Management of Alarm Systems in the Process Industries

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- **Alarm systems**
  - *design,*
  - *development,*
  - *installation,*
  - *management*
- **Terminology, practices,**
- **Process industry – continuous, discrete and batch processes**
- **Lifecycle model**
- **Reason – to improve safety, quality and productivity**

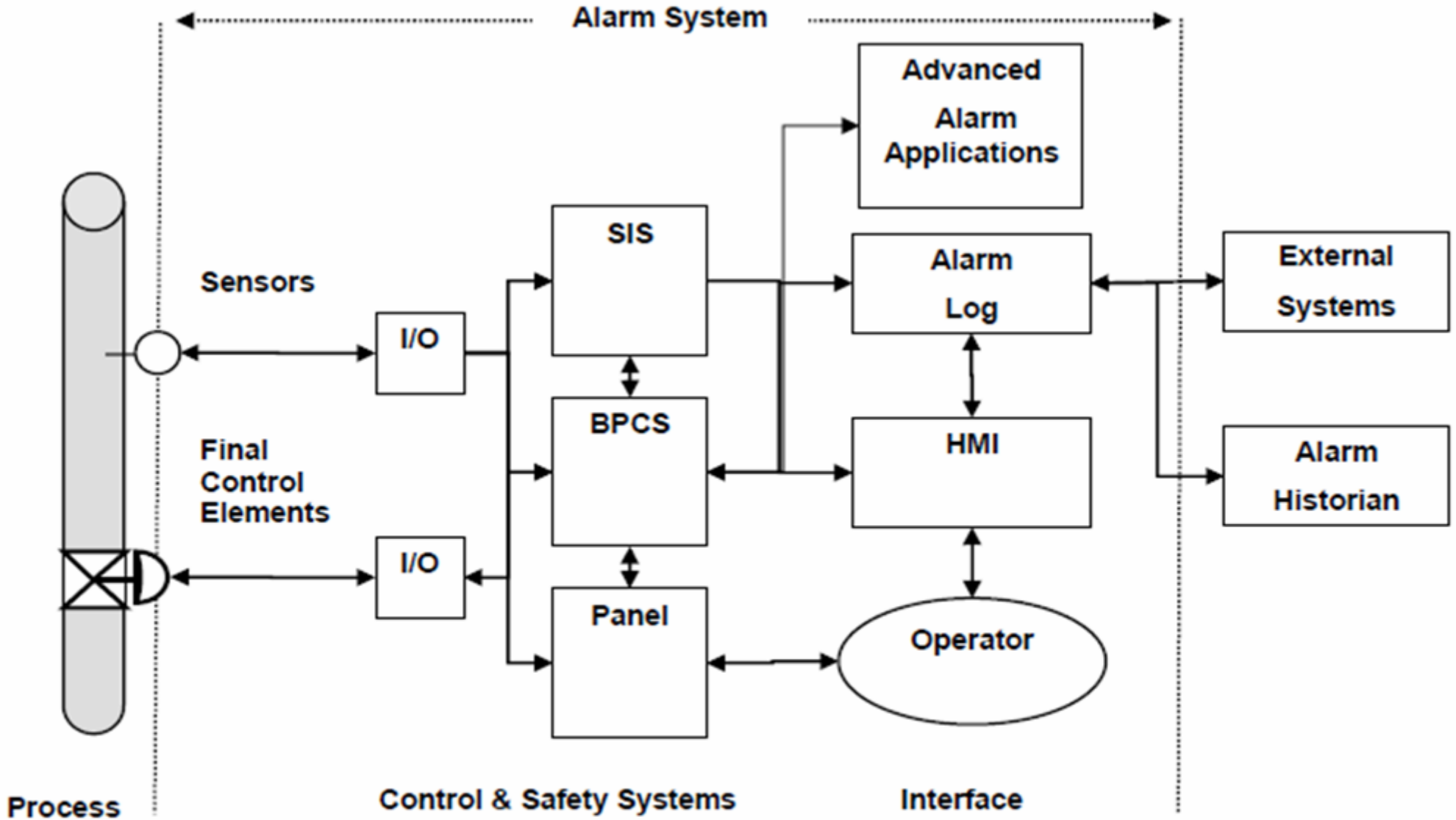
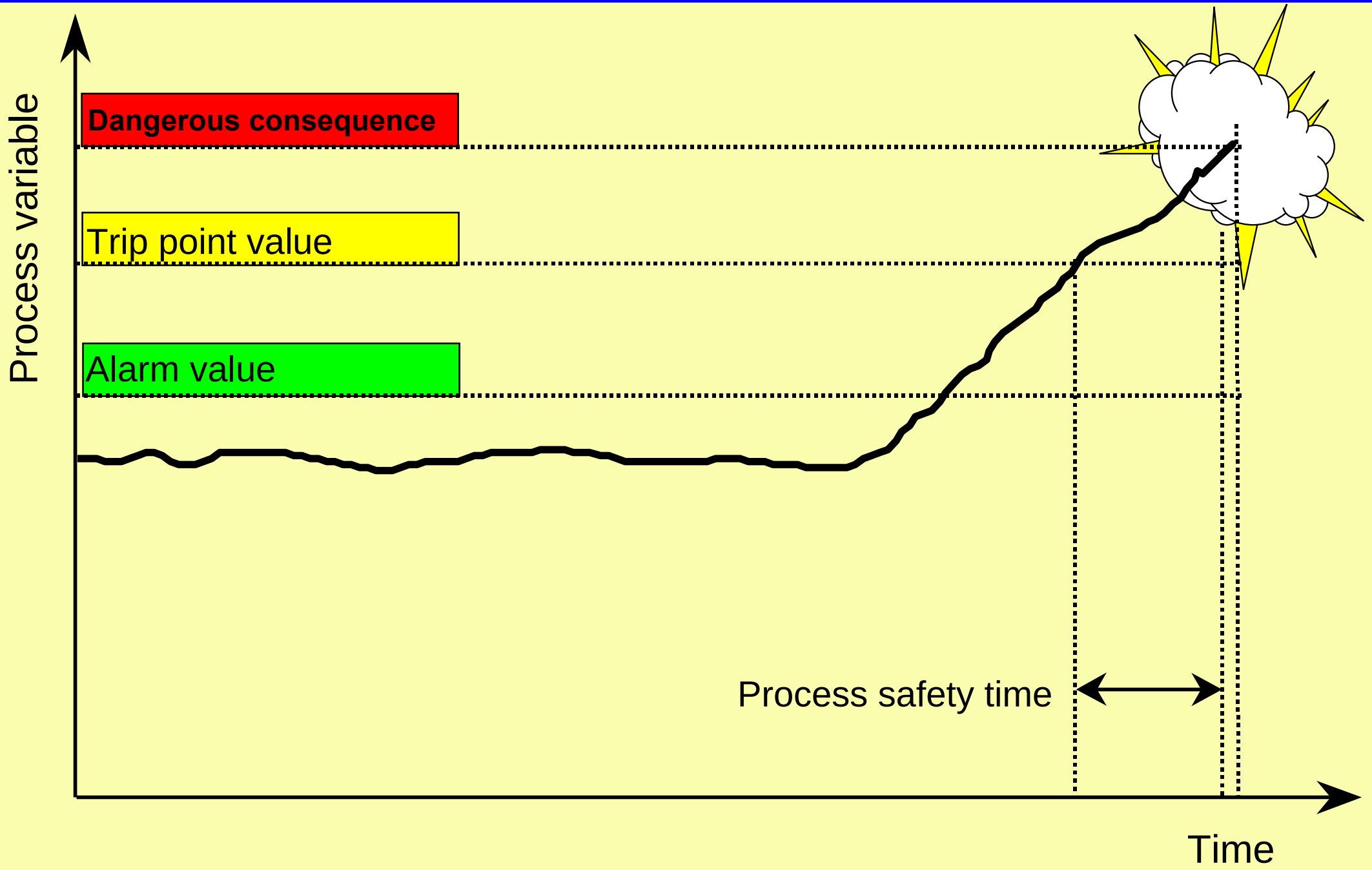


Figure 1 – Alarm System Dataflow

- **An audible and / or visible means of indicating to the operator an equipment malfunction, process deviation or abnormal condition**
  - *for which an operator action is required*
  - *in order to prevent or mitigate process upset or disturbances.*
- **Alarm: deviation from the design intent**
- **Criterions for an alarm:**
  - *Generating by abnormal situation*
  - *Requiring operator action, the more critical the more time needs*
  - *Best indicator of the situation's root cause.*



