Achieving Operational Excellence on a Delayed Coking APC Project

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Speaker Introduction, John Ward

- Consultant/Business Development, Industry Solutions Group, Austin, TX
- B.S. ChE, M.B.A., M.A. Philosophy
- 30+ Years Global Refining/Petrochemical experience
- Process Engineer by Training
- Operated refineries with Texaco/Motiva. Designed refineries for M.W. Kellogg/KBR
- Catalyst, Licensing, Plant Startup for Haldor Topsoe
- APC, Blending, OTS, Process Modeling, MES: Study, Design/Implement with Aspen Tech, Invensys, Honeywell

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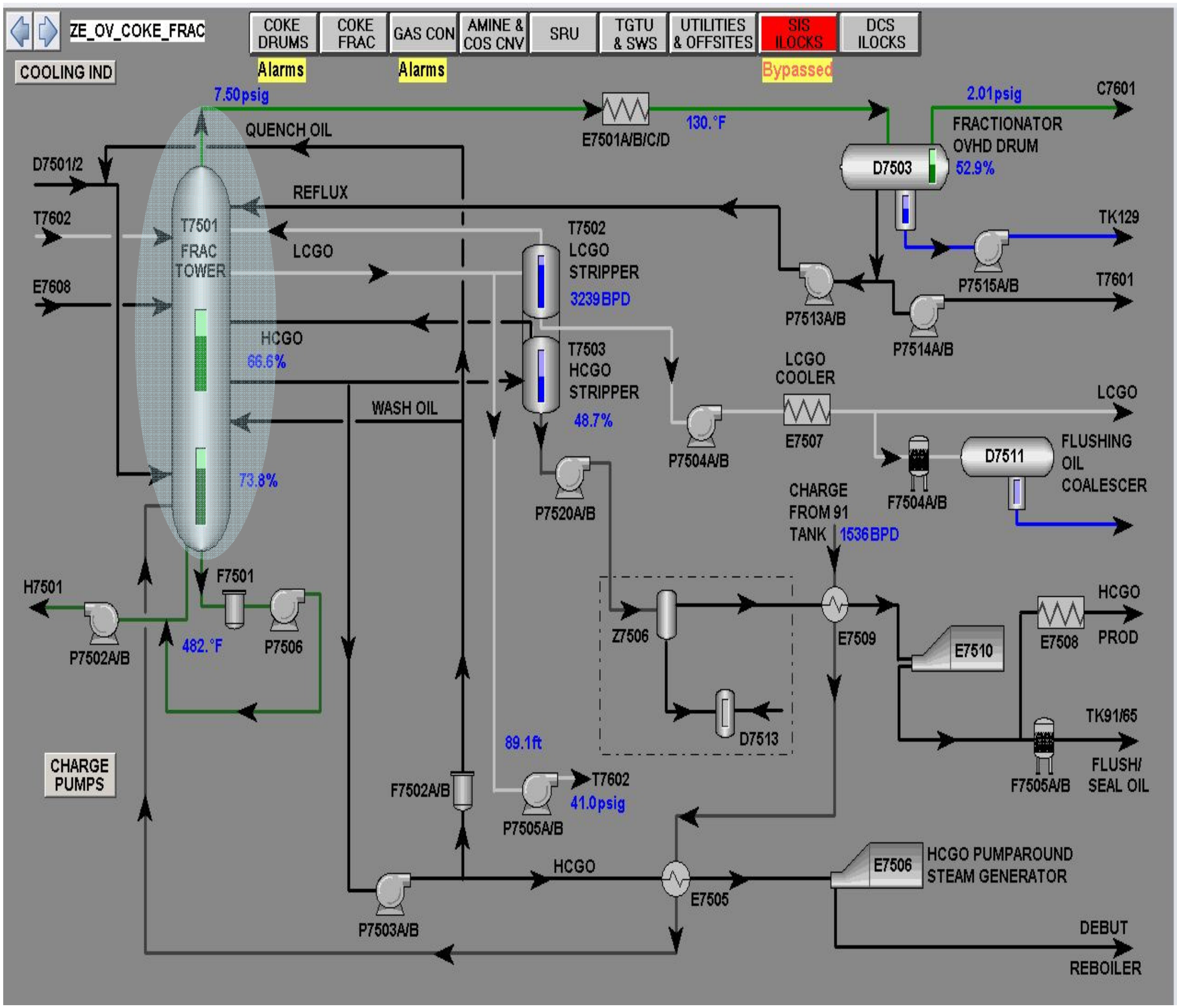
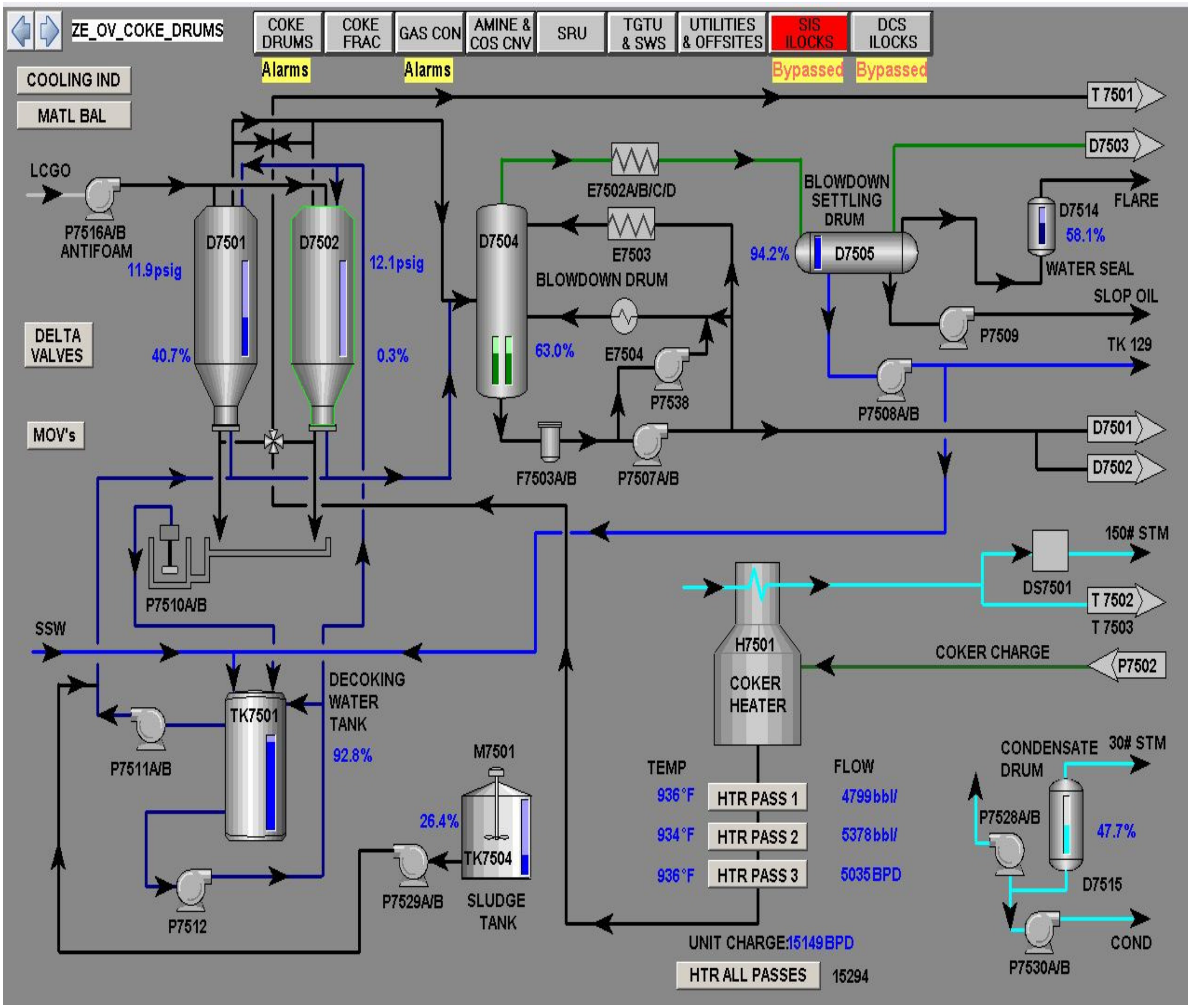
Introduction

