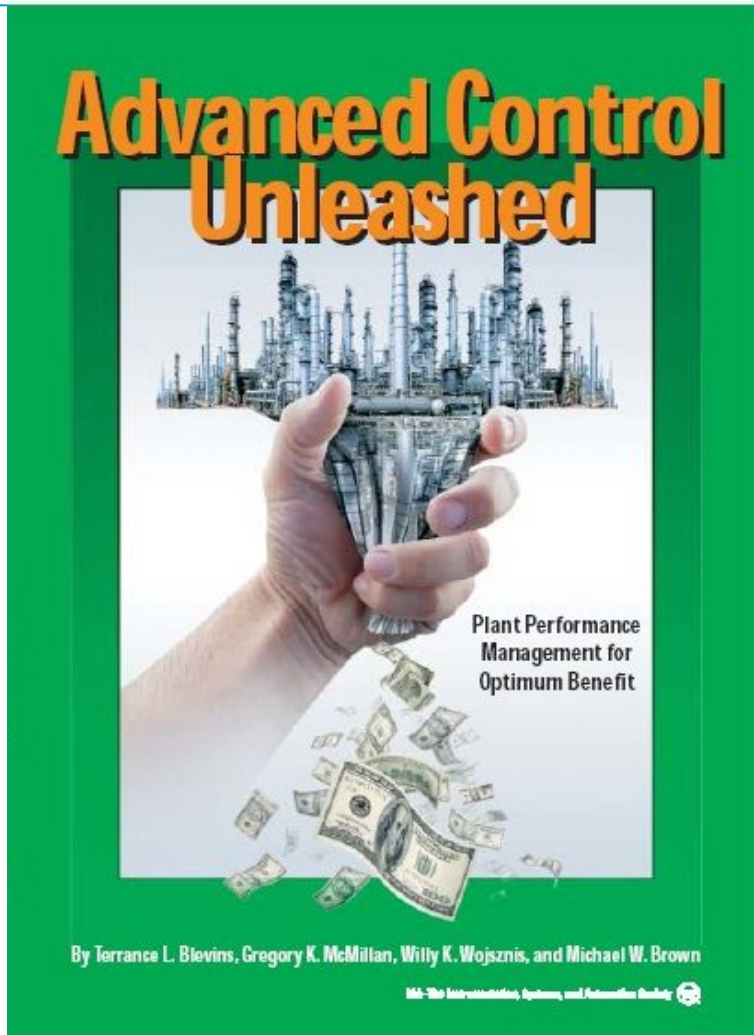


# ***Automation Connections ISA EXPO 2003***

A Practical Guide To Advanced  
Control

Terry Blevins

# ***A Practical Guide To Advanced Control***



- Presentation will provide a summary of key points and examples from Advanced Control Unleashed
- Book was inspired by the latest generation of advanced control products.
- The application sections include guided tours of each technology
- CD provides an overview video for each section and examples.

# ***Book Content***

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- Introduction
- Setting the Foundation
- APC Pathways
- Evaluating System Performance
- Abnormal Situation Management
- Automated Tuning
- Fuzzy Logic Control
- Properties Estimation
- Model Predictive Control
- Virtual Plant

# Structure of each Section

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- Practice
  - Overview
  - *Opportunity Assessment*
  - *Examples*
- Application
  - General Procedure
  - Application Detail
  - *Rules of Thumb*
  - *Guided Tour*
- Theory

# ***Advanced Control Unleashed***

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- **Introduction**
- Setting the Foundation
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# ***APC for the Average Process Engineer***

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- The advent of powerful and friendly integrated software has moved advanced process control (APC) from the realm of consultants into the arena of the average process control engineer
- There is a opportunity of the engineers closest to the process and daily operation to take a much more active role in the development and support of APC applications
- Rule of thumb and concise explanations are employed to save the reader time to obtain specific implementation guidance.

# ***Advanced Control Unleashed***

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- Introduction
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## ***A Solid Foundation is Essential***

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- The core of a solid foundation is good measurements and final elements.
- Deficiencies in the measurement and final element can increase the time required for process testing and identification by a factor of 5 or more and can significantly reduce the improvement in process capacity and efficiency provided by APC.



