Process Optimization using Smart Automation

Presented By: Shuchi Tripathi

Manager-Inst

HURL

ISA-D: “Fertiliser , Food and Pharma Symposium-2019”

Instrumentation

- Instrumentation is a tool for efficient plant operation in any process industry. Efficiency means increased productivity, cost reductions and increased profitability of operations.

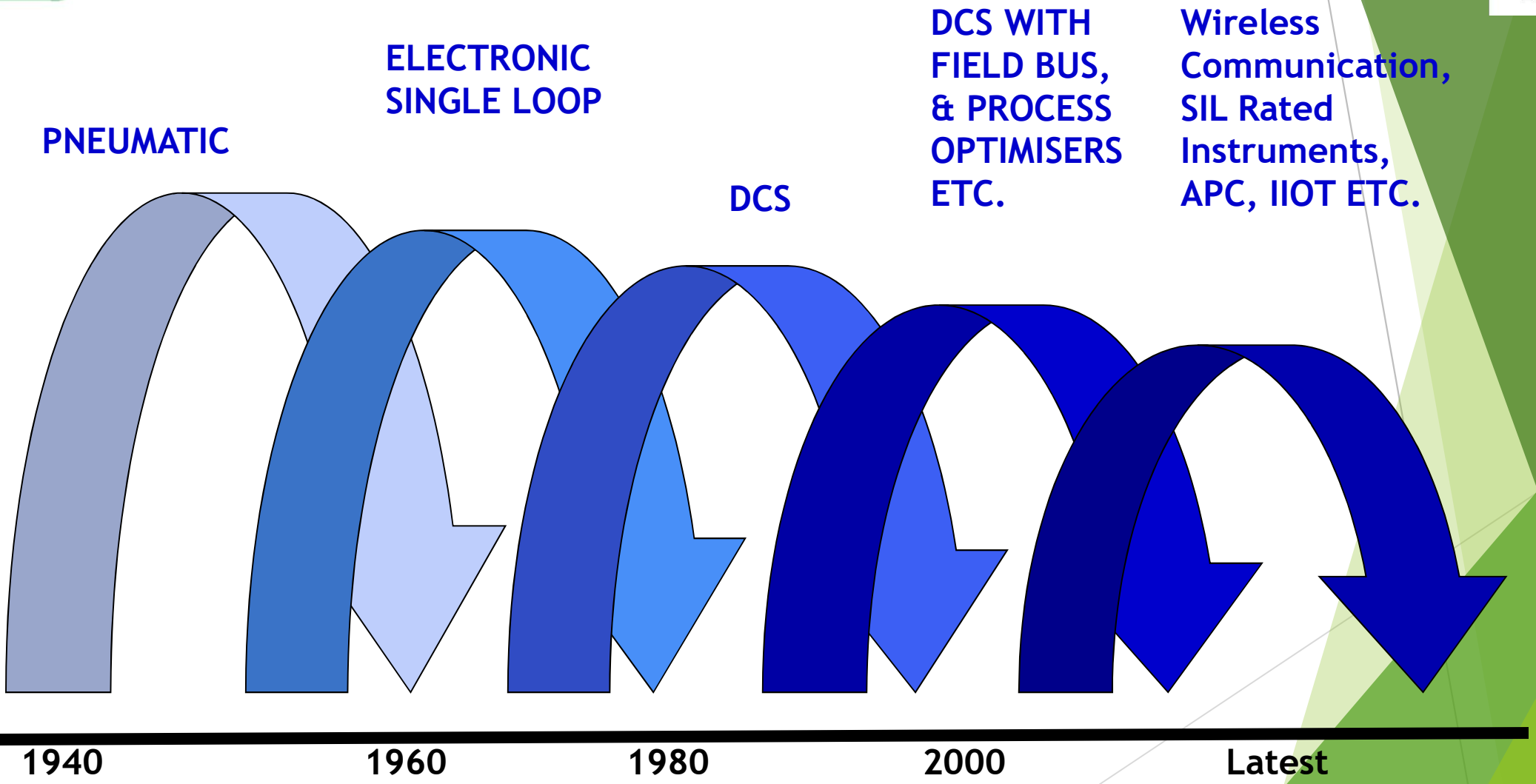
- Today we are living in the era of Information. Information is required in time for making right decisions at right time.

- Today's Instrumentation has evolved as a combination of Instrument and Information Technology to integrate seamlessly both worlds of Industrial Process Control and Business Process.