- Process Overview
- Successful APC Execution Plan
- Business Results Achieved
- Summary

Process Overview - PFD



Process Overview - PFD



Process Overview Summary

- Challenges:
  - Continuous process with significant cyclic disturbances
    - Inconsistent operator response to process disturbances
    - Product quality and yield variation
- Project Objectives:
  - Compensate for disturbances
  - Maximize LCGO production
  - Minimize product quality variation (Naphtha, LCGO)
- APC facilitates:
  - Automates and optimizes “Best operator responses”
  - Control loops in desired modes
  - Minimize operator intervention

Process Overview – Disturbances

- Unmeasured & Unquantified Process Disturbances
  - Drum Cycles
    - Backwarm
    - Drum Switches
  - HCGO Pall Filter Switches
    - HCGO pumparound integrated into the product circuit
      - Amplified the effects of HOURLY Pall filter switches
- Control Induced Variability
  - Feed pump spillback pressure control valve
  - Tower reflux flow control valve

APC Development

- Justification
  - Internal Sponsorship
  - ROI Assessment
- System Preparation
  - Control Foundation Analysis & Improvement
- APC Execution
  - Embedded MPC and SmartProcess® Composites
  - Model Identification & Validation
  - Optimizer Objective Function Definition
- Quantify Benefits

System Preparation – Control Foundation

- Analyze key control loops, not just tune loops!
- Improve PROCESS performance not just “LOOP” performance
- Review control configuration and scheme
- Maximize PROCESS performance

