



**DEPT. OF NUCLEAR TECHNOLOGY**  
**CHULALONGKORN UNIVERSITY**

**Presentation - 5**

***“QUALITY in DESIGN”***

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## OBJECTIVES of PRESENTATION

**This presentation will discuss  
the following topics :**

- ◆ **Product development**
- ◆ **Fitness for use**
  - **reliability**
  - **maintainability**
  - **safety**
  - **ergonomics**
  - **cost effectiveness**
- ◆ **Review and validation of design**
- ◆ **Quality program as applied to design**



## **PRODUCT DEVELOPMENT -** **KEY MANAGEMENT DECISIONS**

- ◆ **Scope of product development process**
- ◆ **Desired level of Quality vs competition**
- ◆ **Intended use vs actual use**
- ◆ **Relative priorities of reliability and maintainability**
- ◆ **Quantification of “fitness for use” parameters**
- ◆ **Who controls product specification ?**
  - **marketing**
  - **designers**
  - **manufacturing**
  - **a team**



## PHASE CONCEPT of DESIGN

### Concept and feasibility phase

- marketing specification

### ◆ Detailed design phase

- product requirement specification

### ◆ Prototype phase

- confirming basic capability

### ◆ Demonstration phase

- performance
- manufacturing (productability)

### ◆ Production and operation phase

- performance improvement
- minimize failures



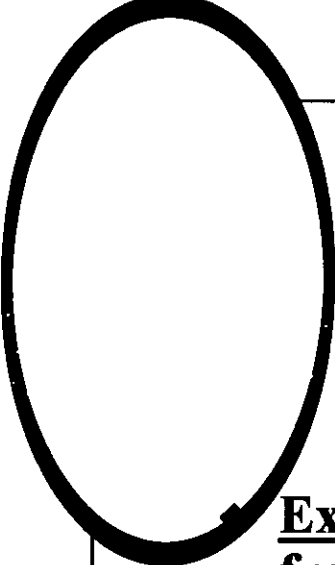
**PRODUCT DEVELOPMENT -**  
**TYPICAL DESIGN INPUTS**

- ◆ **Performance requirements**
- ◆ **Codes, standards and regulatory requirements**
- ◆ **Design conditions and loads**
- ◆ **Material requirements**
- ◆ **Operational requirements**
- ◆ **Engineering requirements and limits**
- ◆ **Instrumentation and control**
- ◆ **Fitness for use considerations**
- ◆ **Transportability limitations**



## **PRODUCT DEVELOPMENT - TESTING**

- ◆ **Problems in testing arise from :**
- ◆ **Intended use versus actual use**
- ◆ **Prototype construction versus production model**
- ◆ **Variability due to small numbers**
- ◆ **Validity of test conditions**
- ◆ **Evaluation and interpretation of results**



## **PRODUCT DEVELOPMENT -** **CANADIAN NUCLEAR PROGRAM**

◆ **Experimental Reactors at Chalk River,  
from late 40's :**

- **exploring feasibility**

◆ **Nuclear Power Demonstration Reactor  
(20 MW), from early 60's :**

- **validate fuel channels, heavy water,  
fuelling and safety concepts**

◆ **Douglas Point prototype Reactor (200 MW)  
from late 60's :**

- **develop and advance design concepts**

◆ **Pickering commercial production Reactors,  
(540 MW), from early 70's**

- **produce economical, environmentally  
friendly , commercial electrical power**



## **FITNESS for USE CONSIDERATIONS:**

- ◆ **Reliability**
- ◆ **Maintainability**
- ◆ **Safety**
- ◆ **Human factors**
- ◆ **Manufacturing (productability)**
- ◆ **Cost effectiveness**



## RELIABILITY DEFINITIONS of MERIT

- ◆ Mean time between failures (MTBF)
- ◆ Failure rate
- ◆ Mean time to failure (MTTF)
- ◆ Mean time to first failure (MTFF)
- ◆ Mean time between maintenance (MTBM)
- ◆ Longevity
- ◆ Availability
- ◆ System effectiveness
- ◆ Probability of success