Components of Instrumentation & Automation

- Measurement
- Control
- Transmission/Communication

Evolution of Instrumentation Technologies



Smart Instrumentation Benefits:

- Transmitter Rangeability increased many fold
- Transmitter accuracy increased
- Calibration stability improved
- Controllers became configurable
- Peer to Peer communication became a reality
- Advent of multi loop controllers
- Advent of DCS and PLC systems
- Hart Communication

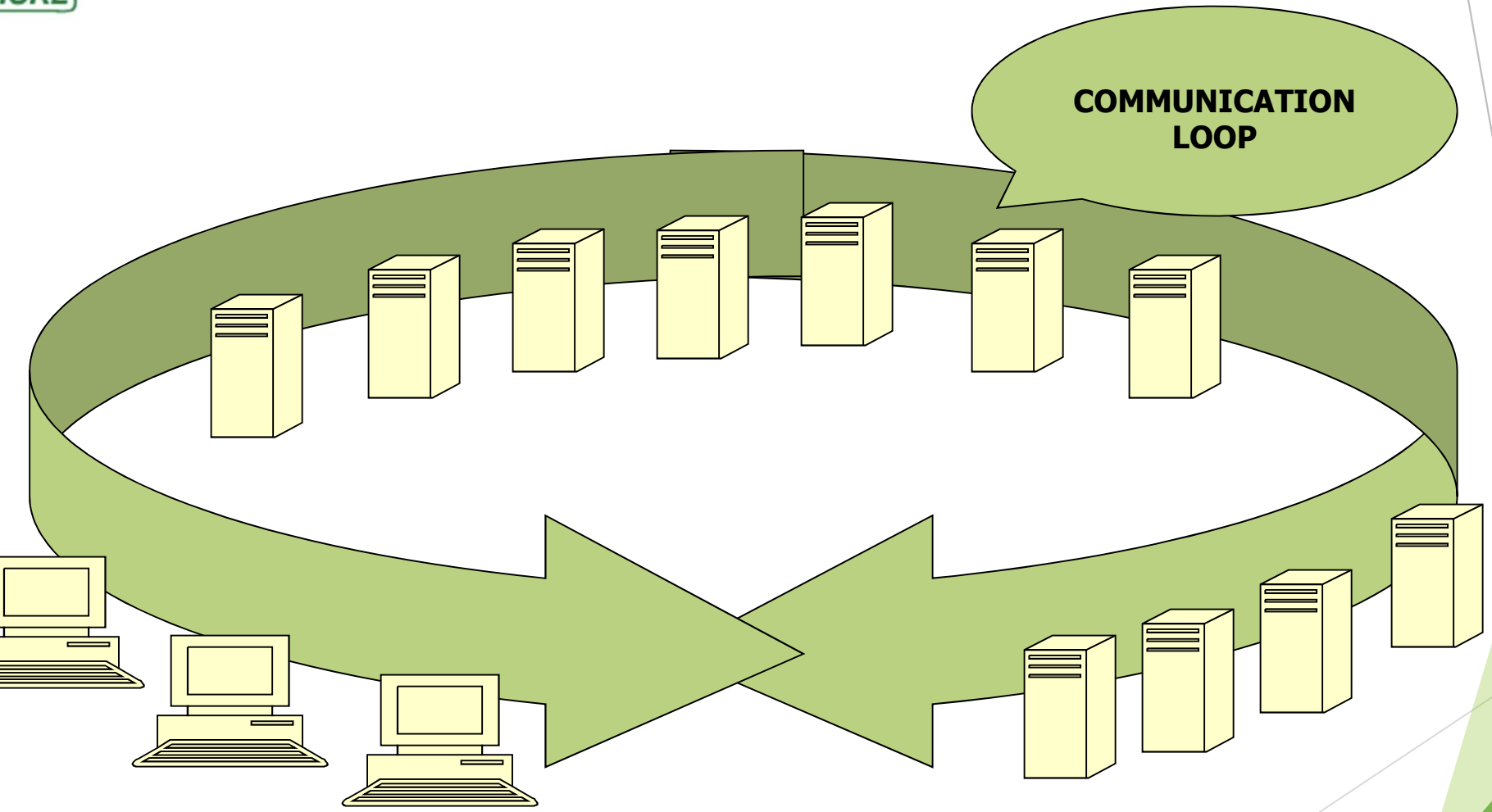
HART Benefits

- **HART is Safe, Secure, and Available**
  - Tested and Accepted global standard
  - Supported by all major instrumentation manufacturers
- **Saves Time and Money**
  - Install and commission devices in fraction of the time
  - Enhanced communications and diagnostics reduce maintenance & downtime
  - Low or no additional cost by many suppliers