Process Safety Time

Critical alarms

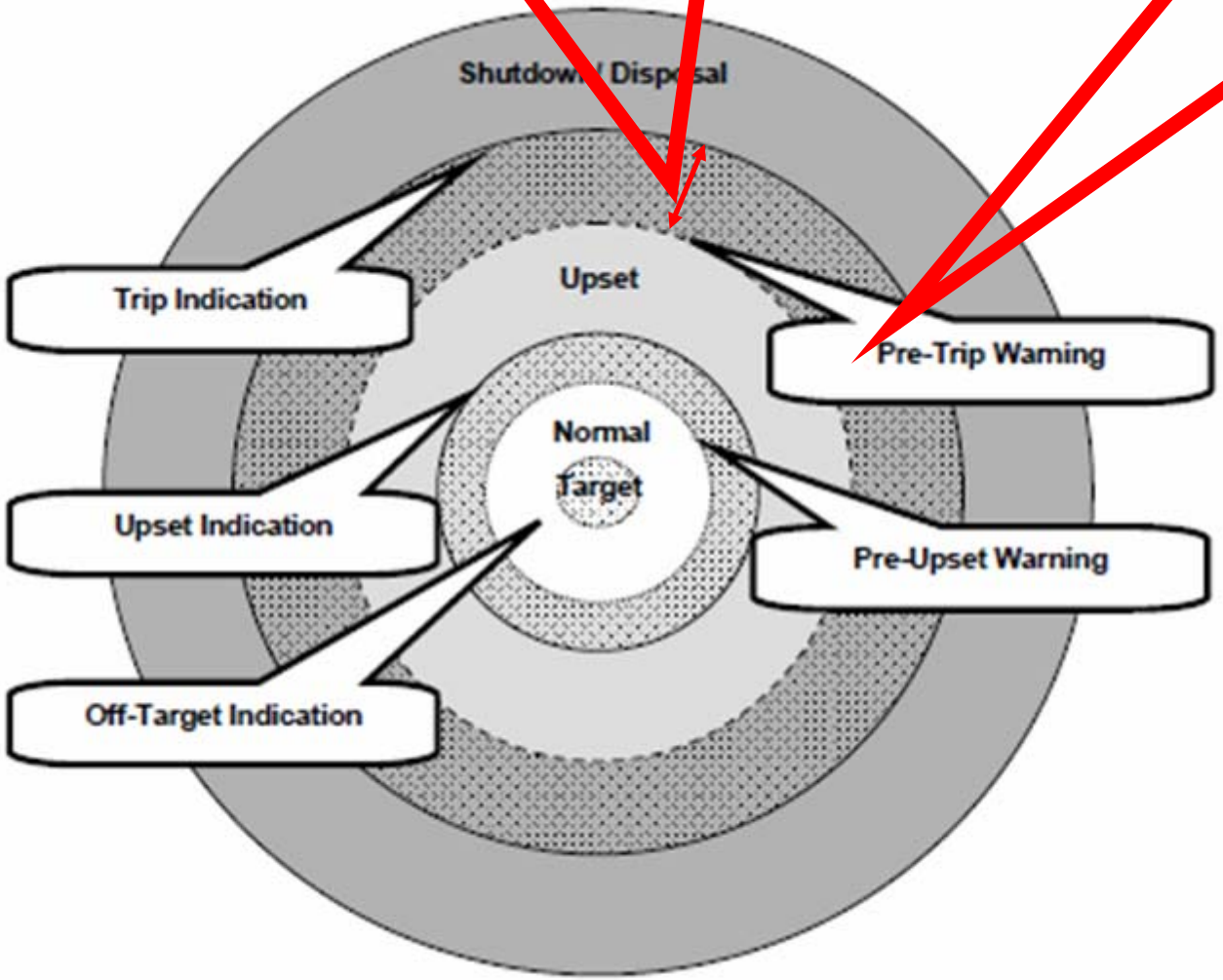
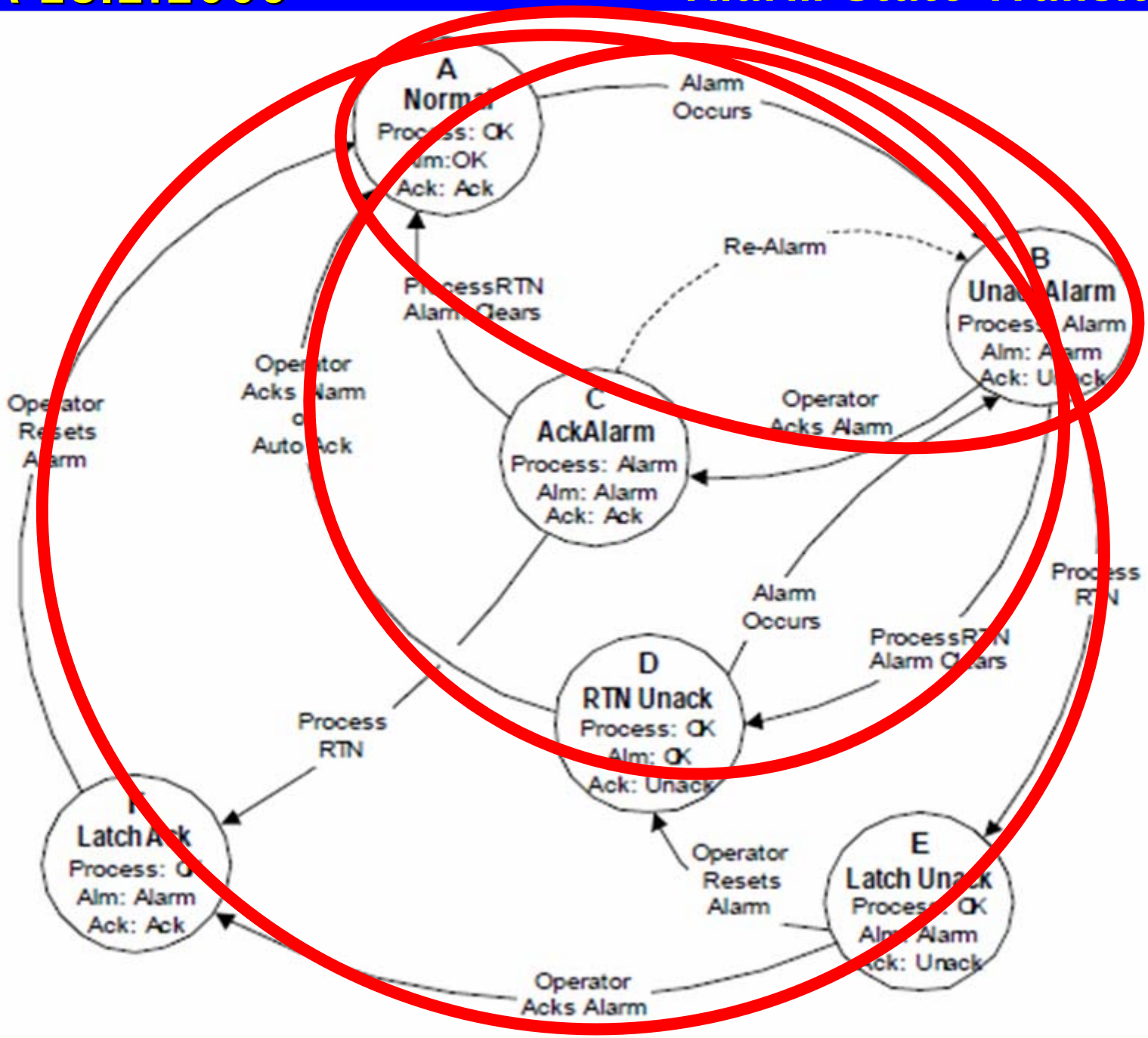


