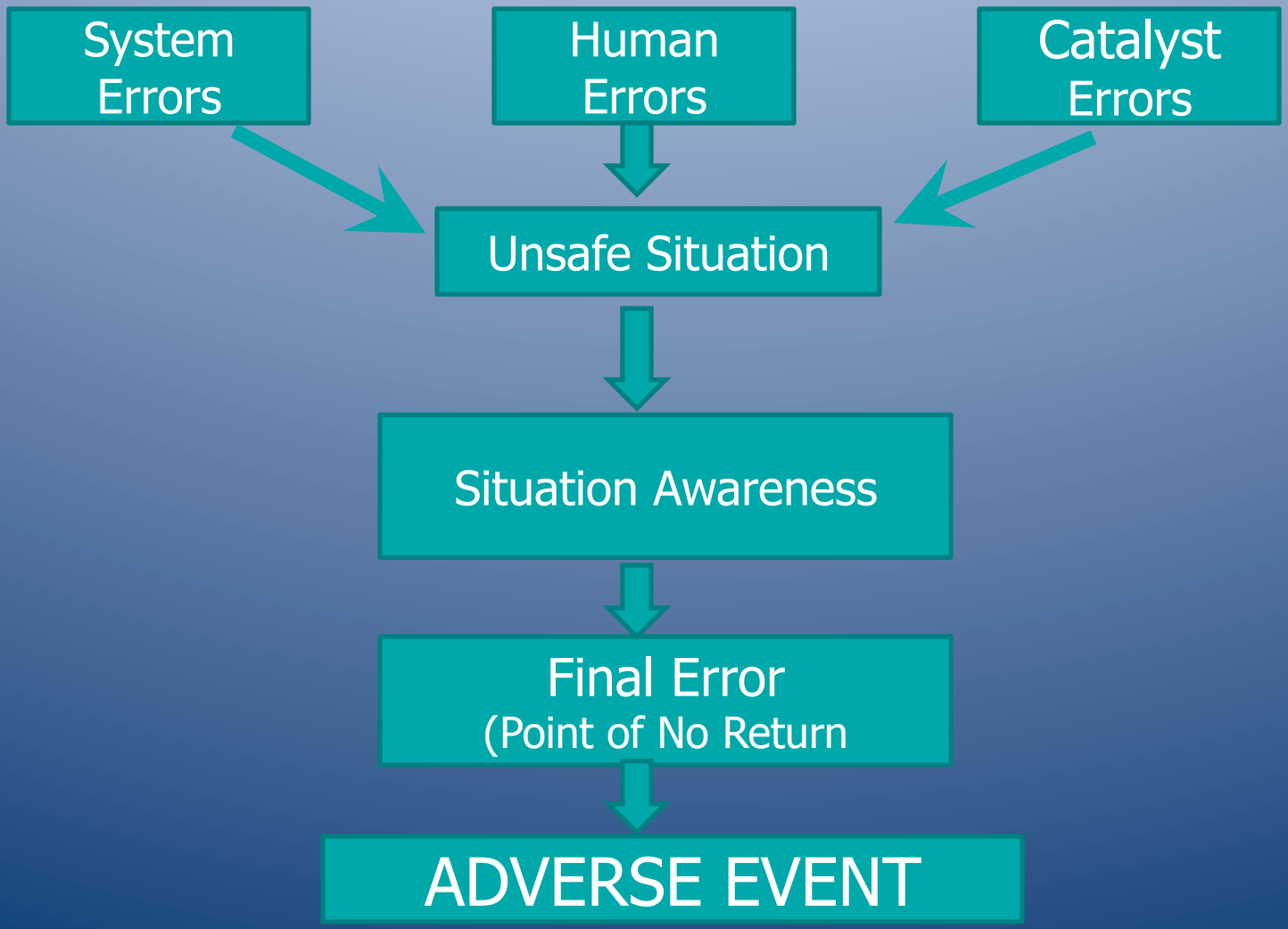


Successive Approaches to Nuclear Power Safety



Classification of human errors

Human Error Chains



Dimensions of the Human Factors

- Cultural and Organizational Factors
- Optimizing human performance
- Human factors in high demand situations
- Human factors as a part of the engineering design process (HFE)
- Human performance in Plant outages
- Outline of HFE Program at CNPGS
- Human Performance Improvement Program at CNPGS