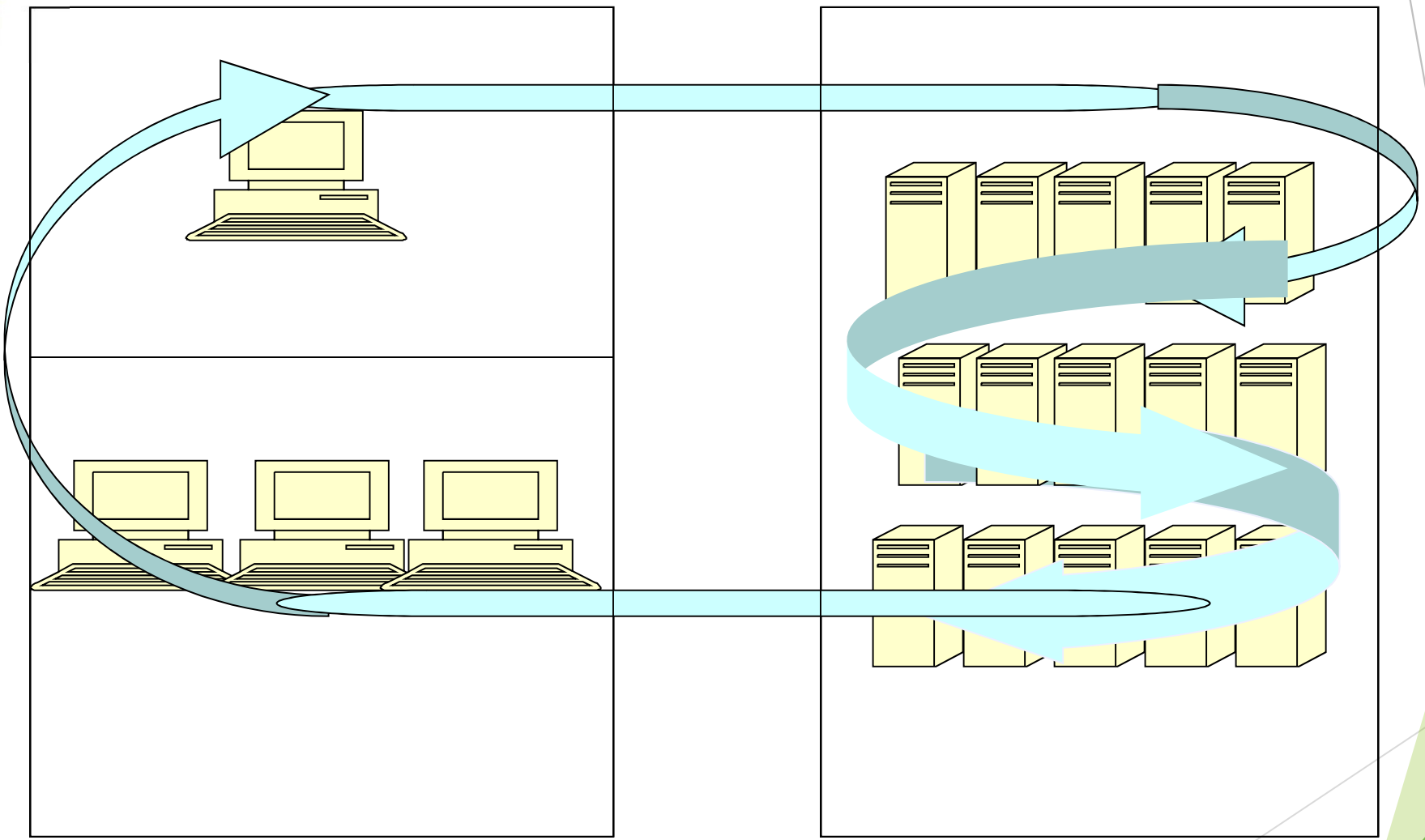
HART Benefits

- **Improves Plant Operation and Product Quality**
  - Additional process variables and performance indicators
  - Continuous device status for early detection of warnings and errors
  - Digital capability ensures easy integration with plant networks
- **Protects Your Asset Investments**
  - Compatible with existing instrumentation systems, equipment and people
  - Allows benefits to be achieved incrementally
  - No need to replace entire system

DCS Architecture



Placement of Equipments



Benefits of DCS

- **Process Optimization**

  DCS is the appropriate platform for APC

- **Improved Operator Performance**

  All information of plant is a ‘click’ away; more loops per operator can be handled

- **Better reliability** owing to redundancy

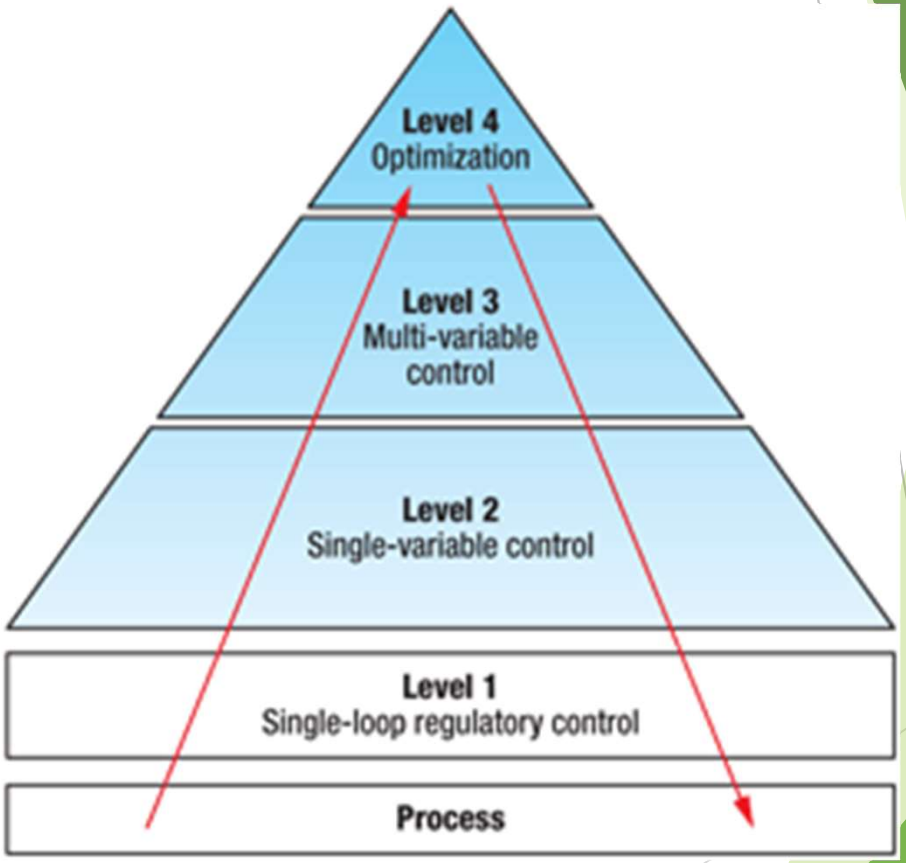
- **Ease of Maintenance** due to Self-Diagnostics & features like On-Line Calibration of field devices from Control Room