Figure 4 – Process Condition Model

Off target

- *Pre-upset*
- *Upset*
- *Pre-trip*
- *Trip*



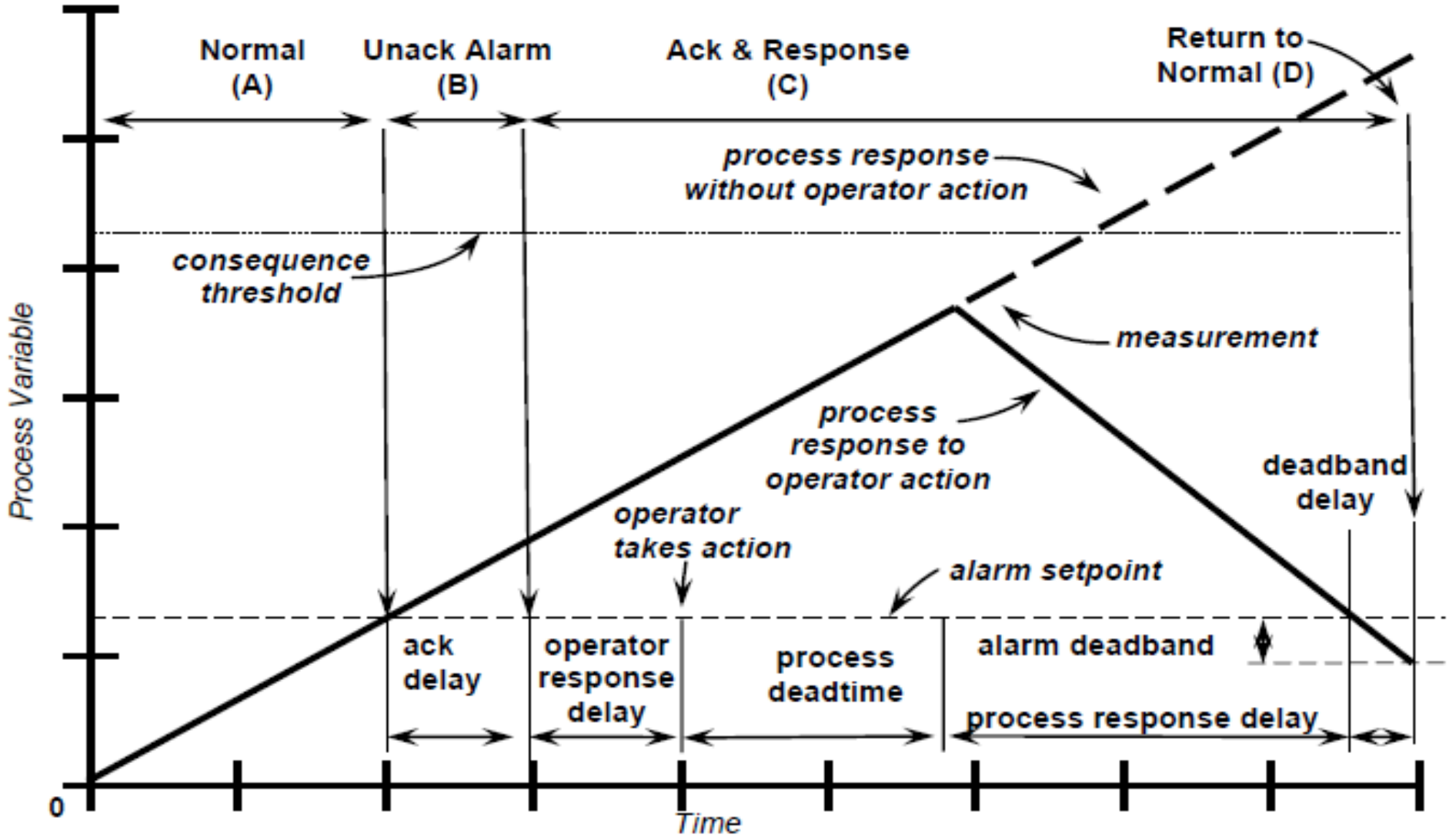
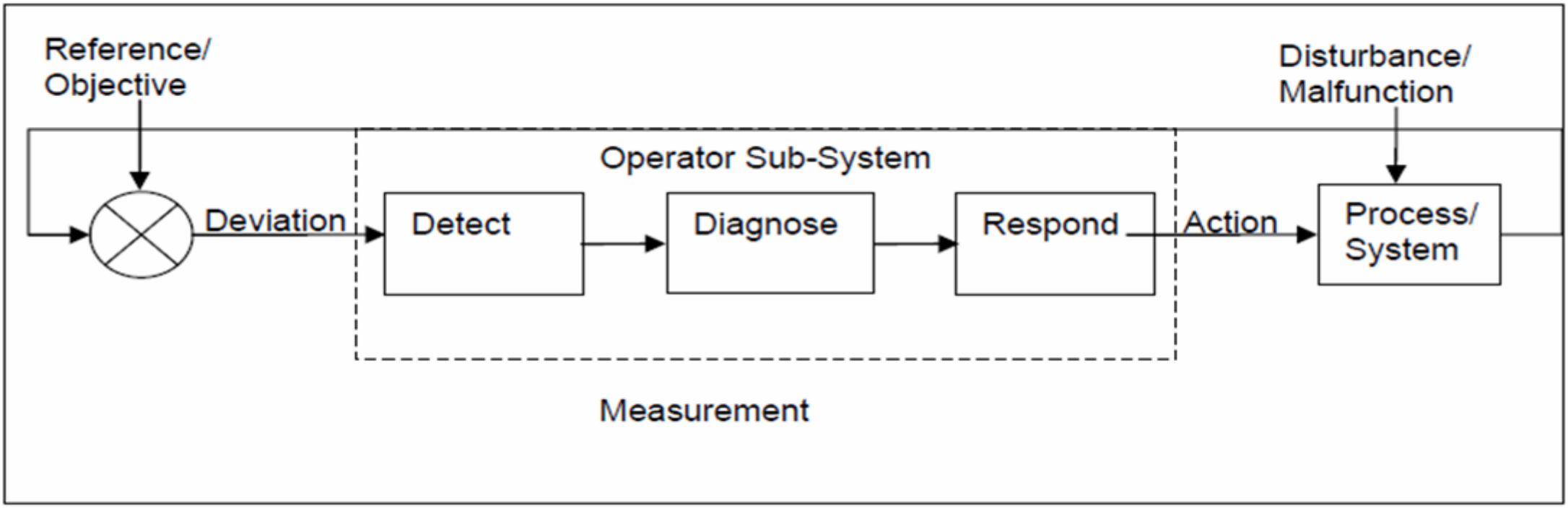
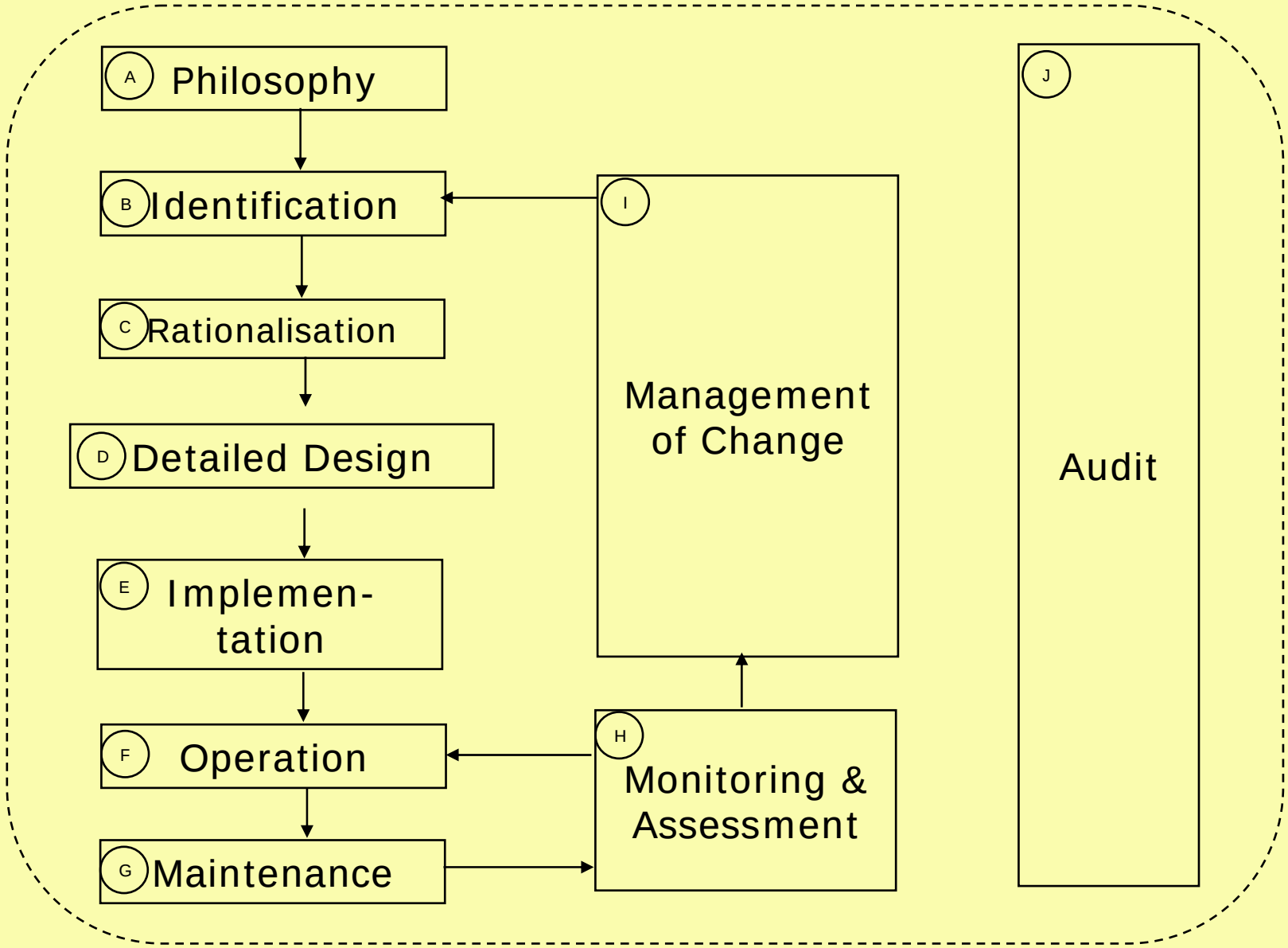
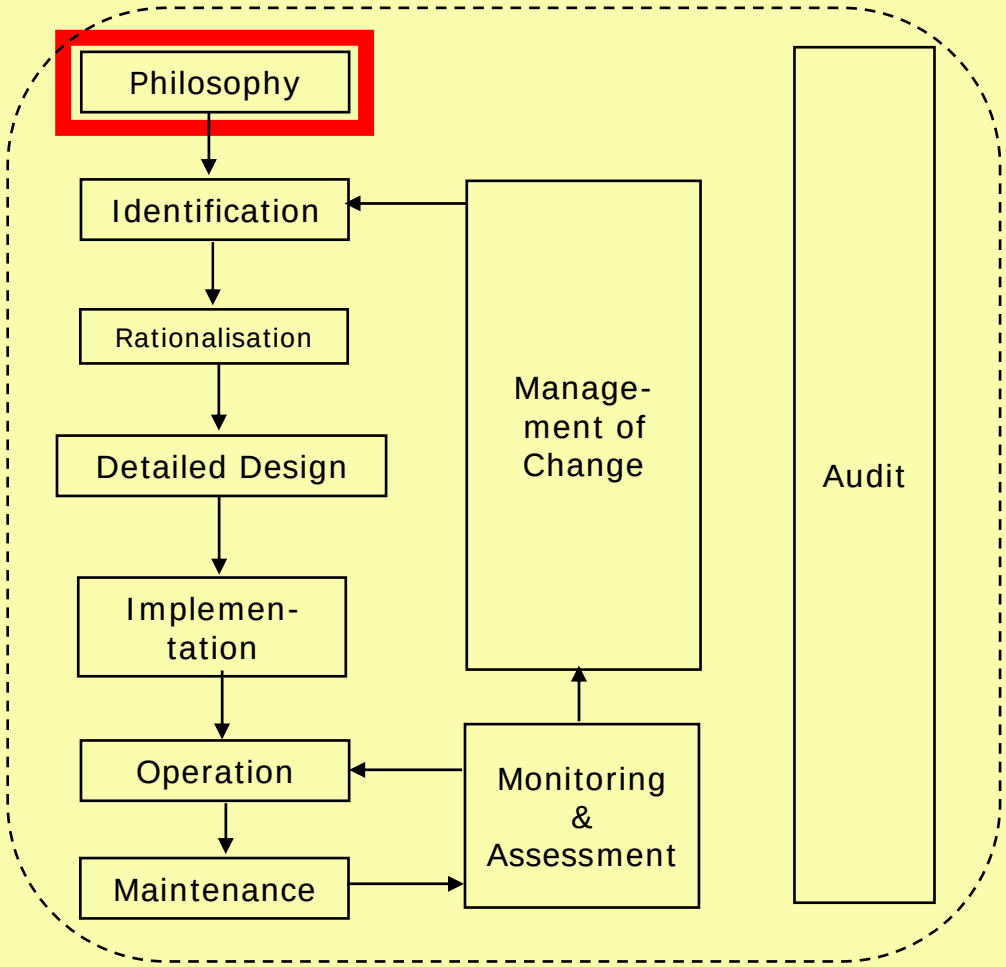