Human Factors Profile

ORGANIZATIONAL ISSUES

Design process
Ergonomic assessment
Human reliability assessment
Safety culture

PERSONNEL ISSUES

Selection
Teams
Stress
Shift work
Training
Operators

DESIGN ISSUES

Input devices
Simulators
Alarms
Procedures

Safety Culture

Safety Culture – Success Factors

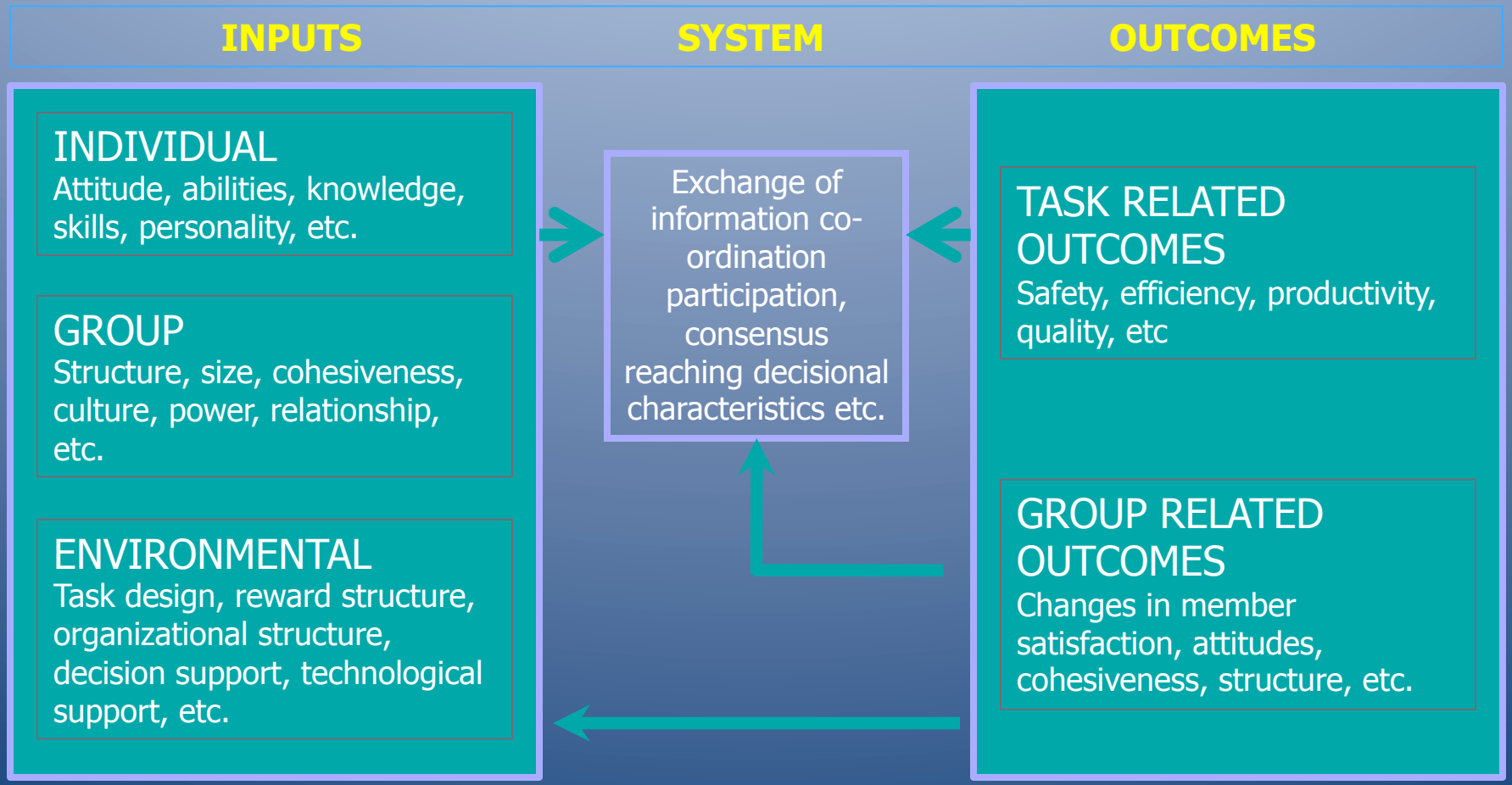
- Active participation of workforce and management
- Issue card reminders and checklists of behaviors that need to be observed
- Constantly reinforce and encourage behavioral change
- Measurement through surveys, questionnaires.