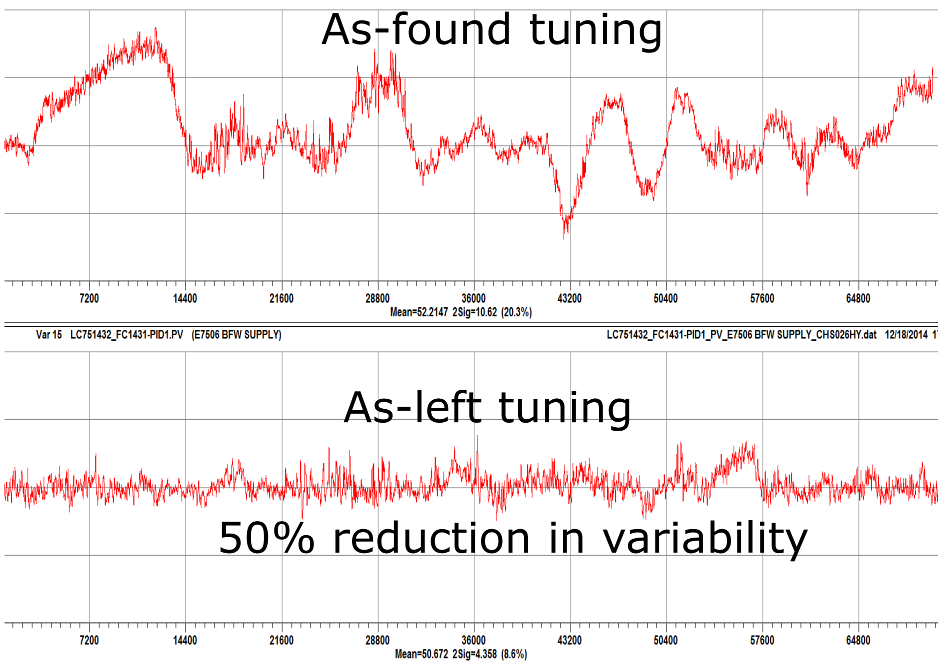
System Preparation – Control Foundation

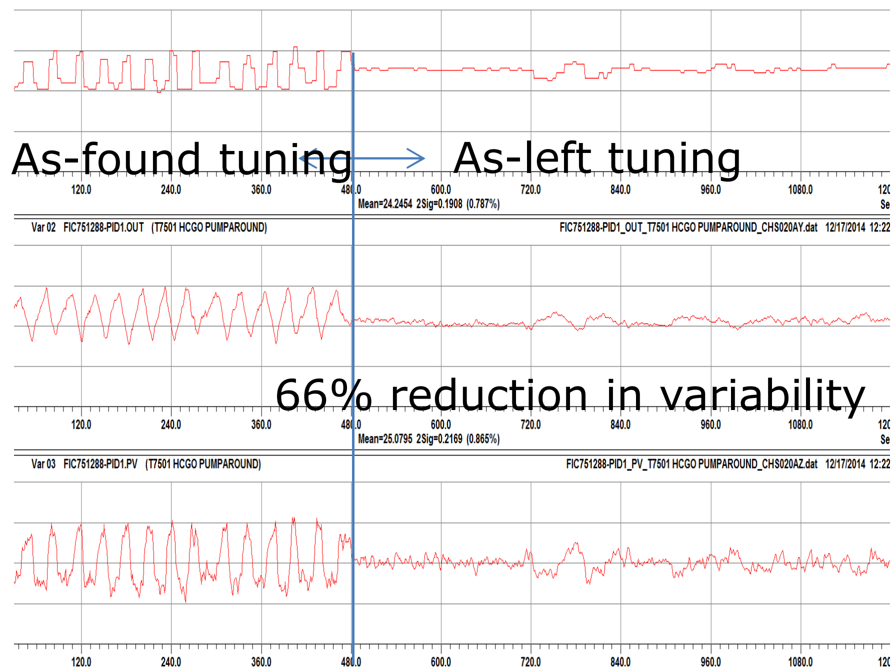
- Field walk down
  - Assess equipment installation against best practices
  - Assess general type and condition of control valves and instrumentation
- Conduct Operator interviews
  - Facilitates better understanding of the process
  - Understand control problems and operator responses
- APC Project Scope
- Reviewed and analyzed 30 key loops
  - Found issues with 3 key instruments and 2 critical valves