## ***Rules of Thumb***

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- The largest opportunity for final elements is to eliminate stick-slip and deadband. The effect of slip is worse than stick and stick is worse than deadband.
- The largest opportunity for measurements is the selection and installation of sensors.
- Check the life-cycle cost, including the cost of variability before choosing a less expensive control valve or measurement.
- Use smart transmitters. The improved accuracy and diagnostics are worth the extra cost. Use Fieldbus for major upgrades and new installations.

# ***Advanced Control Unleashed***

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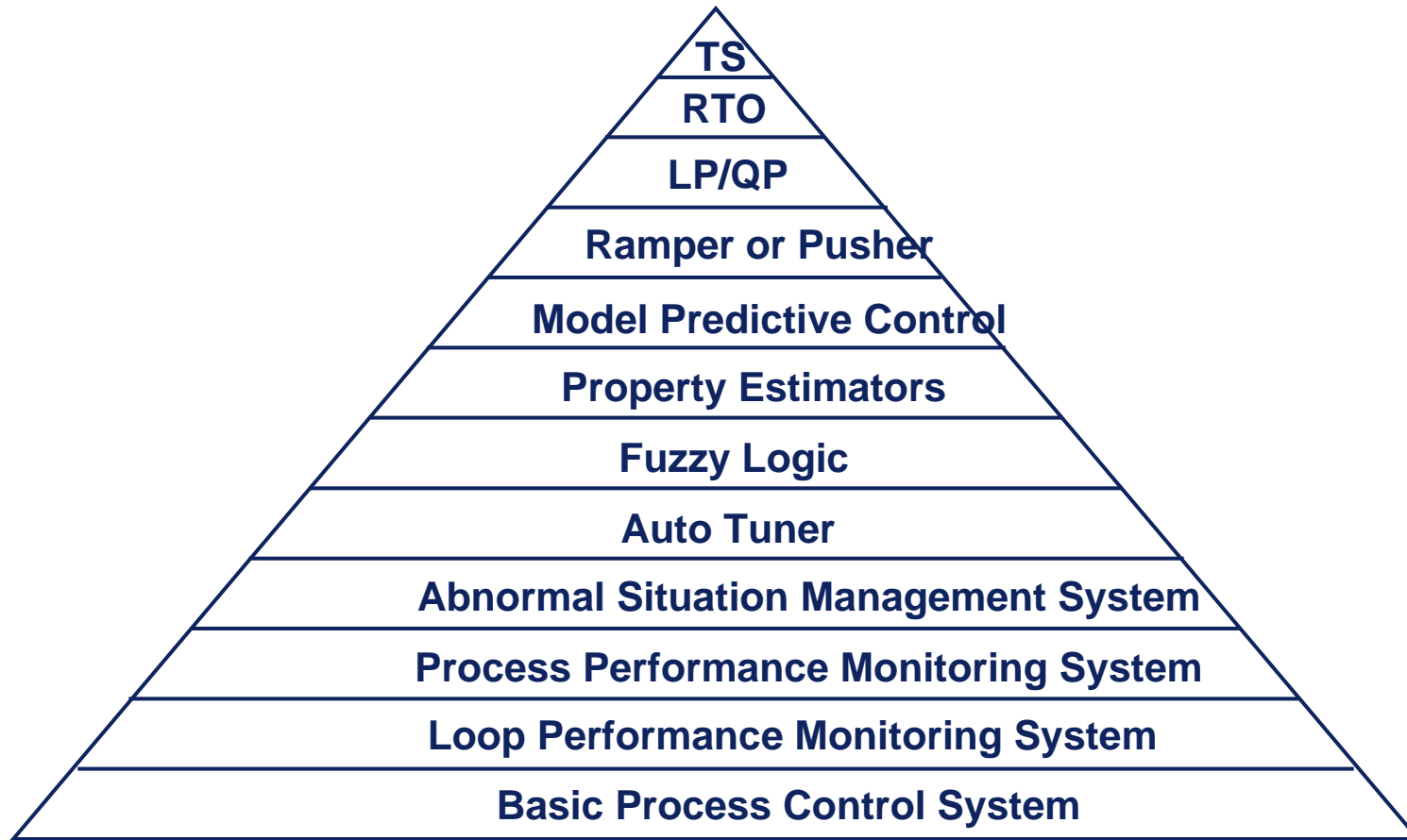
- Introduction
- Setting the Foundation
- **APC Pathways**
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## ***Objective – APC Pathway***