Figure 6 – Alarm Timeline





- **Framework to establish the criteria, definitions and principles.**
- **Contents – methods for**
  - *design.*
  - *operation.*
  - *maintenance.*
  - *monitoring and assessment.*
- **Basis for the Alarm System Requirements Specification (ASRS).**

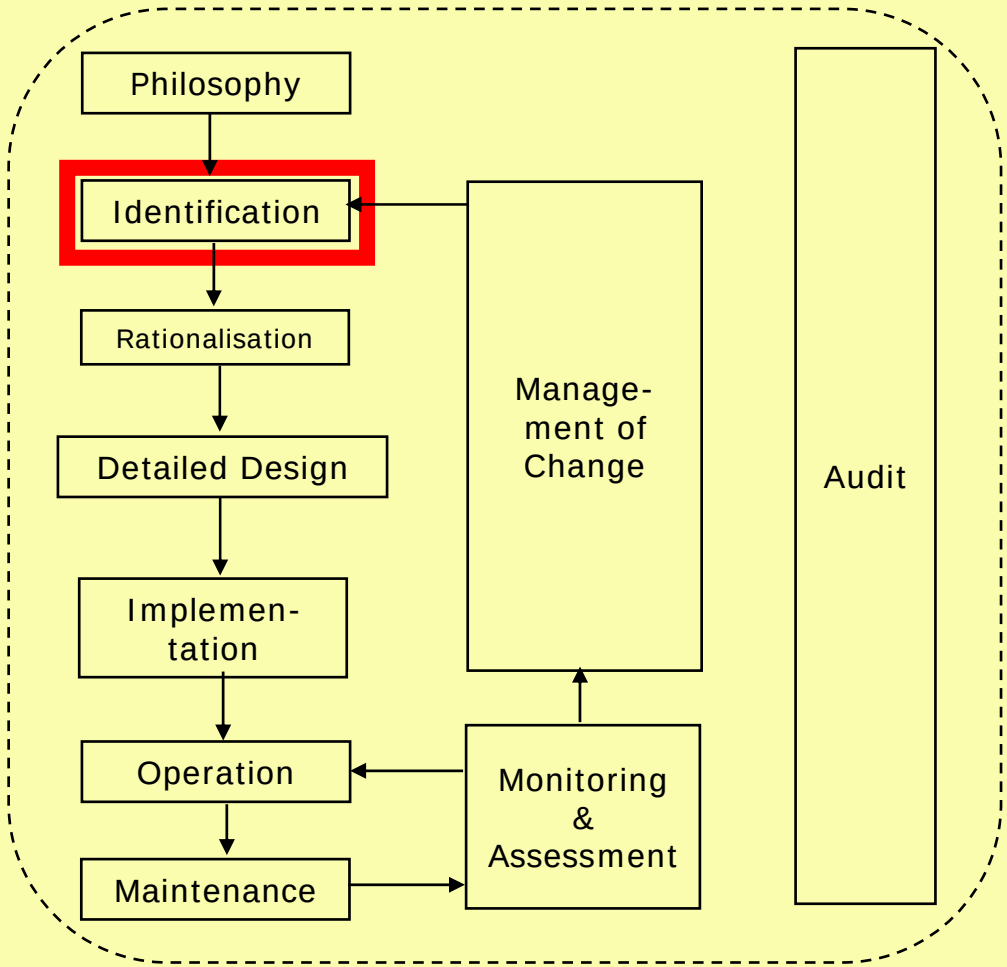


Contents	Required	Recommended
Purpose of alarm system	**Y**	
Definitions	**Y**	
References		**Y**
Roles and responsibilities people for alarm management	**Y**	
Alarm design principles	**Y**	
Rationalization	**Y**	
Alarm class definitions	**Y**	
Highly managed alarms		**Y**
HMI design guidance	**Y**	
Alarm setpoint determination		**Y**
Prioritization method	**Y**	

Contents	Required	Recommended
Alarm system performance monitoring	Y	
Alarm system maintenance	Y	
Testing of alarms	Y	
Approved advanced alarm management techniques		Y
Alarm documentation		Y
Implementation guidenance	Y	
Management of change	Y	
Training	Y	
Alarm history preservation	Y	
Related site procedures		Y
Special alarm design considerations		Y

Where do alarms come from?

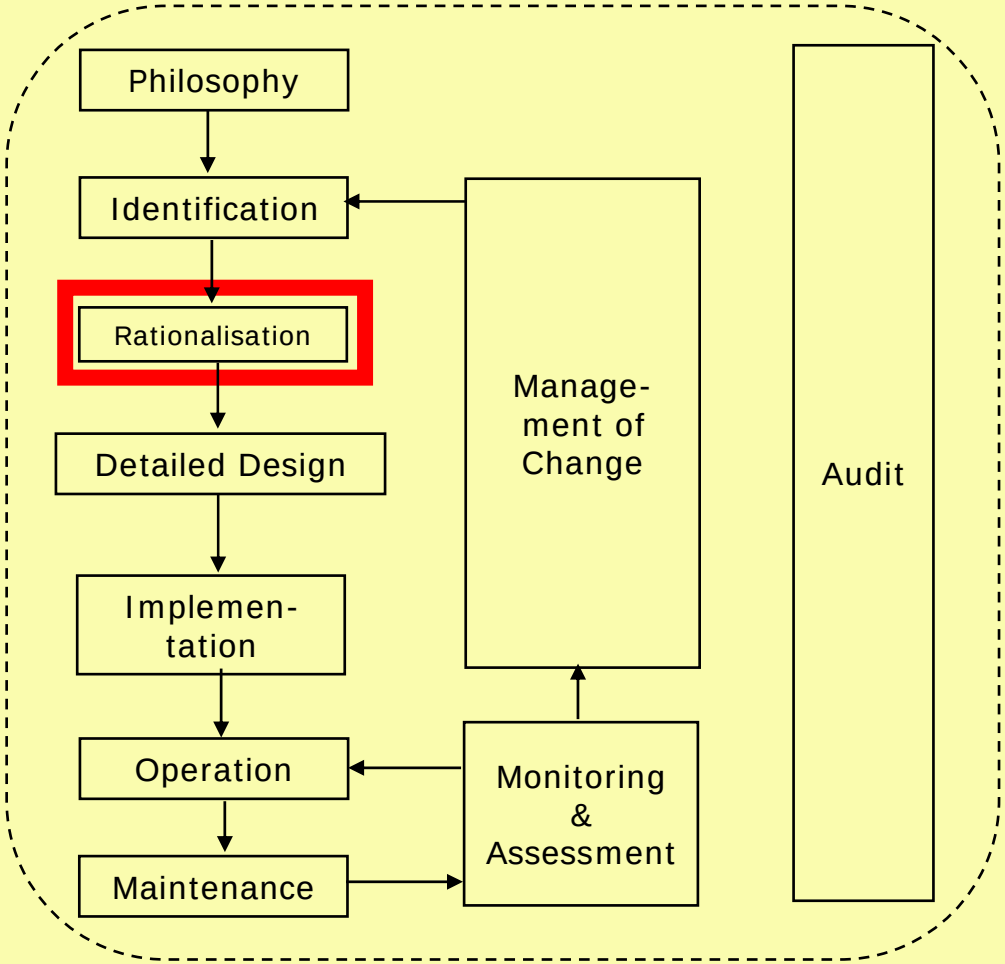
- **Input point of the alarm lifecycle**
- **Methods:**
  - *P&ID reviews*
  - *PHA – Process Hazard Analysis*
  - *LOPA – Layer Of Protection Analysis*
  - *FMEA – Failer Mode and Effects Analysis*
  - *Incident investigations*
  - *Allocation of safety layers*
  - *Environment permits*
  - *ISO quality reviews*
  - *Operating procedures reviews*
  - *Packaged equipment manufacturer recommendations*