Introduction to APC
Advanced Process Control

Advanced Process Control is one of the most important ways in which the production situation can be improved resulting to optimized production & increased throughput.

A model-based control offers a very direct and feasible solution for an appropriate operation.

APC is often used for solving multivariable control problems o discrete control proble



Advanced Process Control (APC)

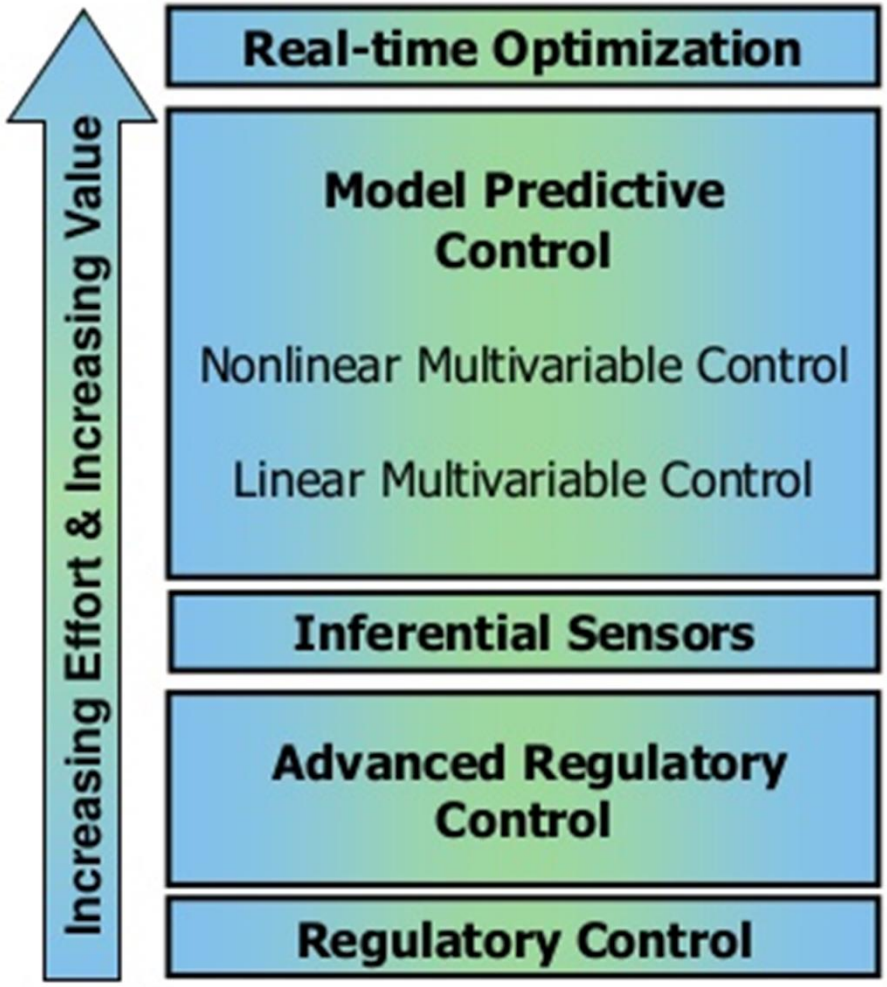
Advance Process Control system consist of three components :

- a computer-simulation model that integrates process knowledge and historical data,
- control and optimization algorithms, and
- current, real-time process information.

APC relates manipulated variables and control variables, provides multivariate control, and also provides adaptive tuning and predictive/process diagnostics.

Advanced Process Control (APC)

- Scalable to meet a wide range of advanced process control requirements
- Improve yield, increase throughput, reduce costs, and improve quality



- Economic optimization
- Maximize throughput
- Increase yield
- Reduce variability
- Improve product transition
- Virtual lab readings
- Gain scheduling
- Rule-based control
- Loops with long lag times
- Basic loop PID control

Model Predictive Control

- Model Predictive Control (MPC) is a popular technology, usually deployed on a supervisory control computer, that identifies important independent and dependent process variables and the dynamic relationships (models) between them, and uses matrix-math based control and optimization algorithms, to control multiple variables simultaneously.