Optimizing Human Performance

Through:

- **Procedures**
- **Training**
- **Incorporation of Human Factors in the design Process**

Factors affecting human performance



Procedures and compliance

- **Well known fact: people don't respect procedures! 90% of the accidents have at least one root cause related to mistakes within procedures.**

WHY?

→ Complex, not updated, too restrictive, do not describe the best way to do the job….

→ Technical accuracy and usability of procedures

→ Need to address normal and Emergency Procedures and assessed descriptions of EOP related practices

Training

- Training helps people acquire the skills, knowledge, and attitudes to make them competent in the safety aspects of their works and assigned tasks to diagnose plant upsets.
- Should be defined as a function of the needs found in the plant

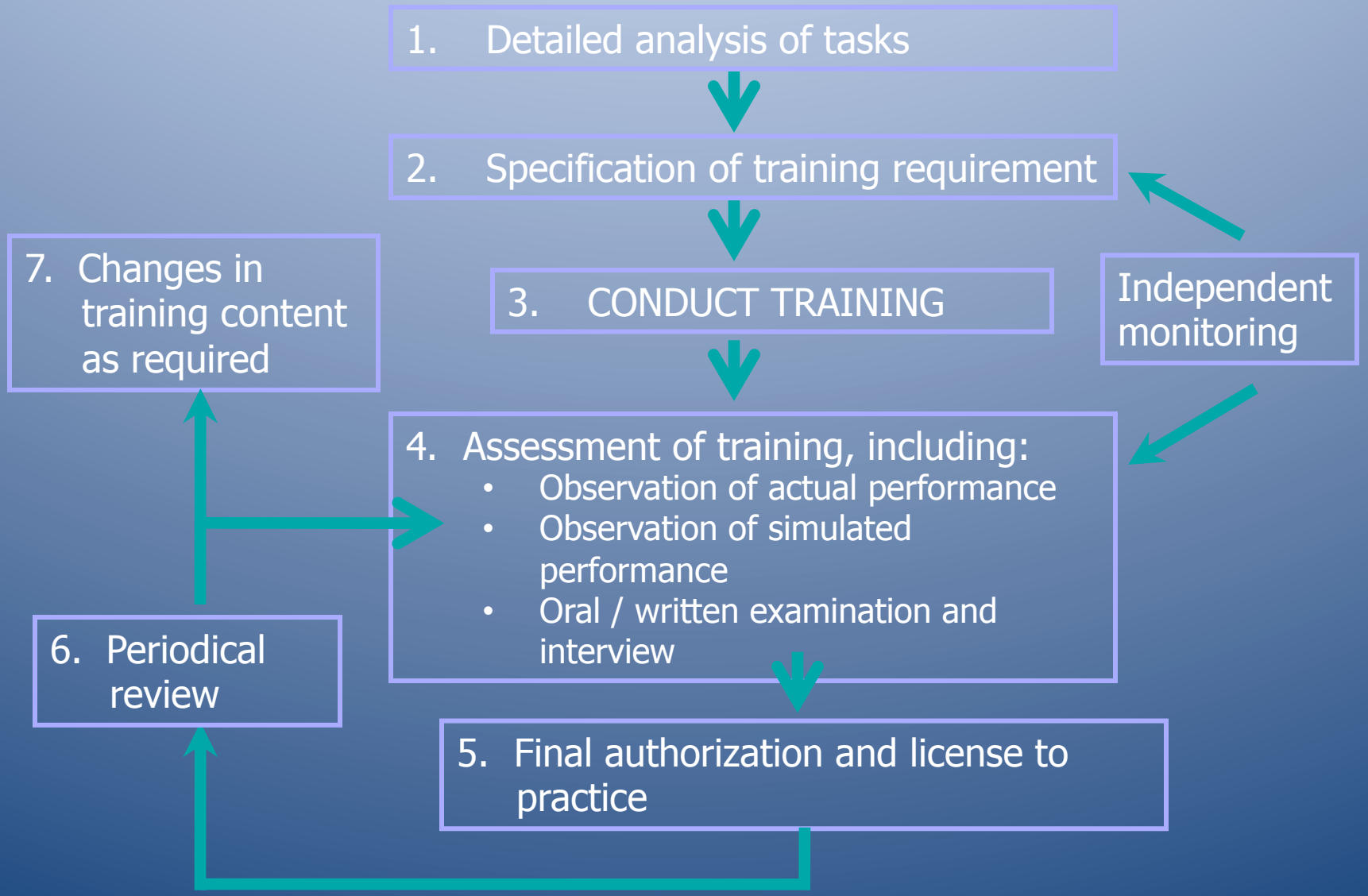
what, how and, why does the trainee need to learn?