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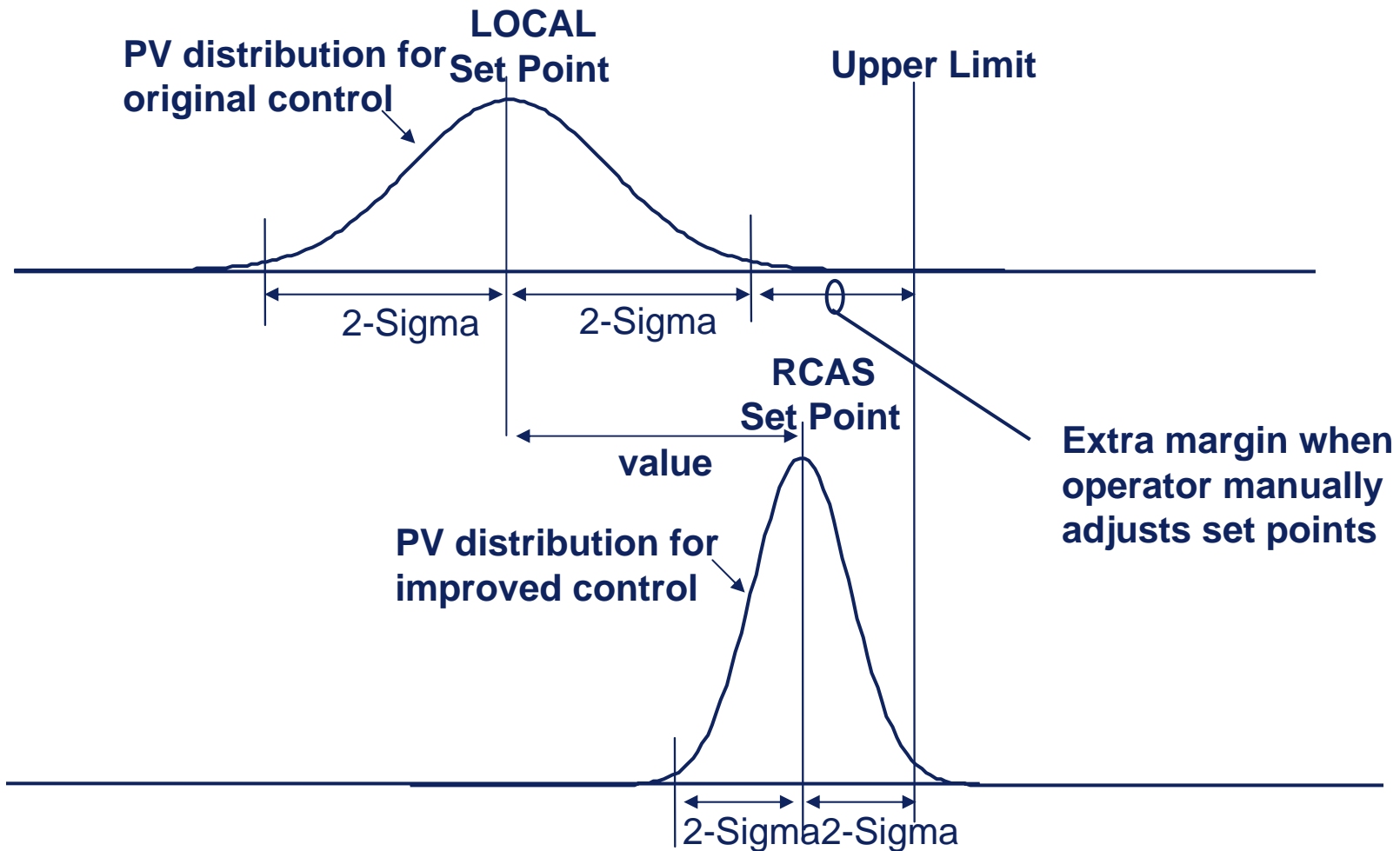
- Examines how to identify advanced process control opportunities, estimate benefits, select the best technology, sustain the solution, track the benefits
- Industry is driven by cost and benefit analysis and is generally not interested in a great technology looking for an application.