- MPC has been a prominent part of APC ever since supervisory computers first brought the necessary computational capabilities to control systems in the 1980s.

Principles of MPC

Model Predictive Control (MPC) is a multivariable control algorithm that uses the following to calculate the optimum control moves :

- an internal dynamic model of the process
- a history of past control moves and
- an optimization cost function J over the receding prediction horizon,

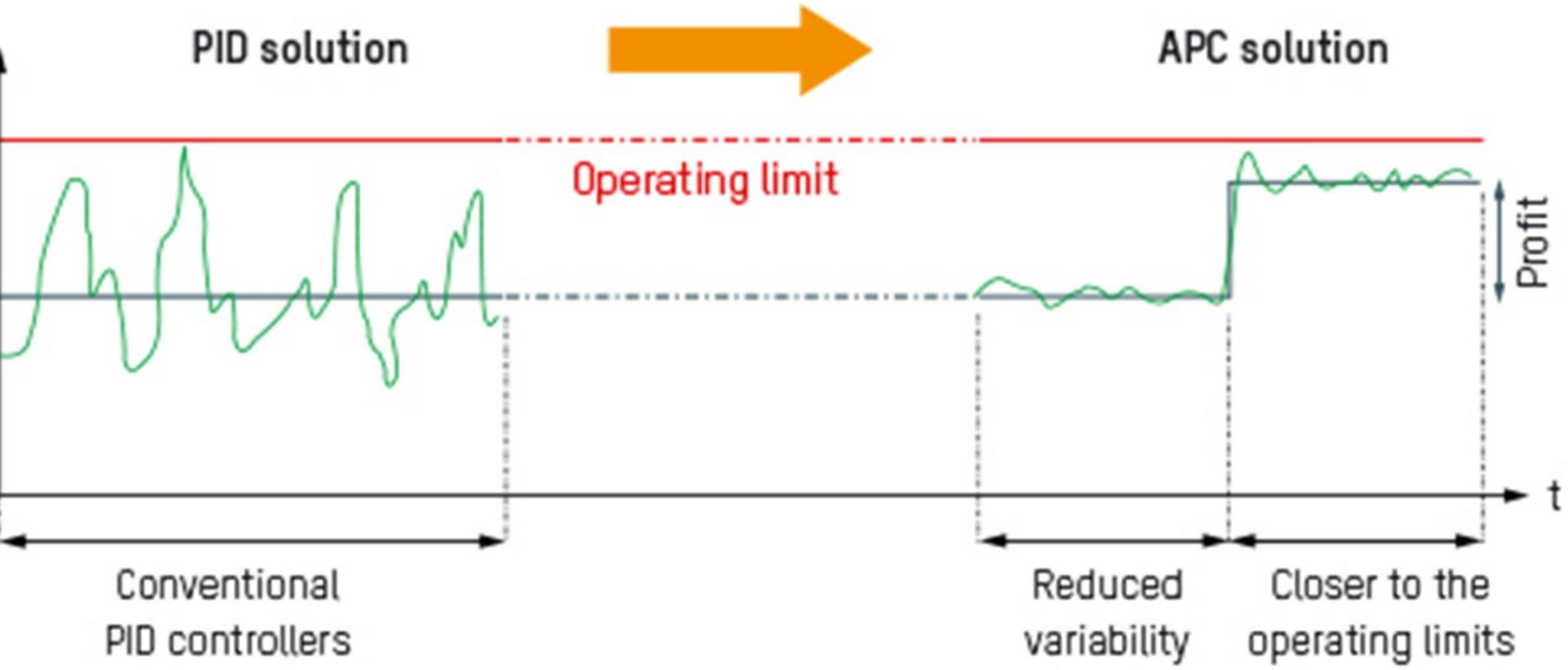
An example of a non-linear cost function for optimization is given by:

$$J = \sum_{i=1}^{N} w_{x_i}(r_i - x_i)^2 + \sum_{i=1}^{N} w_{u_i}\Delta u_i^2$$

without violating constraints (low/high limits) With:

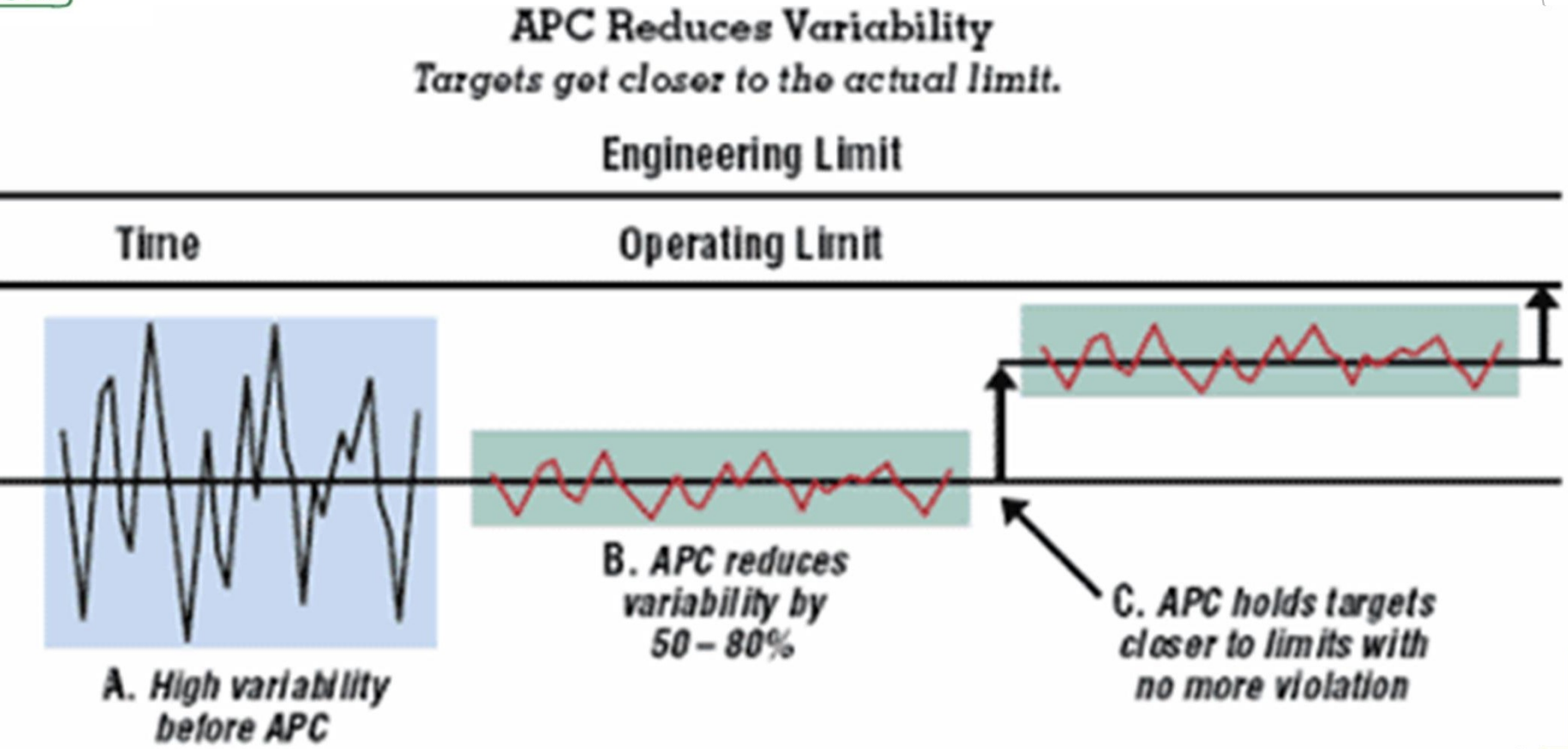
$$J = \sum_{i=1}^{N} w_{x_i}(r_i - x_i)^2 + \sum_{i=1}^{N} w_{u_i}\Delta u_i{}^2$$

- **Xi** : *i* -th controlled variable i.e. PV (e.g. measured temperature)
- **ri** : *i* -th reference variable i.e. SP (e.g. required temperature)
- **ui** : *i* -th manipulated variable i.e. OP (e.g. control valve)
- **Wxi** : weighting coefficient reflecting the relative importance of **Xi**
- **Wui** : weighting coefficient penalizing relative big changes in **ui**


PID solution
APC solution
Operating limit
Profit
t
Conventional
PID controllers
Reduced
variability
Closer to the
operating limits