  - "Significant" (>30%) tuning changes on 27 of 30 loops
  - Recommended new control scheme on critical equipment

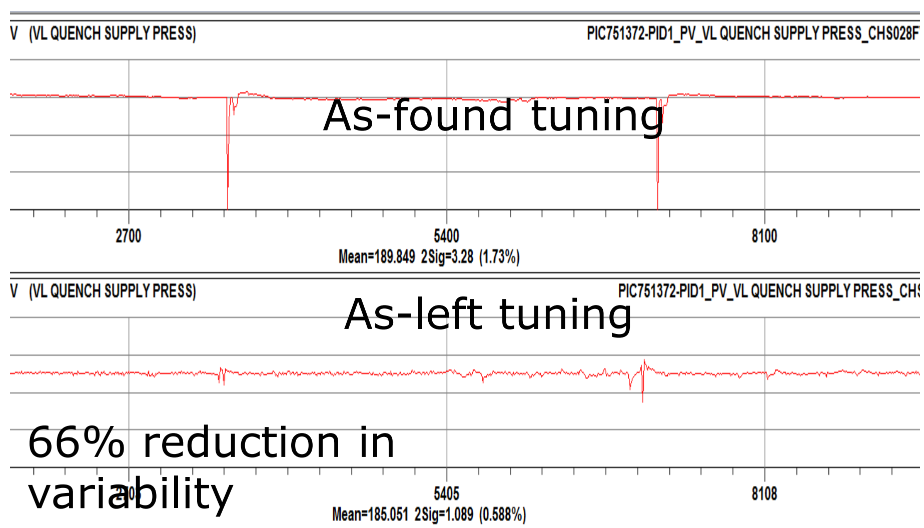
Tuning Procedure

- Step 1: Identify the basic process type
  - Self-regulating
  - Integrating
- Step 2: Measure process dynamics
  - Must use %Process Variable (%PV) and %OUT
  - %ΔPV = ΔPV_Eng_Units*(100%/Span_PV_Eng_Units)
  - %ΔOUT= ΔOUT_Eng_Units*(100%/Span_OUT_Units)
- Step 3: Choose desired closed loop response time, "Lambda"
- Step 4: Calculate tuning constants