What knowledge, skills and abilities?

- Implementation of a training management

Annual training plan, training team, assessment, use of Simulator training frequency of training, and instructors qualifications.

- Examination based on a task analysis



General framework for training

Cognitive Task Load Design

- Tasks to be designed considering human limits: Interactions among multiple work members, equipment and systems.
- A specific database to analyze operator tasks.
- Available time – response to alarms

The combination of the three load factors determines the cognitive task load

Response to Alarm Handling

- A wide issue about assuring the human response to an alarm
- Operators routinely ignore alarm in the plant control room

Operators facing as few as 10 alarms (say) a minute in an emergency may quickly abandon the alarm list to reduce stress. They may find a way to solve the problem without using the alarms

How to face this problem?

Implementation of an alarm philosophy

Notify operators of events required more focus attention

Help to prioritize response

Guide operator towards most appropriate response

How to Incorporate HF in the Design Process?

- We cannot change the Human Condition but we can change the conditions in which humans work.
- To take human factors into account as part of the engineering design requires the design of:
  - Equipment,
  - Operations,
  - Procedures,
  - Work environments.

  such that they are compatible with the capabilities, limitations and needs of the workers, and respected in all engineering design decisions.

Procedures to Reduce Human Errors within a Plant / Project

- **Identification of Errors Causes**
  - **Task analysis**
  - **Action error analysis**
  - **Performance goals of HFE**
- **Design solution to address the Error Causes**

Task Analysis

- Identification of the list of human operations performed and their relation to the system tasks
- Specification of the systems' manning level i.e. what personnel is needed and how its members be selected
- Identification of training needs
- Evaluation of control room instrumentation
- Writing of operating and maintenance procedures
- The aim is to maximize the overall system capabilities in performing plant operation