APC v/s Classical Control

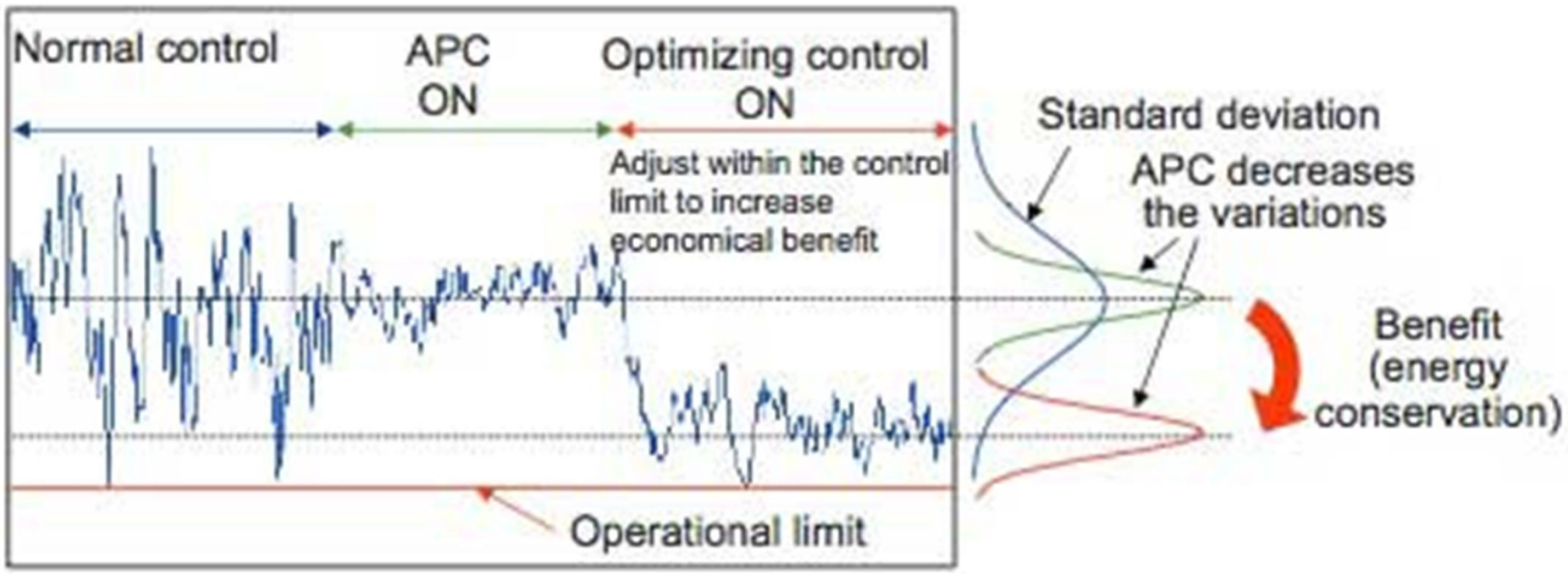
- APC is an intelligent and active software layer that sits above the classical regulatory control layer or the DCS in a traditional automation hierarchy.
- APC is designed to reduce changeability of key variables and continuously adjust the process to guarantee the desired end result.
- APC software solutions are developed by building a mathematical model of the process.
- The model is built using all available knowledge of the process including human operators' knowledge, operating data, and any known scientific principles, such as First Principle equations.


APC Reduces Variability
Targets get closer to the actual limit.
Engineering Limit
Time
Operating Limit
A. High variability before APC
B. APC reduces variability by 50 – 80%
C. APC holds targets closer to limits with no more violation

APCs : Benefits

APCs are recognized as best practices and proven investment opportunity typically offering 3 to 9 month payback and operational benefits

- Increased capacity and increased production of preferred/profitable products by 3% to 5%.
- Tighter control of important product quality or operational variables (>50% reduction in variance).
- Increased recovery or operational efficiency, process optimization by 2% to 4% or more.
- Reduced energy per unit feed or product (>3%).
- Improved stability and increased operating reliability in response to process upsets.


Normal control
APC ON
Optimizing control ON
Adjust within the control limit to increase economical benefit
Operational limit
Standard deviation
APC decreases the variations
Benefit (energy conservation)

Smart Automation in HURL

- Dedicated Redundant Electronic micro-processor based DCS System.
- SIL3 certified dedicated PLC (TMR/QMR/VMR/FMR) based Emergency Shutdown System for plants.
- SIL3 certified dedicated PLC (TMR/QMR/VMR/FMR) based System for Fire & Gas and Ammonia Storage Control/Shutdown (same make /model as of main plant ESDS).
- PIMS-Plant information management System.
- AIMS-Alarm Information Management System with automatic alarm generation report and auto SMS.

Smart Automation in HURL

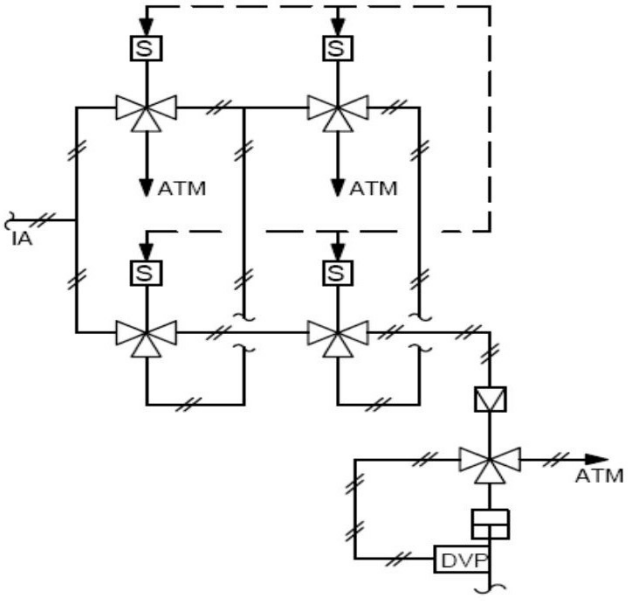
- Advance Process Control system for Process Optimization.
- ITCC based dedicated Control System for all Turbines & Compressors.
- Mass Spectrometer Based Analyzer System.
- Operator Training Simulator for Urea and Ammonia Plants.
- Dedicated Historian for data Storage.
- Dedicated CCTV system with Large Video Display for plant monitoring.
- RTDBMS system for l complex

Smart Automation in HURL

- Continuous Emission Monitoring System through dedicated Analyzers with their Hook with CPCB.
- Dedicated Clean Agent System for all control rooms.
- Dedicated Machine Monitoring System with System-1 Monitor Enterprise and Rule packs for monitoring and Diagnostics of critical machines.
- Dedicated On-Off valves for Process Isolation.
- Fire Alarm System to monitor all buildings.
- Gas Detectors, Dedicated Deluge System for fire monitoring and control.