System Preparation – Control Foundation



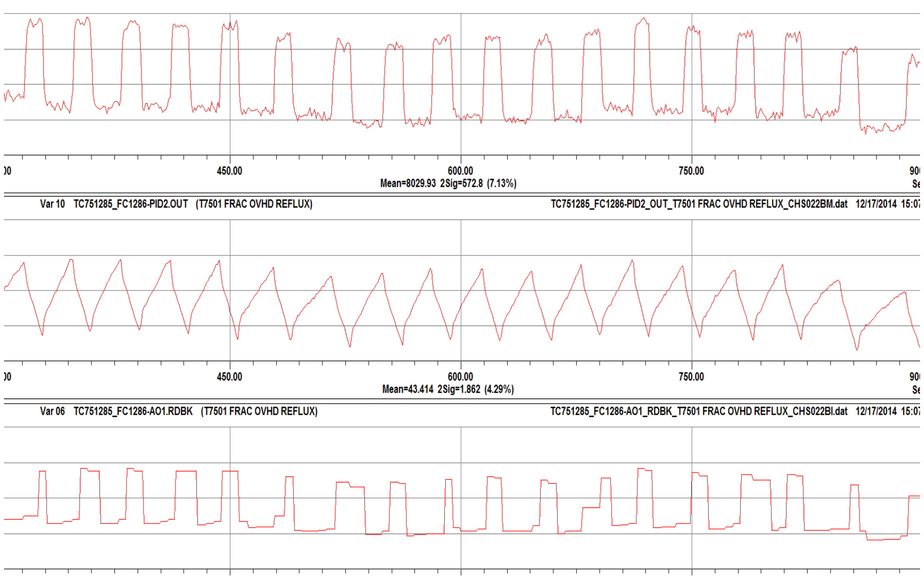


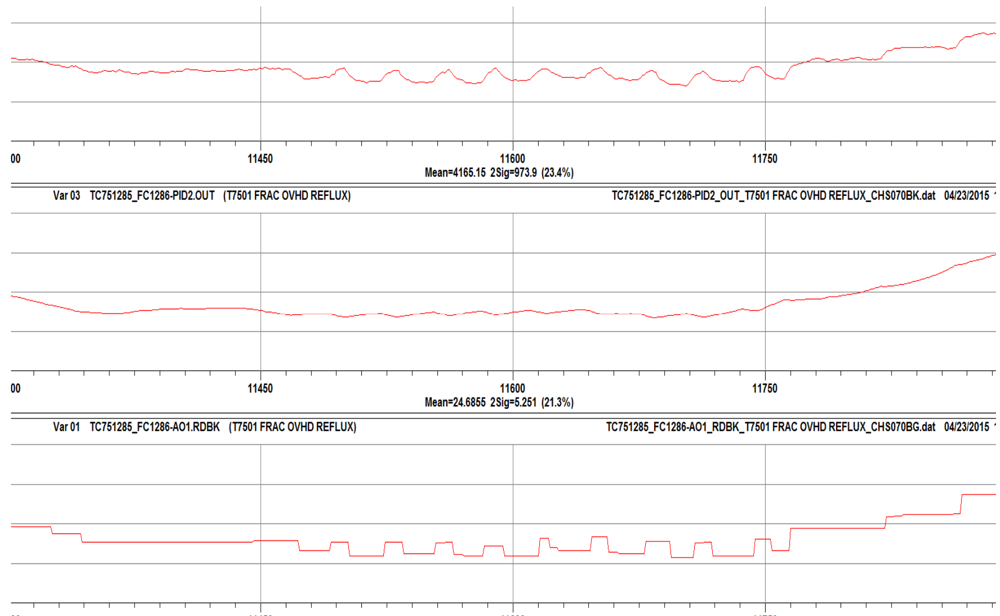


System Preparation – Control Foundation

Before Repair Valve Readback

After Repair Valve Readback





Fractionator Reflux Control Valve (Temp to Flow Cascade)