# ***Pyramid of Technologies***

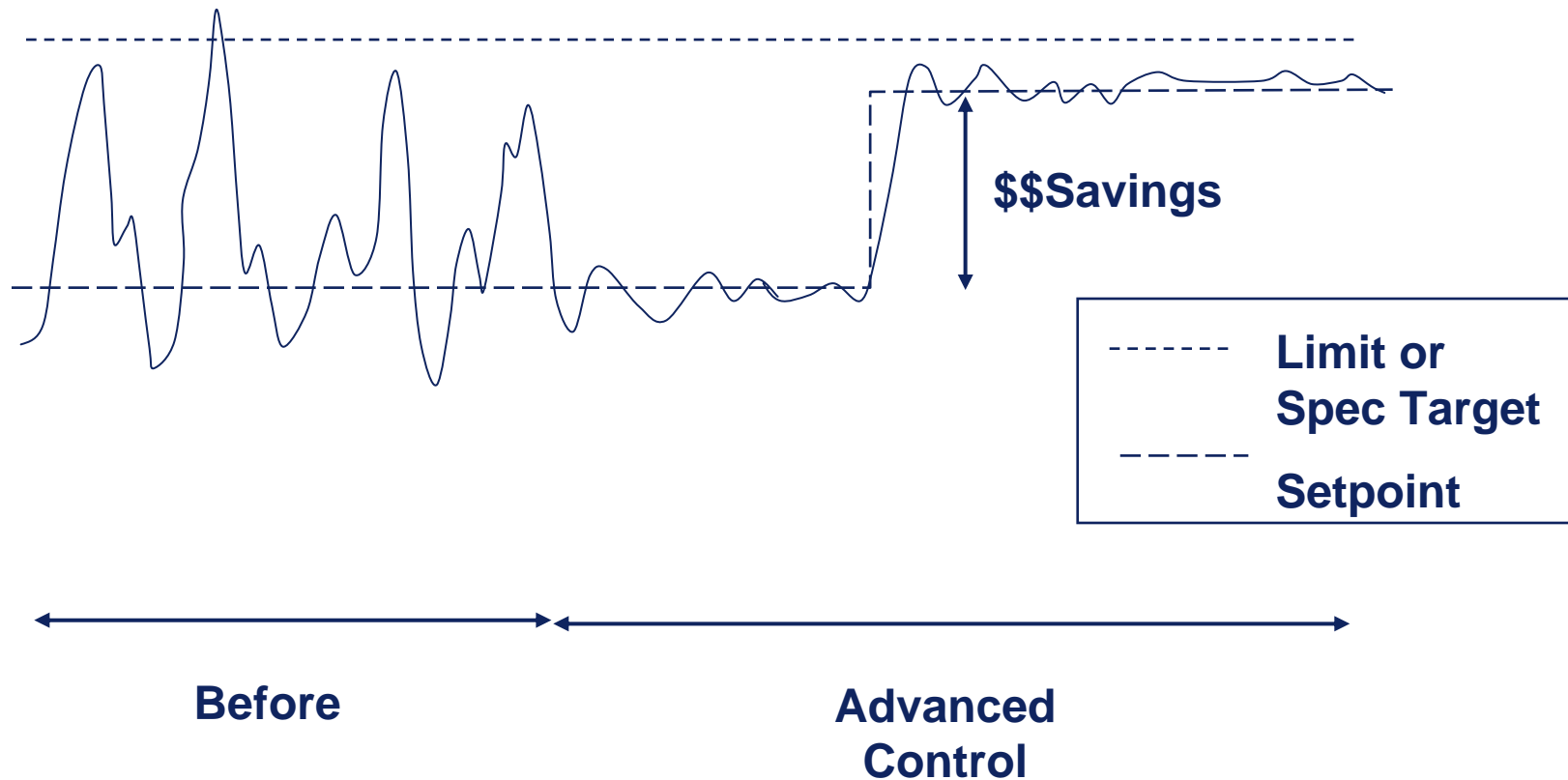


**TS is tactical scheduler, RTO is real time optimizer,  
LP is linear program, QP is quadratic program**

# Effect of Operator Conservatism on Proximity to Constraint



# Benefits from Operation