- Relevant
- Unique
- Timely
- Prioritized
- Understandable
- Diagnostic
- Advisory
- Focusing

EEMUA: Engineering Equipment and Materials Users' Association

- **Comparison of existing or potential alarms to the criteria**
- **Goal – to determine the minimum number of alarms to drive process in safe manner**
- **For every alarm**
  - *Review / analyze / approve*
  - *Teamwork – conducted by alarm expert*
  - *Software aided*
- **Result - Master Alarm Database**



In parallel with HAZOP study using the HAZOP team?!

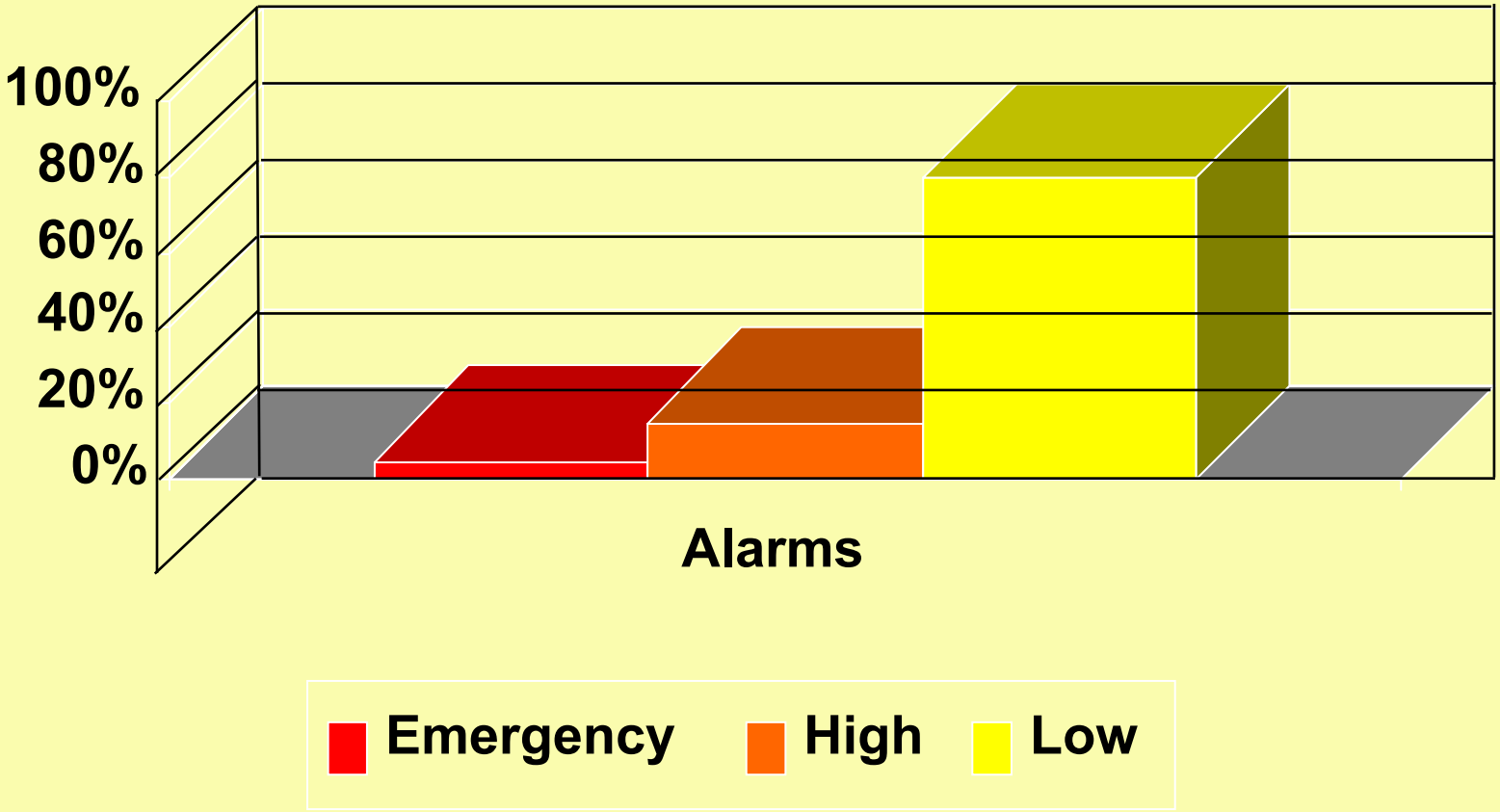
- **Determine and document at a minimum:**
  - *Alarm type (max, min, etc.)*
  - *Priority (critical, emergency, etc.)*
  - *Class (safety, environmental, etc.)*
  - *Setpoint value (trip point)*
  - *Operator action (what to do)*
  - *Consequence of inaction (or incorrect action)*
  - *Need for advanced alarm techniques (state based, etc)*

Impact category	None	MINOR	MAJOR	SEVERE
Personal Safety	No injury or health effect	Slight injury or health effect	Max. 1week disability Reversible health effect	Severe injures, Life threatening
Public or Environment	No effect	Local effect	Nonpermanent damage Single exceedance of statutory limits	Limited or extensive toxic release
Costs / Production loss / Downtime / Quality	No loss	< 10 000 $	10 e$ - 100 e$	> 100 000 $

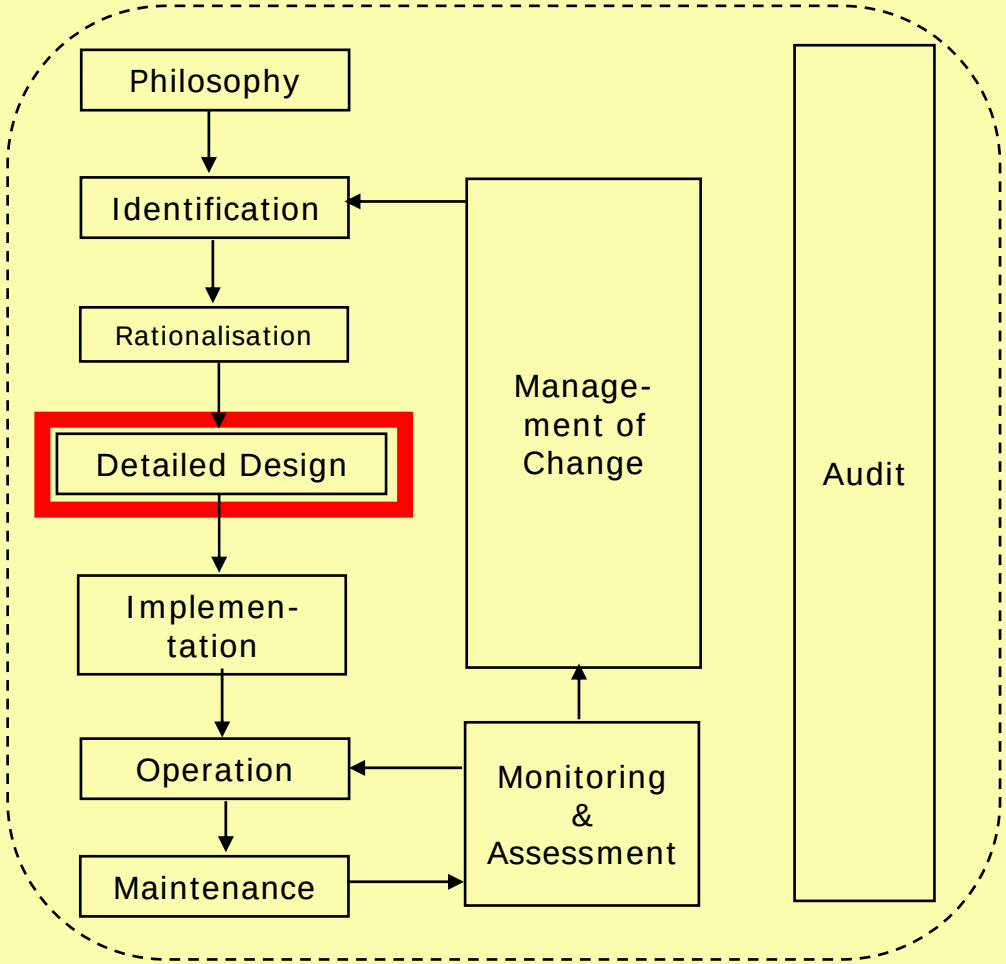
Description	Option 1	Option 2
No Alarm	> 30 minutes	> 30 minutes
Promptly	10… 30 minutes	15… 30 minutes
Rapidly	3… 10 minutes	5… 15 minutes
Immediately	< 3 minutes	< 3 minutes