Rules of Thumb

- Largest opportunity for final elements is to minimize resolution, deadband and variation in response time.
- Largest opportunity for measurements is the selection and installation of sensors.
- Check the life-cycle cost
- Use smart transmitters.
- Deadtime limits control capability, design carefully to minimize

Rules of Thumb

- Use cascade, feed-forward and decoupling when appropriate
- Change control scheme when required
- An open-loop process identification method helps identify non-linearities in the loop (valve, measurement, etc.)
- A closed-loop tuning method can be a faster and safer way to identify process dynamics if non-linearities are not significant

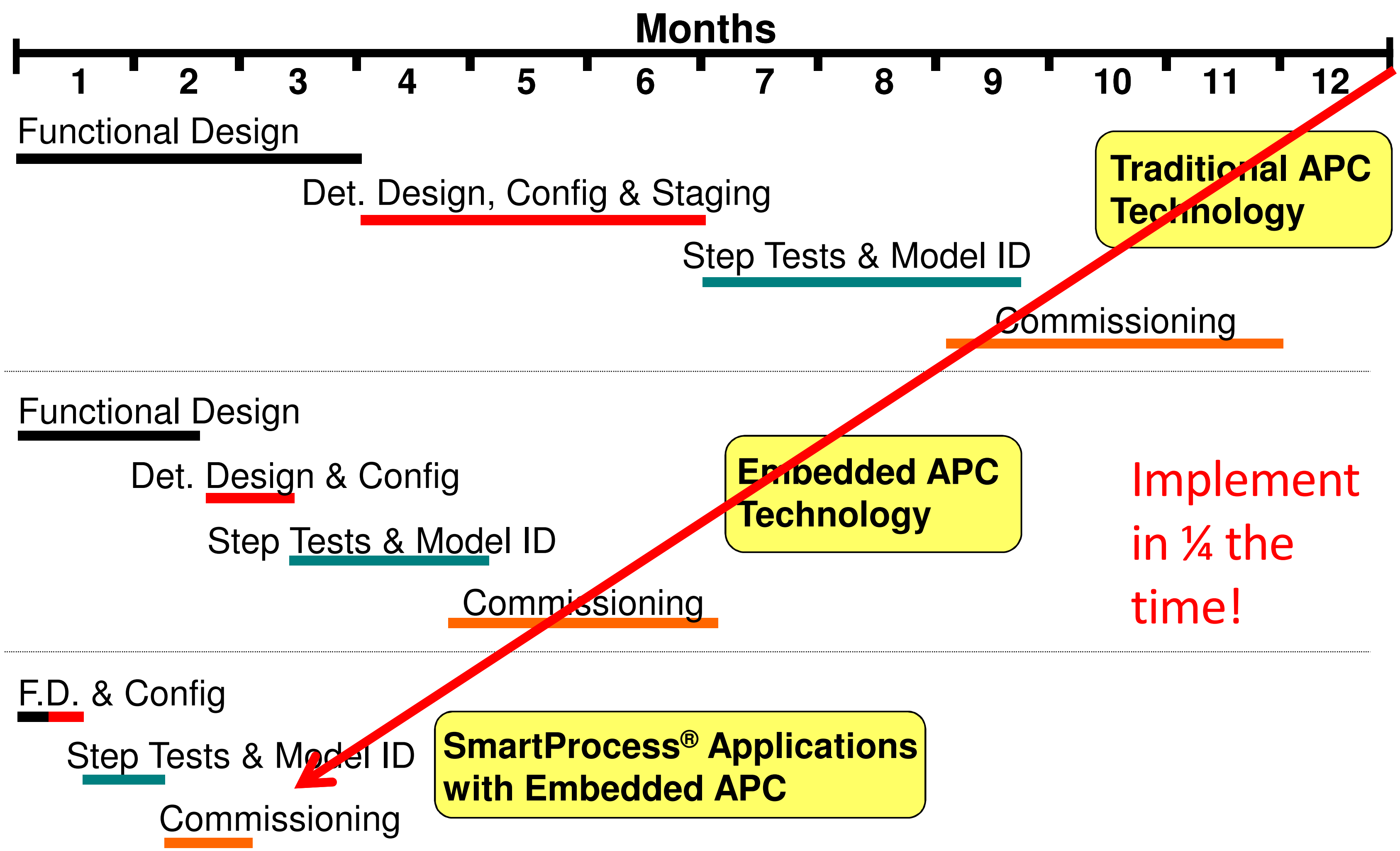
Rules of Thumb

- Processes benefit from coordinated response of all loops in a system using Lambda tuning techniques
- Some loops require aggressive tuning
- Manage resonance of control loops.
- Now you are ready for APC!

APC Execution – Control Foundation

- Results
  - Significant (>30%) reduction in variability on 10/30 of the loops
  - Found opportunity for small MPC to increase waste heat recovery - $70K/year benefit!
  - Identified critical valves that required maintenance
- Reduces time required to implement APC
- Increases benefit of APC projects
  - Coordinated control loop responses contribute to project success
- Provides 25-50% of benefit of total APC project!

APC Execution - SmartProcess®



APC Execution – MPC Variables

- ***Controlled Variables* (CV)** - Process variables which are to be maintained at a specific value; i.e., the setpoint
    - Naphtha Draw Comp Temp
    - LCGO Draw Comp Temp
    - HCGO Draw Comp Temp
- ***Manipulated Variables* (MV)** – Controller setpoints written to by the MPC.
    - Ovhd Temp (TC751285)
    - Net LCGO (FIC751349)
    - Lean Oil to E7610 (FIC
    - HCGO P/A (FIC751288)
    - Total Wash Oil (FC75
- ***Constraints (LV)*** - Variables which must be maintained within an operating range (a special type of CV)
    - Debut Reboiler Bypass Valve
    - Frac Ovhd Rec LIC Out
    - Sponge Oil Static Head
    - LCGO To Strpr Vlv
    - Etc.
- ***Disturbance Variables (DV)*** - Measured variables which may also affect the value of controlled variables
    - Backwarm (calculated)
    - Drum Switch (calculated)
    - Fresh Feed
    - Reflux Flow
    - Reflux Temp
    - Coke Drum Quench Temp
    - Etc.