Closer to a Controlled Variable Limit



# ***Advanced Control Unleashed***

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- Introduction
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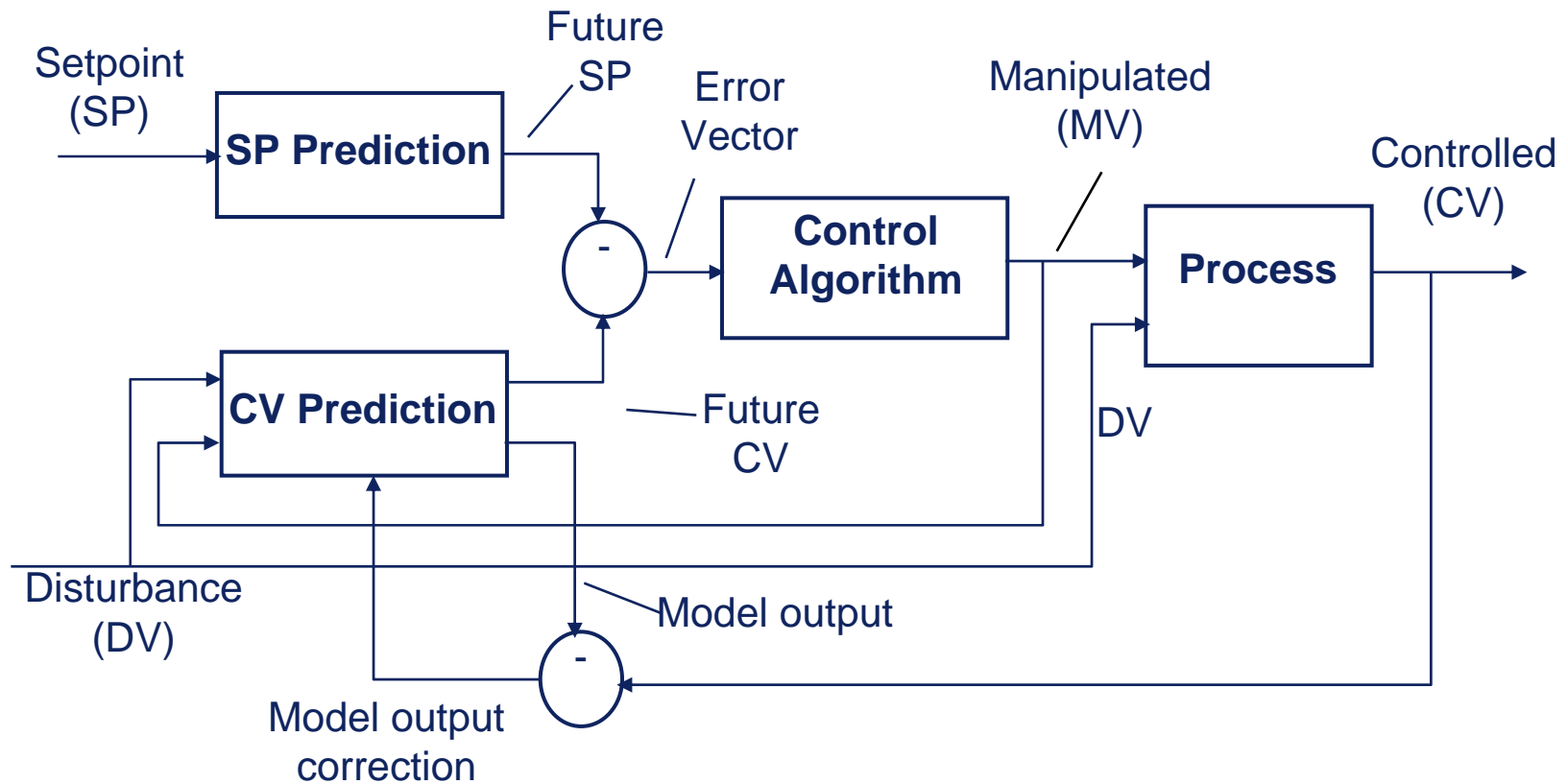
# ***Model Predictive Control***