Maximum Time to Respond	*MINOR consequence*	*MAJOR consequence*	*SEVERE consequence*
> 30 minutes	**No Alarm**	**No Alarm**	**No Alarm**
10... 30 minutes	**Low Priority**	**Low Priority**	**High Priority**
3... 10 minutes	**Low Priority**	**High Priority**	**High Priority**
< 3 minutes	**High Priority**	**Emergency**	**Emergency**

Priority distribution



- **Input – list of rationalized alarms**
- **Three topics:**
  - *Basic alarm design*
    - *Depend on selected PCS*
  - *HMI design*
    - *Graphic requirements*
    - *Priority indication*
  - *Advanced alarm techniques*
    - *State-based alarming*
    - *Dynamic alarming*



- **„Result" of bad configuration – numbers of nuisance alarms**
  - *„chattering" alarms – 3 times / min*
  - *Stale alarm – remains in alarm state for an extended period (e.g. 24 hours)*
  - *Duplicate alarms*
- **Small dead band –chattering and fleeting alarms**
- **Wide dead band –stale alarms**
- **Dead band and delay recommendations:**

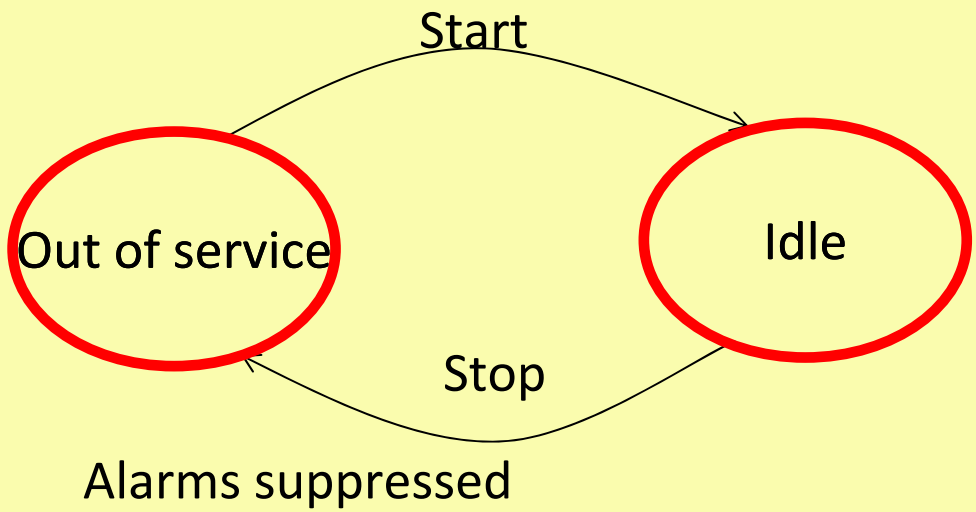
Signal Type	Dead Band, %	Delay Time, seconds
Flow rate	5	15
Level	5	60
Pressure	2	15
Temperature	1	60

- **Visualization:**
  - *Tag in alarm*
  - *Alarm state*
  - *Priority*
  - *Type*
- **Functionality**
  - *Silence (without acknowledgement)*
  - *Acknowledgement*
  - *Out of service*
  - *Modifying alarm attributes*
- **Recommendations**
  - *Shelving*
  - *Designed suppression*
  - *Display of messages*

Alarm state	Audible indication	Visual indication		
		Colour	Symbol	Blinking
Normal	No	No	No	No
Unacknowledged	Yes	Yes	Yes	Yes
Acknowledge	No	Yes	Yes	No
Return to normal station	No	Optional	Optional	Optional
Unacknowledged Latched alarm	Yes	Yes	Yes	Yes
Acknowledged Latched alarm	No	Yes	Yes	No
Shelved alarm	No	Optional	Optional	No
Design suppressed alarm	No	Optional	Optional	No
Out of service alarm	No	Optional	Optional	No

- **If the Basic Alarm Design does not achieve the performance goals.**
- **Costs should be compared to additional benefits**
- **Categories:**
  - *Category 1: Information Linking*
- **Alarm groups**
  - *Category 2: Logic-based Alarming*
    - *First out*
    - *State based*
    - *Dynamic Alarming*
  - *Category 3: Model-based Alarming*
    - *Predictive alarms*
  - *Category 4: Additional Alarming Considerations*
    - *Remote alarm display*
    - *Pager, e-mail,*
    - *Batch – Continuously Variable Alarm Thresholds, Relative Time versus Absolute Time, Iinclusion of Lot Number and other Identifying Marks*
- **Training, testing and auditing**
- **Alarm Attribute Enforcement – scheduled or on request.**

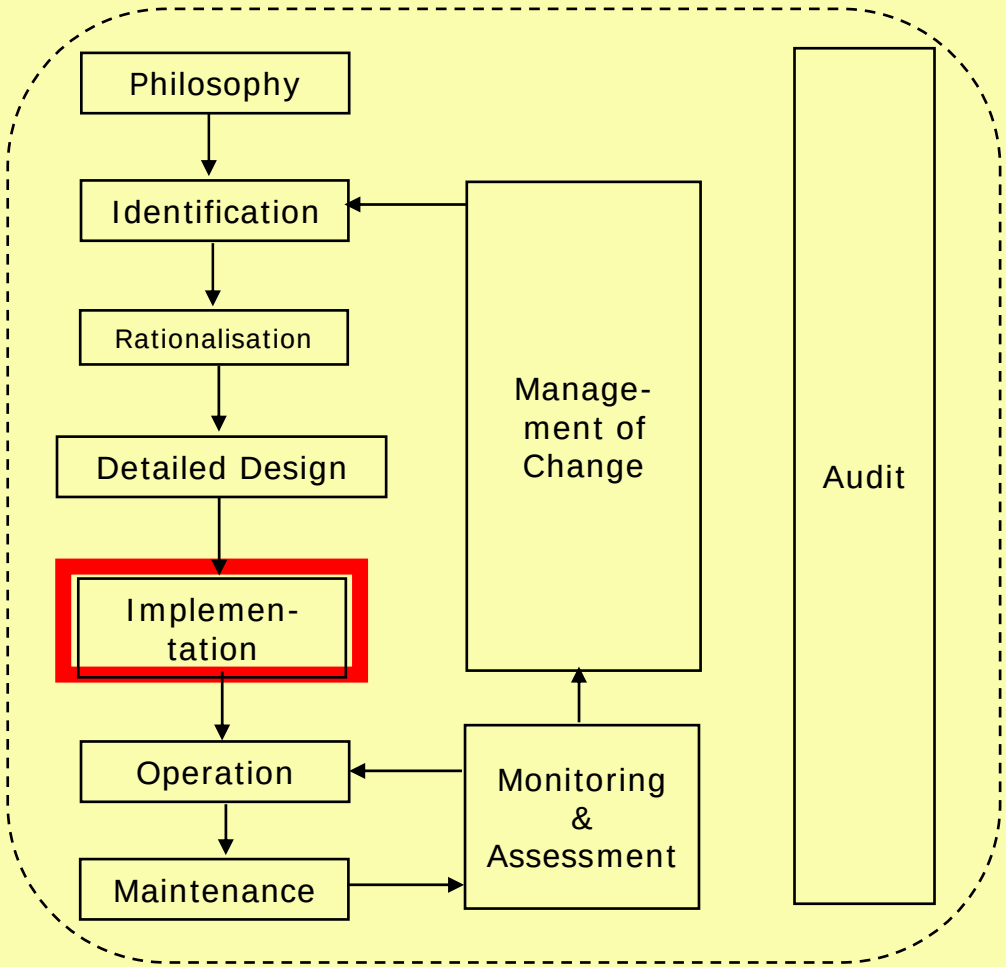
- **Dynamic Alarming**
  - *Modifying of alarm attributes depending on state or condition*
- **First out alarm**
  - *An alarm determined to be the first in a multiple alarm scenario*
- **State-based Alarm**