## **MAINTAINABILITY -** **DESIGN CONSIDERATIONS**

- ◆ **The need to balance following criteria**
- ◆ **Reliability versus maintainability**
- ◆ **Modular versus non-modular construction**
- ◆ **Repair versus throw-away**
- ◆ **Person versus machine**



## MAINTAINABILITY -

### EXAMPLES of IMPROVEMENTS

- ◆ **Aluminium siding**
- ◆ **Maintenance - free batteries**
- ◆ **Self-lubricating and sealed bearings**
- ◆ **Fewer hours to change aircraft engines**
- ◆ **Fiberglass boats and dacron sails**
- ◆ **Introduction of “on condition” maintenance**



## IMPROVING SAFETY through DESIGN

- ◆ **Elimination of hazards and minimizing risk**
- ◆ **Limiting the level of hazard**
- ◆ **Lock-outs, lock-ins and interlocks**
- ◆ **Fail-safe design**
- ◆ **Monitors and warnings**
- ◆ **Escape, rescue and survival**
- ◆ **Isolation of hazards**



## **FITNESS for USE - MANUFACTURING**

- ◆ **Relationship of process variables to product results (minimize rejects)**
  
- ◆ **Value and cost of precision :**
  - **tolerancing**
    - + standardization
    - + by precedent
  - **interchangeability**
    - + interfacing dimensions
    - + position tolerance
    - + tolerance build-up
  
- ◆ **Non-quantifiable characteristics**
  
- ◆ **Rating of designs for ease of manufacture**



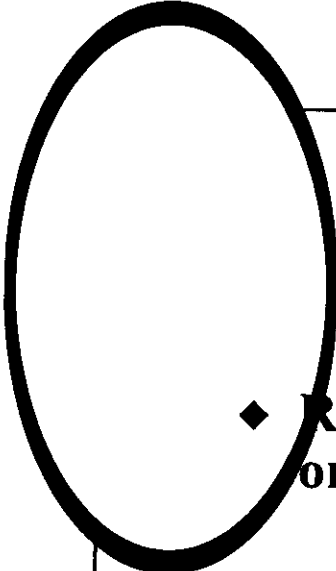
**FITNESS for USE -**

**LIFE CYCLE COST ANALYSIS**

- ◆ **Identify life - cycle phases**
- ◆ **Identify cost structure**
- ◆ **Acquire cost data**
- ◆ **Analyze relationships**
- ◆ **Formulate criteria for decision making**

## **SUCCESS FACTORS for DESIGN REVIEWS**

- ◆ **Management support, structure and directive**
  - ◆ **Emphasis on constructive input to designers, rather than criticism**
- ◆ **Elimination of perception that others are trying to design the product**
- ◆ **Realistic schedules and resources**
- ◆ **Adequate planning for Design Reviews**
- ◆ **Focusing on unproven and untried features of design**
- ◆ **Resolution mechanism for inter-departmental conflicts, if any**



## QUALITY PROGRAM - TYPICAL PROCEDURES

- ◆ Responsibilities and interfaces between organizations
- ◆ Organization and responsibilities within Design
- ◆ Technical information exchange
- ◆ Maintenance and retention of documents
- ◆ Design input requirements
- ◆ Verification methods
- ◆ Control of computer software
- ◆ Control of design changes
- ◆ Implementation of corrective actions





## **SOFTWARE CONFIGURATION - QUALITY MANAGEMENT ISSUE**

### **Attributes :**

**Correctness  
Performance  
Traceability**

### **System configuration management plan:**

- ◆ **Change management :**
  - control procedure
  - software library
  - classification and certification
  - routine validation
  
- ◆ **Change procedure :**
  - proposal
  - development
  - validation/testing/approval
  - installation
  
- ◆ **Documentation**
  - clear definition of programs
  - user manuals
  - details of code changes