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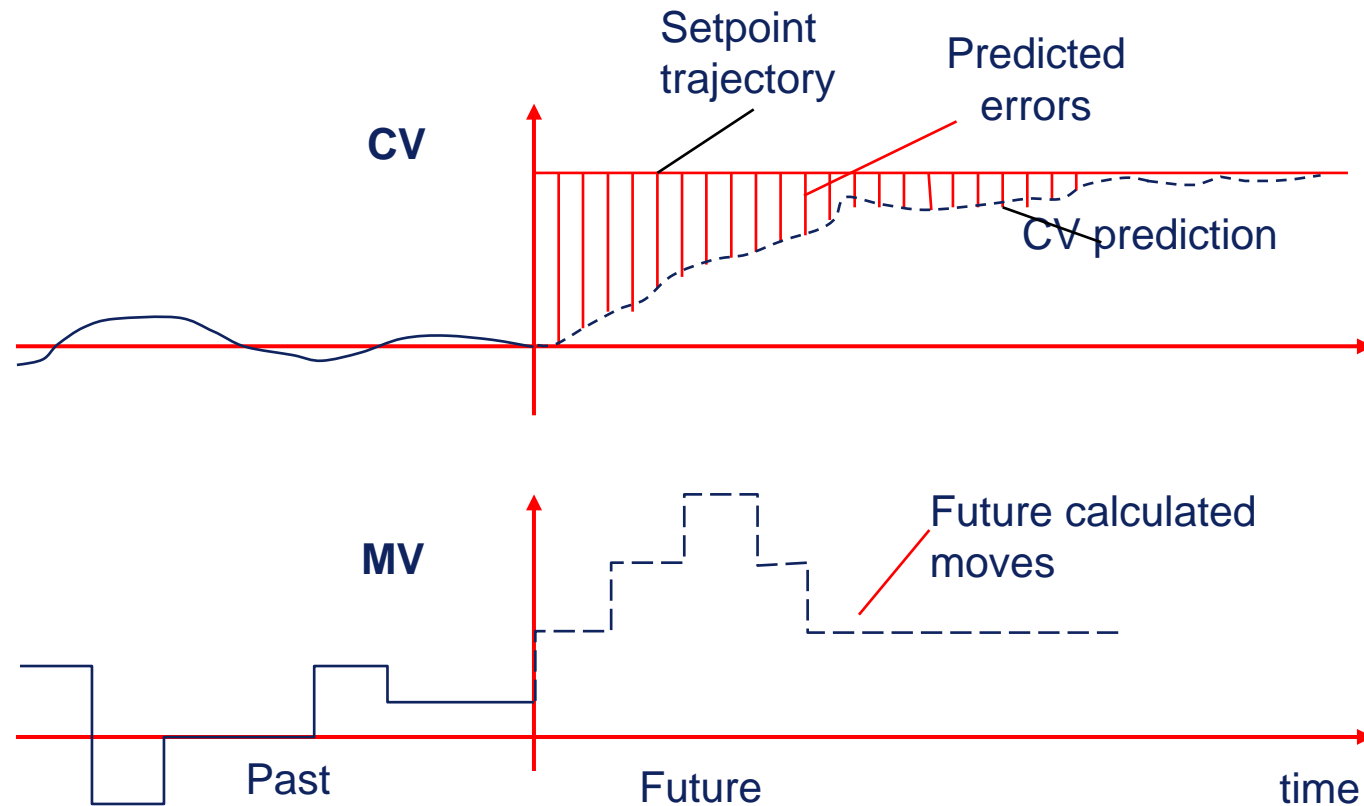
- Model Predictive Control (MPC) has been proven to provide benefits, in the right application, that are greater than those achieved from the improvement of basic control systems.
- The greatest benefits are realized in applications with dead-time dominance, interactions, constraints, and the need for some optimization.
- Optimization is often as simple as the maximization or minimization of a flow.
- The advantage of MPC lies in its knowledge of the effects of past actions of manipulated and disturbance variable on the future profile of the controlled and constraint variables.