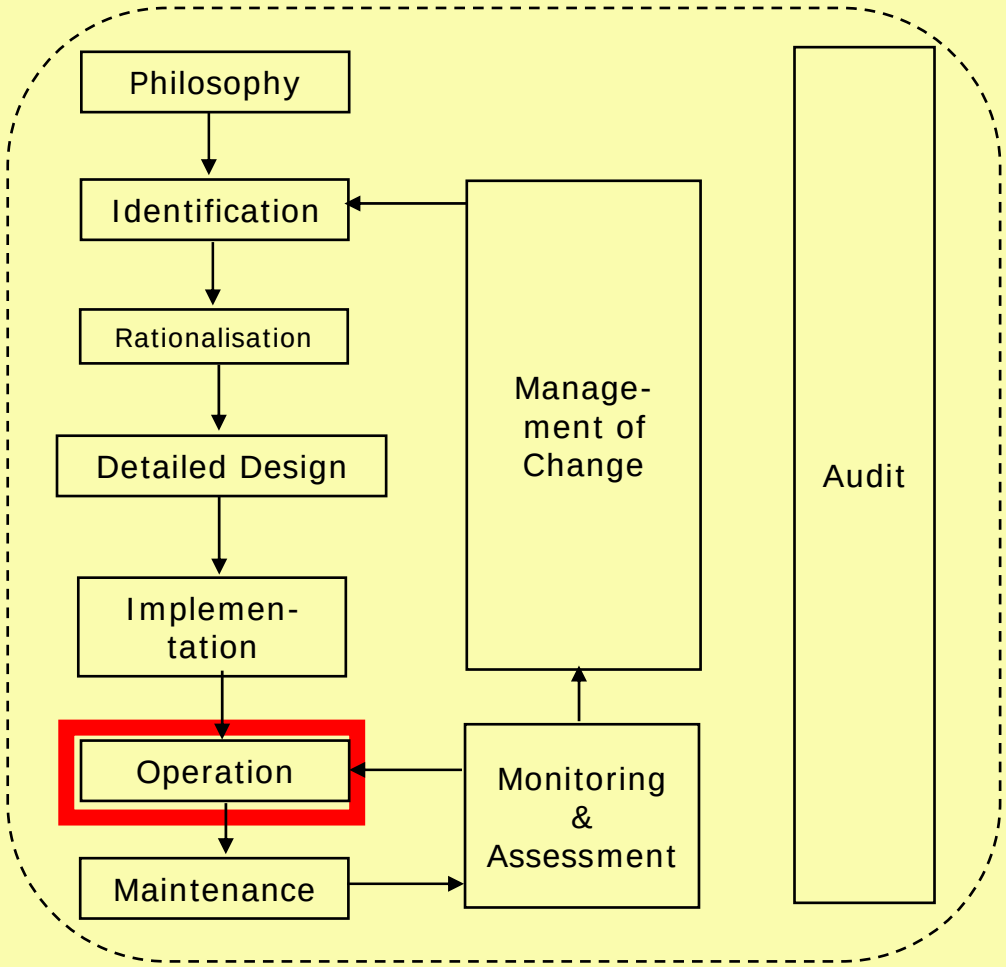
- **Alarm flood**

- **Alarm rate is greater the an operator can effectively manage (> alarms / 10 min)**
- **Complicate process situation becomes more complicate**
- **Solution similar to state- based alarming**
  - *List of suppressed alarms has to be determined,*
  - *Alarm flood situation has to be detected,*
  - *Alarms have to be suppressed*

- **Put into operation**
- **Important:**
  - *Testing*
  - *Training*
    - *After putting into operation*
    - *Yearly*
    - *For new operators*
    - *Using of OTS*

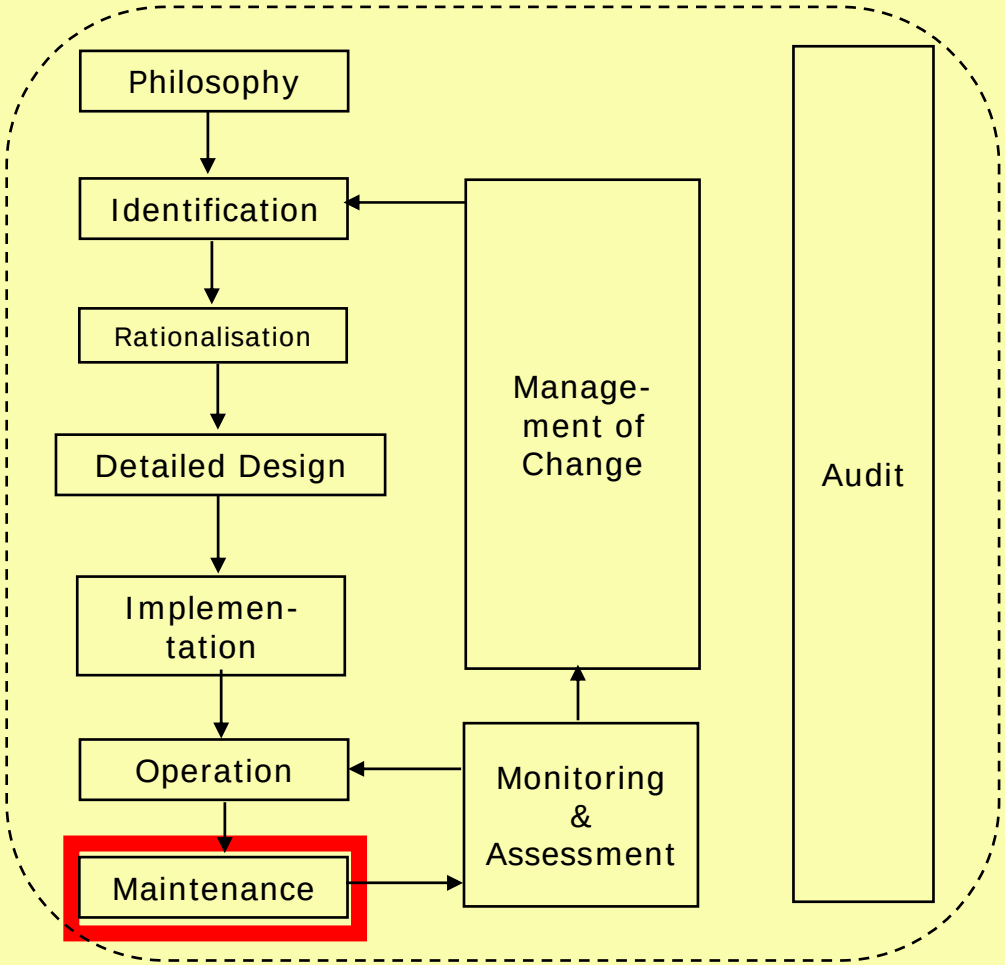


- **Alarm response procedures**
  - *Alarm type, setpoint, potential causes, corrective actions, all owable response time, alarm class*
- **Shelving**
  - *Review at the beginning of each shift,*
  - *Highly managed alarms shelved only after authorization (alarm philosophy),*
  - *Recorded (name, reason)*
- **Refresher training**