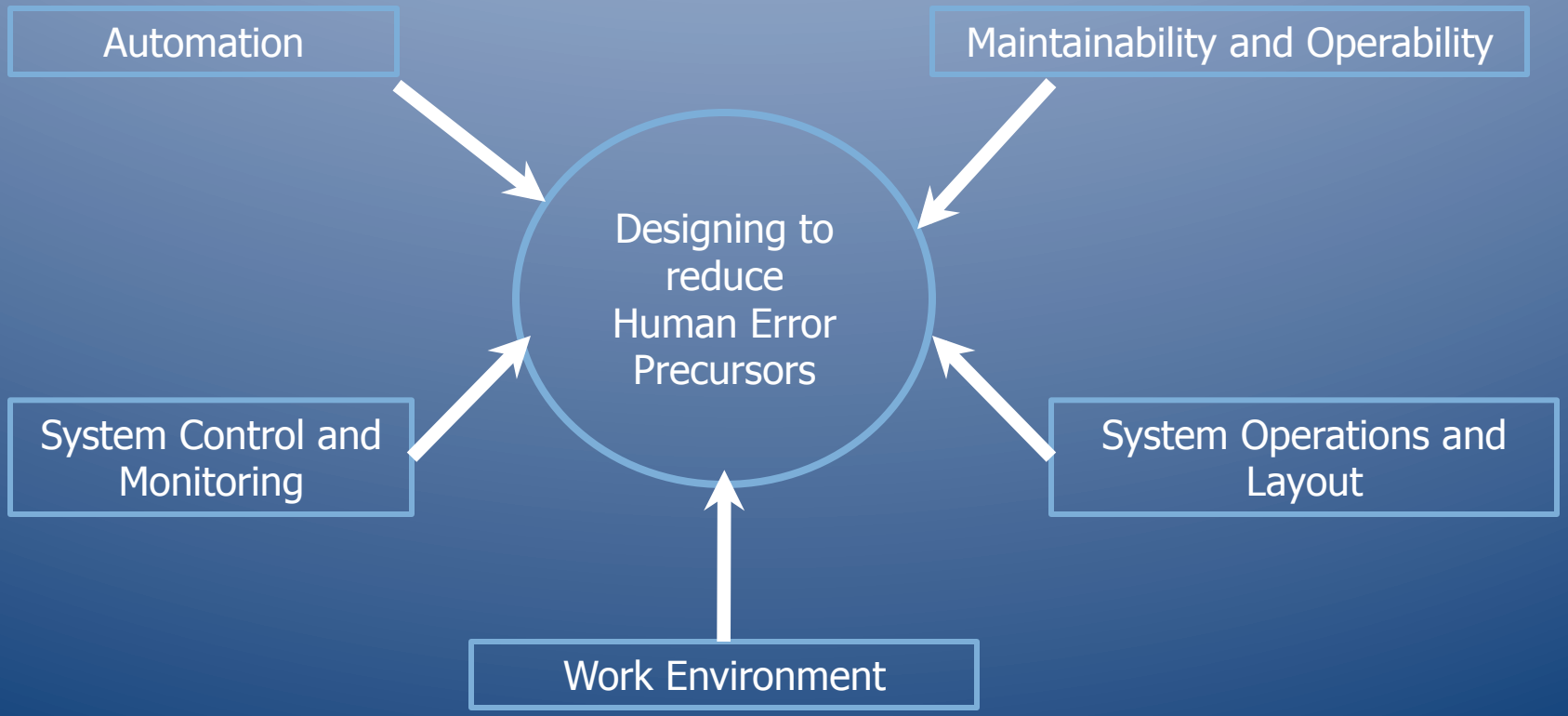
Action Error Analysis

- Cognitive support model
- Review of plant safety in case the operator acts wrongly or does not act at all
- Check of the operators workload in case of demands occurring simultaneously or in fast sequence
- Review if the operator is able to relate alarm and the cause clearly

Performance Goals of HFE

- Identify if there could be factors that affect the task performance
- Stress, work procedures, quality of work environment….
- System is designed to, at least, at best, tolerate and prevent human error or at worst, to recovered from human error
- Synchronized cycle time, flexibility, punctuality, cost effectiveness, and quality.
- Regulatory requirement – credibility, auditability, reliability and validity

Design solution to address the error causes



Human-Machine Interface (HSI)

- It includes alarms, Information Systems and Control Systems
  - Rectification of programming errors and erroneous operator inputs.
  - Operators are properly trained, software is tested and programming changes are strictly controlled.
  - Labeling and color coding reduce human errors.
  - Alarms need to be designed to be noticed but not overload the workers.
  - Design for operability, maintainability, flexibility of HSI be given a top priority.

Collection of Human Factor Data

- The need for qualitative information
  - By in-depth Event Notification Reports (ENRs) by plant personnel
  - By on-site investigation of significant abnormal events carried out by experienced human factor experts
  - By the use of simulators

Approaches to Human Performance in Plant Outages

Kindly click to this hyperlink

*HFE Program Review Model Elements at CNPGS

<table>
<tr><th>Planning and Analysis</th><th>Design</th><th>Verification and Validation</th><th>Implementation and Operation</th></tr>
<tr><td>HFE Program Management</td><td>Human-System Interface Design</td><td rowspan="6">Human Factors Verification and Validation</td><td rowspan="3">Design Implementation</td></tr>
<tr><td>Operating Experience Review</td><td rowspan="2">Procedure Development</td></tr>
<tr><td>Functional Requirements Analysis and Function</td></tr>
<tr><td>Task Analysis</td><td rowspan="3">Training Program Development</td><td rowspan="4">Human Performance Monitoring</td></tr>
<tr><td>Staffing and Qualification</td></tr>
<tr><td>Human Reliability Analysis</td></tr>
</table>

* - Incorporated in FSAR of Unit-2
  - Using PSA input in HFE

How to incorporate HF in the design process?

- **Applicable Standards and Regulatory requirement i.e.**
  - **NUREG-0800 (Standard review plan)**
  - **NUREG-0711 (HFE program review model)**
  - **NUREG-0700 (Human-system design review guidelines)**