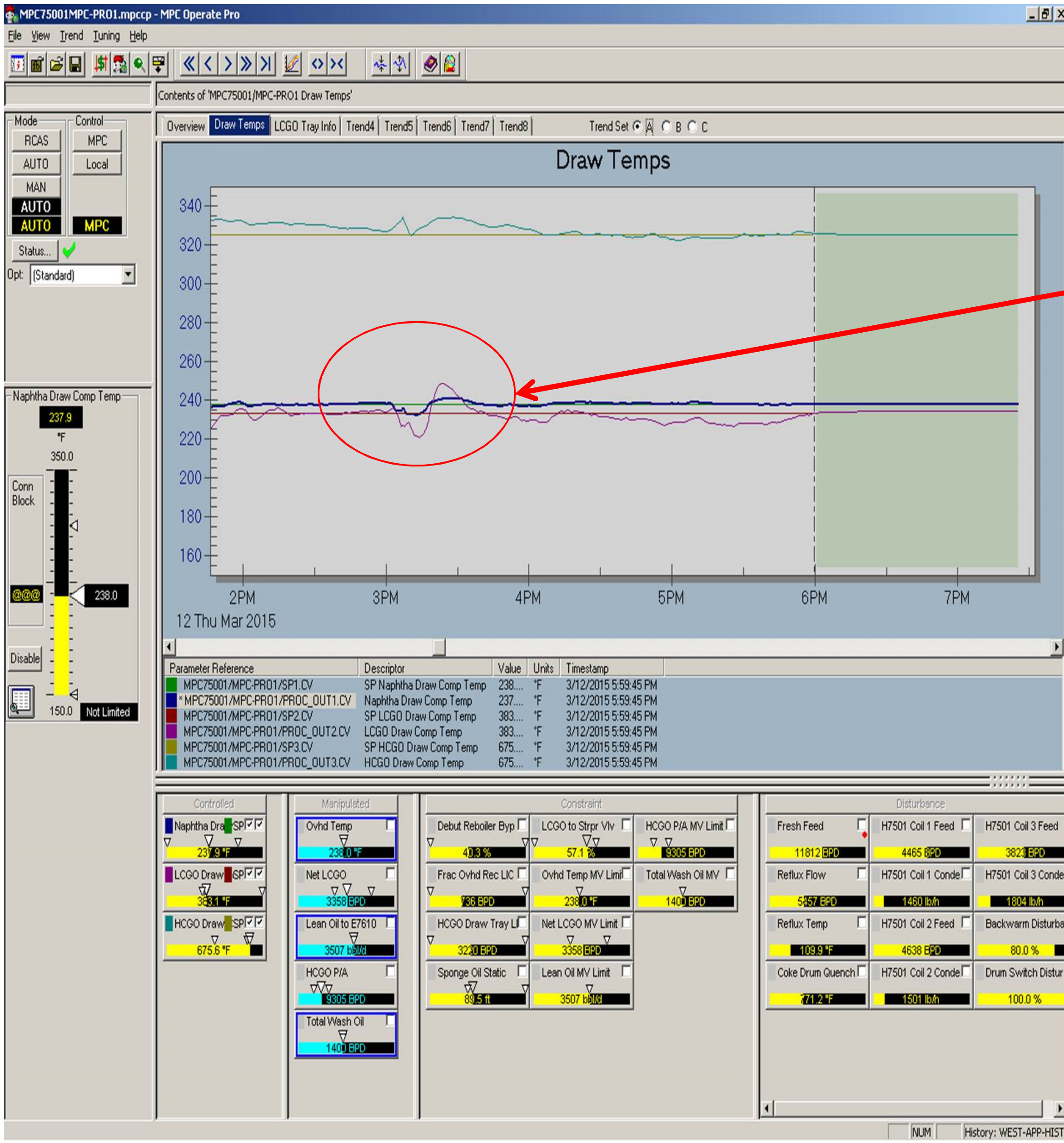
APC Execution – MPC Process Models

- Measurements are not available for Backwarm and Drum Switch
- Created “calculated” DV’s for Backwarm and Drum Switch
- Backwarm
  - Reduction in heat input to the Fractionator
  - Change in composition to the Fractionator
  - Created a DV with scale 0-100%, reduce from 100 to 80 when triggered
- Drum Switch
  - Reduction in heat input to the Fractionator
  - Minor change in composition to the Fractionator
  - Created a DV with scale 0-100%, reduce from 100 to 70 when triggered

APC Execution – MPC Process Models

- Each DV triggered with key process variables and associated switching valves
- DV’s ramped slowly back to 100% after event to “re-arm”
- Calculated the models for both DV’s
  - Knowing approximately how much key MV's would move to compensate for the heat and composition change
  - Use the opposite amount of MV move, multiplied by know MV to CV/LV models to obtain the model from the calculated DV’s

APC Execution – Performance



Minimal deviation during major disturbance!

Business Results Achieved

- **Eliminated operator intervention during coke drum backwarm and drum switch operations!**
- **The average LCGO production was increased by almost 5% of rate which resulted in a payback of 6 months for the project!**
- **Reduced downstream unit constraint**
  - **Shifted HCGO production to LCGO - Right barrels in the right place!**
- **Reduced Naphtha quality exceedances by 32%, LCGO by 40%**
- **ROI < 6 months!**
- **Management & Operators gained confidence in Advanced Control**
  - **More opportunities!**

Summary

- APC can be successful on continuous process with large unmeasured disturbances
- Implementation plan ensures success
  - Project Sponsor
  - Benefit Assessment
  - Control Foundation Improvement
  - Embedded MCP and SmartProcess® Application Package saves time
- Reduced product quality exceedances by >32%
- ROI on project was 6 months!
- Identified other opportunities
- Questions