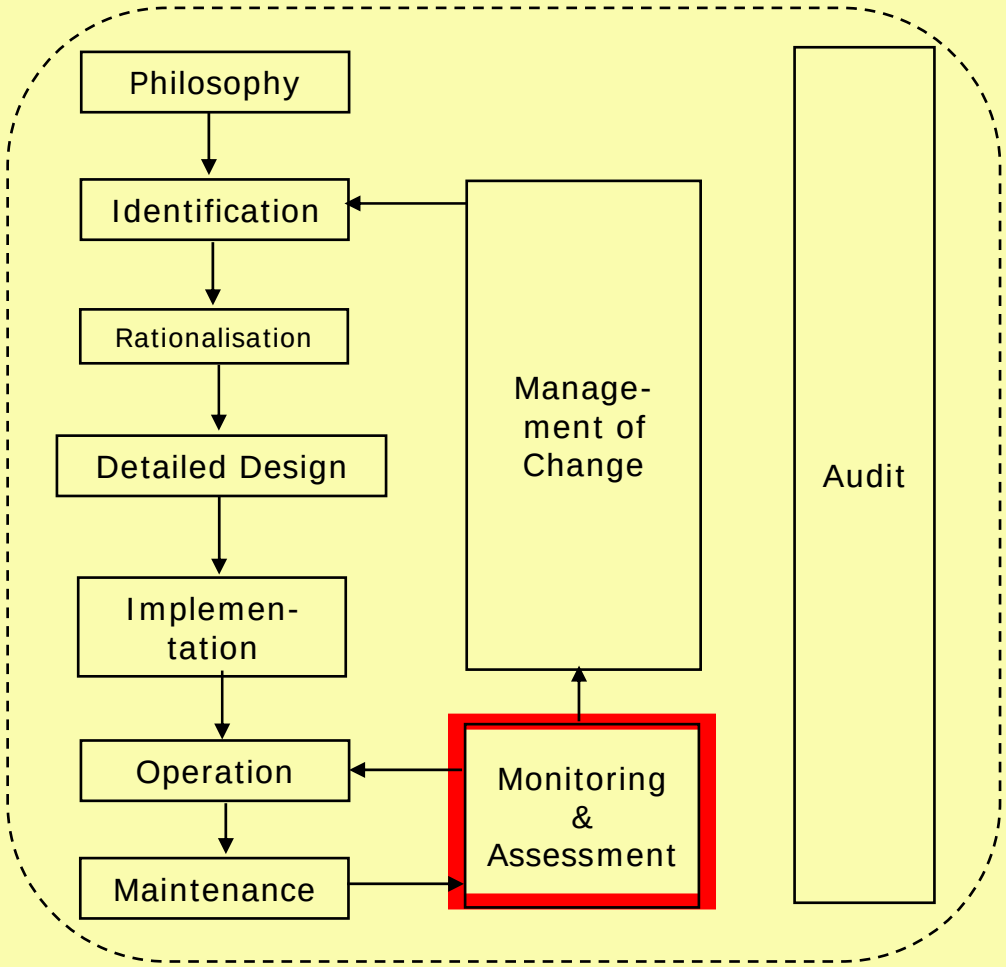


Suppression method	Definition	Relevant Phase
Shelving	A mechanism, typical initiated by operation, to temporary suppress an alarm	Operations
Suppressed by Design	Any mechanism within the alarm system that prevent the transmission of the alarm indication to the operator based on plant state or other condition	Advance Alarm Design
Out of Service	The state of the alarm during which the alarm indication is suppressed, typically manually, for reason such as maintenance	Maintenance

- Periodic testing
- Out of service
- Equipment repair
- Equipment replacement
- Returning alarms to service

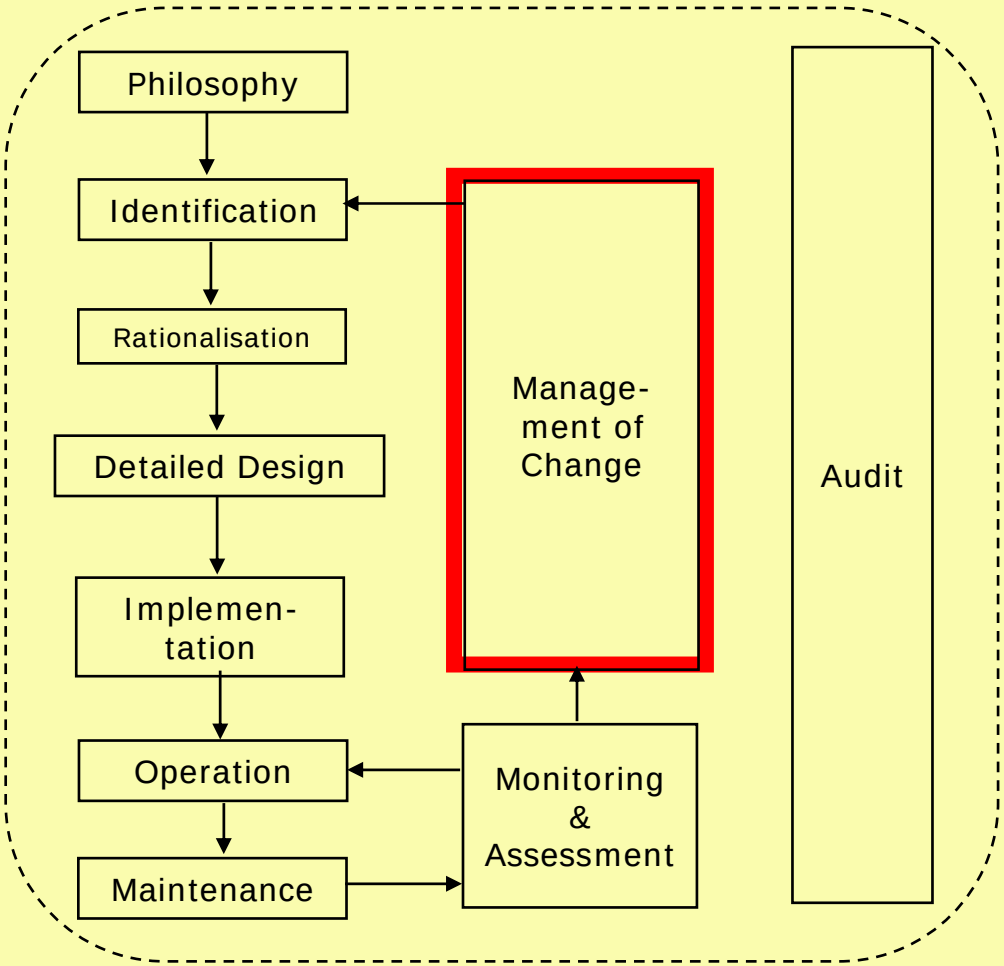


- Measurement of alarm system characteristics
- KPI-s
- Lack of this phase alarm system management collapses

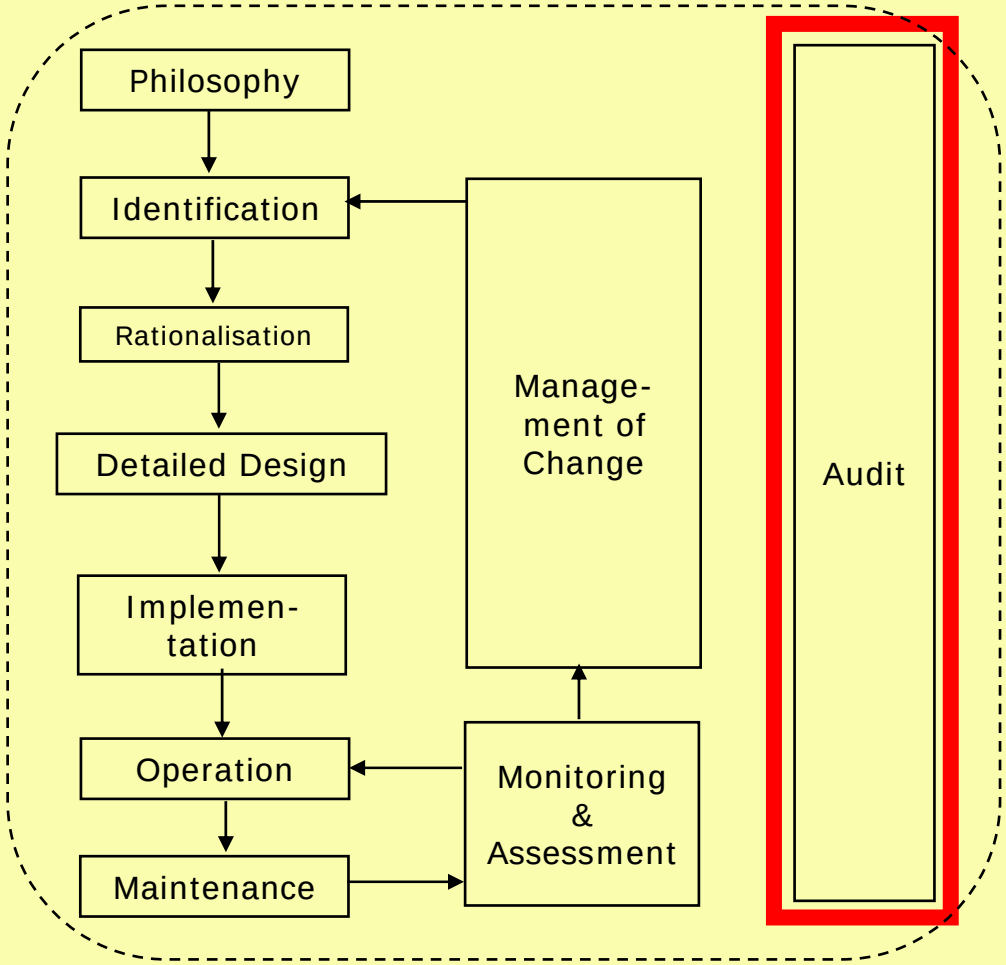


Key Performance Indicators (KPI)	Max manageable	Acceptable
Annunciated alarms per day	**< 300**	**< 150**
Annunciated alarms per hour	**~ 12**	**~ 6**
Annunciated alarms per 10 min	**~ 2**	**~ 1**
Contribution of Top 10 alarms to the overall alarm load	**< 1…5 %**	
Chattering and fleeting alarms	**0 / nap**	
Stale alarms	**≤ 5 / nap**	
Annunciated alarm distribution (%) **L-H-HH,LL**	**80-15-5**	
Alarm flood (>20 alarm / 10 min)	**< 1 %**	

- To ensure that changes are authorized and evaluated
- Master Alarm Database has to be up to date
- Good practice – compare Master Alarm Database to real database of PCS



- **To maintain the integrity of the alarm system and alarm management processes**
- **Reveal gaps not apparent from monitoring**
- **Comparing**
  - *practices vs procedures,*
  - *Procedures vs policy (alarm philosophy)*
- **Modifications to the alarm philosophy**



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