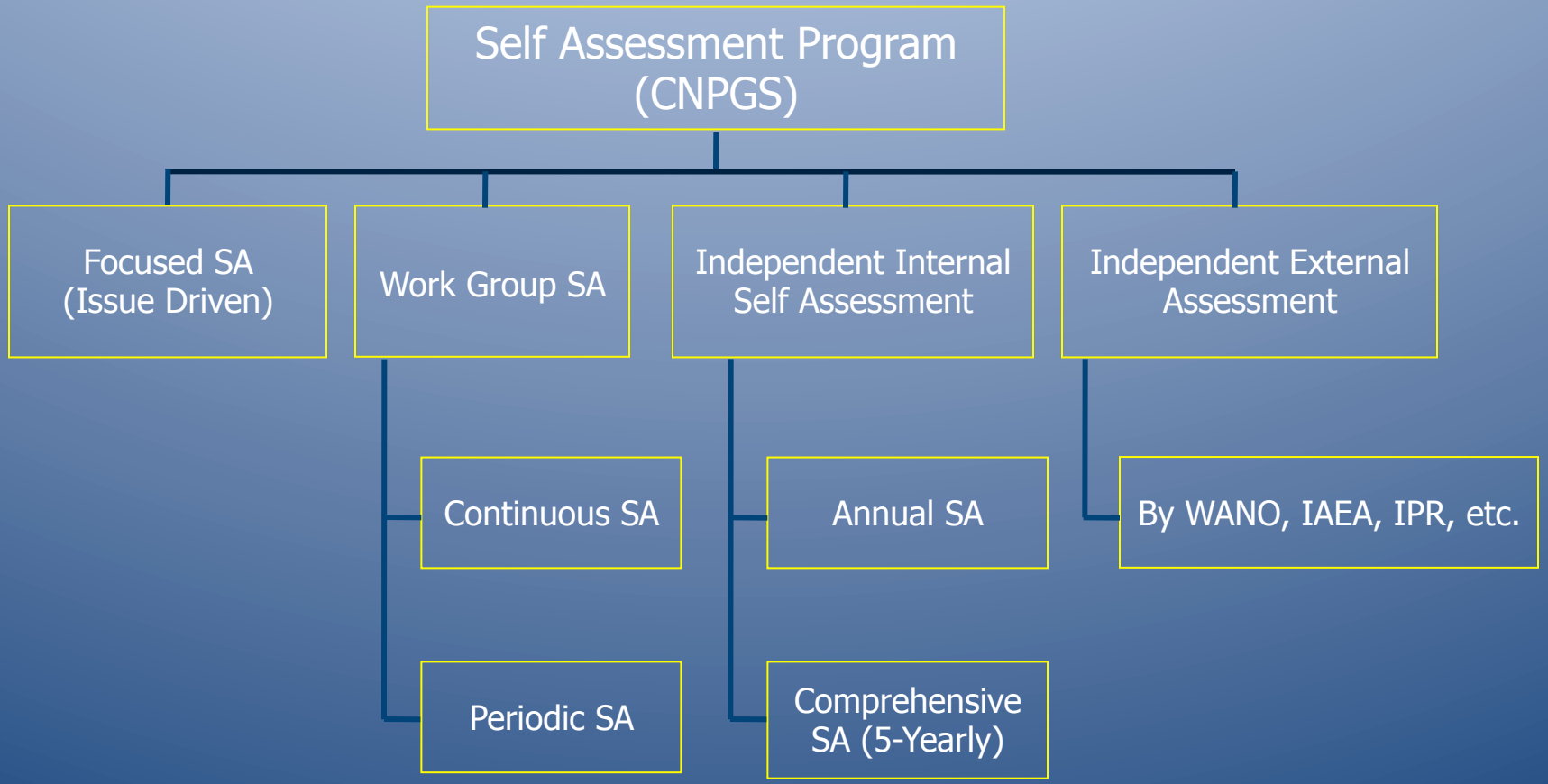
WANO-TC, Technical Support Mission (TSM) at CNPGS, October 15-18, 2012

Discipline: Organization and management of Multi-Unit site and establishment of an overall Human Performance Program (HUP) at CNPGS.

Recommendations:

- May be centralized responsibility / de-centralized responsibility / area oriented / function oriented.
- Fundamental function to be assured by respective organizational elements with single point responsibility and without any overlap in responsibilities.
- Regarding Human Performance, a high respected nuclear professional with strong supervisory and project management skills to be selected to lead the effort for complete success, the HUP to be seen with reference to examples of two different US utilities to facilitate HUP development

Self-Assessment Program



A final thought

- Human behaviour can be predicted with reasonable accuracy.
- Correctly integrating HFs into incident/ event investigating process will reap rewards.
- Separating error, mistake and violation represents a high valuable first step.
- Managing human failure requires a high degree of corporate honesty:
  - What behaviour is really rewarded?
  - Are we willing to look at organizational factors, especially when see rule breaking?
  - Are we willing to make the investments that are likely to prevent reoccurrence?
  - Are we willing to strive for objectivity and pragmatism?

A final thought

- **Too soon to think about it: still a long way to go with Human Factors.**
- **Chashma Nuclear Power Station continues to measure success, identify new problems and form new initiatives. We plan to continue improving our score in collaboration with IAEA, WANO and PNRA (Regulatory body) regulations.**