# FITNESS FOR USE - COST EFFECTIVENESS

## COST EFFECTIVENESS

### LIFE - CYCLE COSTS

COST TO MANUFACTURE

COST TO USER

### EFFECTIVENESS

FUNCTIONAL PERFORMANCE

RELIABILITY

MAINTAINABILITY

SAFETY

AESTHETICS

HUMAN FACTORS

ECOLOGICAL

PRODUCTABILITY

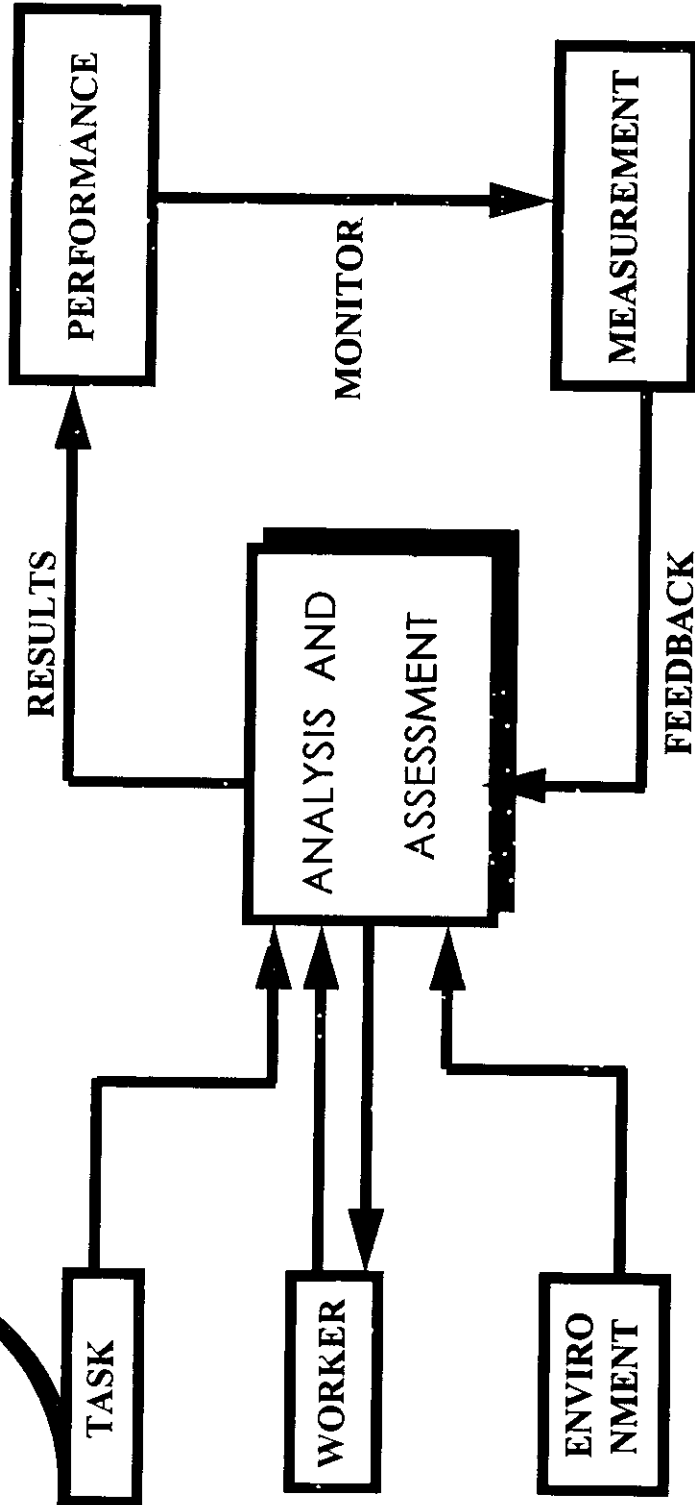
STANDARDIZATION

LEGAL

INSPECTION

TRANSPORTATION

FITNESS for USE - ANALYSIS of HUMAN FACTORS



ADDRESS the CAUSE, not SYMPTOMS