Smart Automation in HURL

- All Trip solenoids considered are dual redundant, IS certified with SS316L as its MOC . Critical operational loops are separately identified and provided with 2oo3 SOV philosophy with plunger feedback in control system.
- Partial stroke testing (PST) considered for all ESD valves with Remote testing facility.



SOLENOID VALVE WITH 2OO3 VOTING,
ONLINE COIL CHANGE-OVER FACILITY
& PARTIAL STROKE TESTING

Smart Automation in HURL

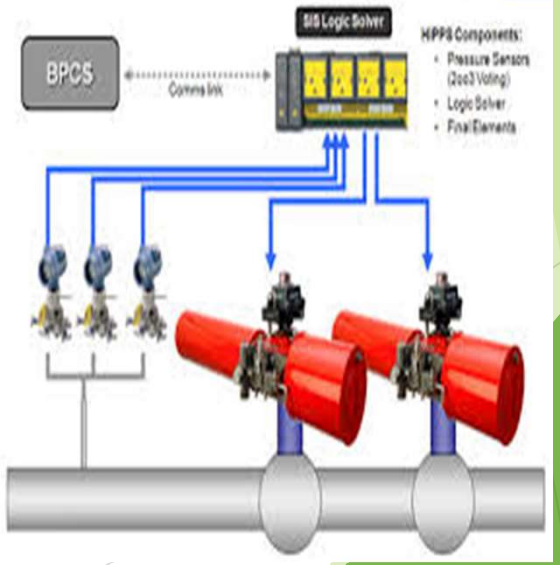
Where ever valve position feedback is used in tripping, it is designed on 2oo3 philosophy.

Redundant Mass Spectrometers configuration connected to APC is considered for plant optimization and increased analyzer availability .

Extrel

Smart Automation in HURL

- LVS (large Video screen) considered for monitoring of Process parameters & CCTV.
- All servers and engineering stations are Server grade PC (Raid-5 configuration).
- All interlock and control transmitters considered separate right from field junction box to DCS/ESDS I/O Modules.
- Parameters, which are directly or indirectly tripping the plant or may cause production loss are based upon 2 out of 3 transmitter trip voting interlock in ESDS.

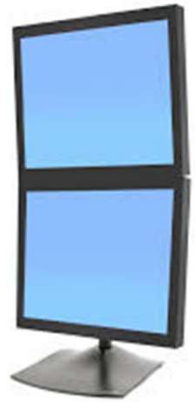


Smart Automation in HURL

- All trip parameters are provided with separate Process Override (POS) and Maintenance Override Switch (MOS) switches for ease of process and maintenance function.
- 3”, 300# Diaphragm seal Instruments are considered for all condensing, congealing and corrosive services.
- 5-Path Ultrasonic flowmeter for custody transfer and performance guarantee.
- Clamp-on type Ultrasonic flowmeter for Cooling water applications.

Smart Automation in HURL

- Dual monitors are considered for all Operator consoles.
- Dual personality ES with OS.
- Ammonia Storage, CPP parameters can be viewed from CCR.
- All vibration logic are designed on 2oo4/2oo2, Axial and Overspeed logic on 2oo3 philosophy.
- All power supply, MCB, power feed modules, Barrier Motherboards and diode O-rings are monitored in control system f



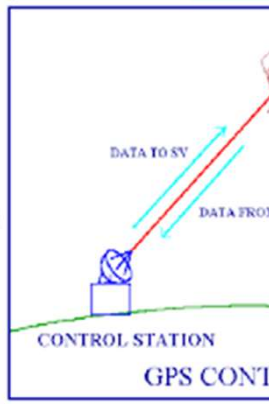
Smart Automation in HURL

- Network securities is considered in all control rooms as per IEC 62443 for protection of the system from both internal and external threat.
- Nucleonic Gauge detectors are considered with cooling water arrangement to ensure healthiness and long availability.
- All DO signals from BN system are wired to plant ESD on 2oo3 philosophy.
- All control and trip transmitters are hooked up with separate Process Tapings.
- All control valves are provided with position feedback signals.
- Auto Start for igned on 1oo2 philosophy.

Smart Automation in HURL

No switches are considered in project and interlocks are designed on transmitters.

- Ceramic capped Bentley Probes are considered for ammonia services.
- GPS based time synchronization has been considered for the complete complex to ensure all systems show same timing.
- All steam valves are provided with FC9 body to ensure reliability.
- First Out feature is considered for all systems for ease of trip analysis.
- Semi Automatic Bagg control of Demurrage.



Thanks!!!