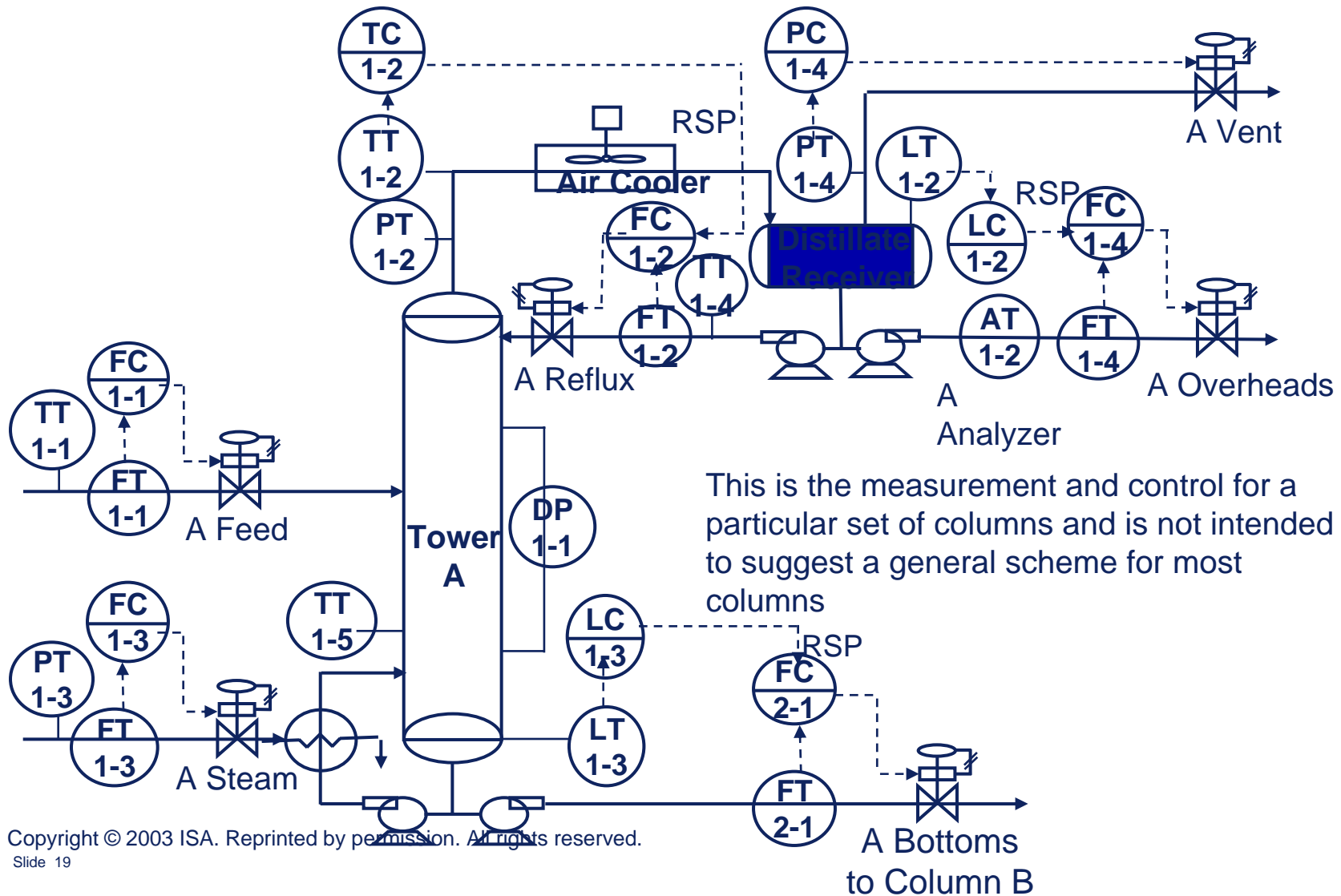
# Feedback of Future Trajectories for Model Predictive Control



# Graphic illustration of the operation of a MPC controller



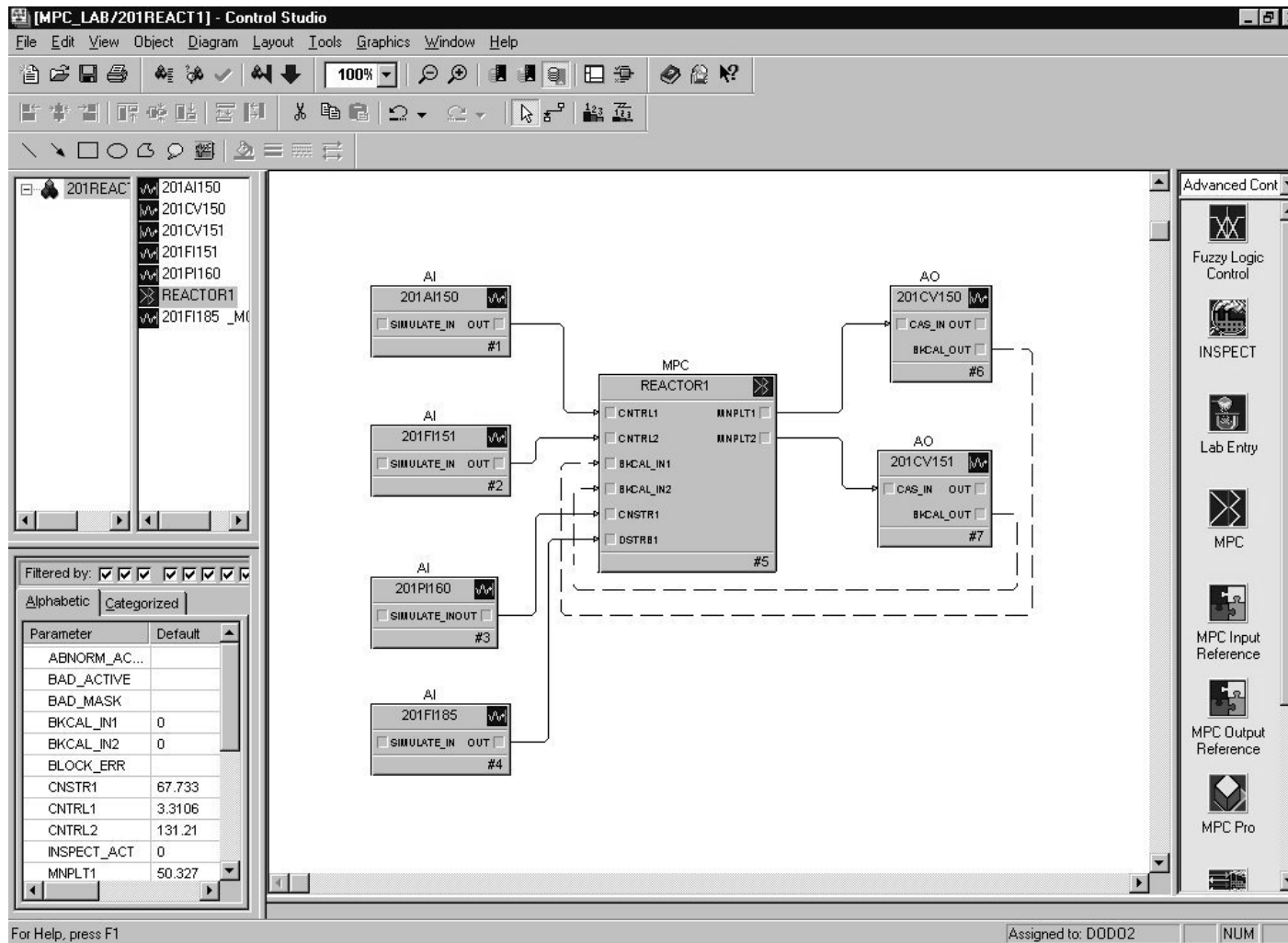
# Distillation Tower Example



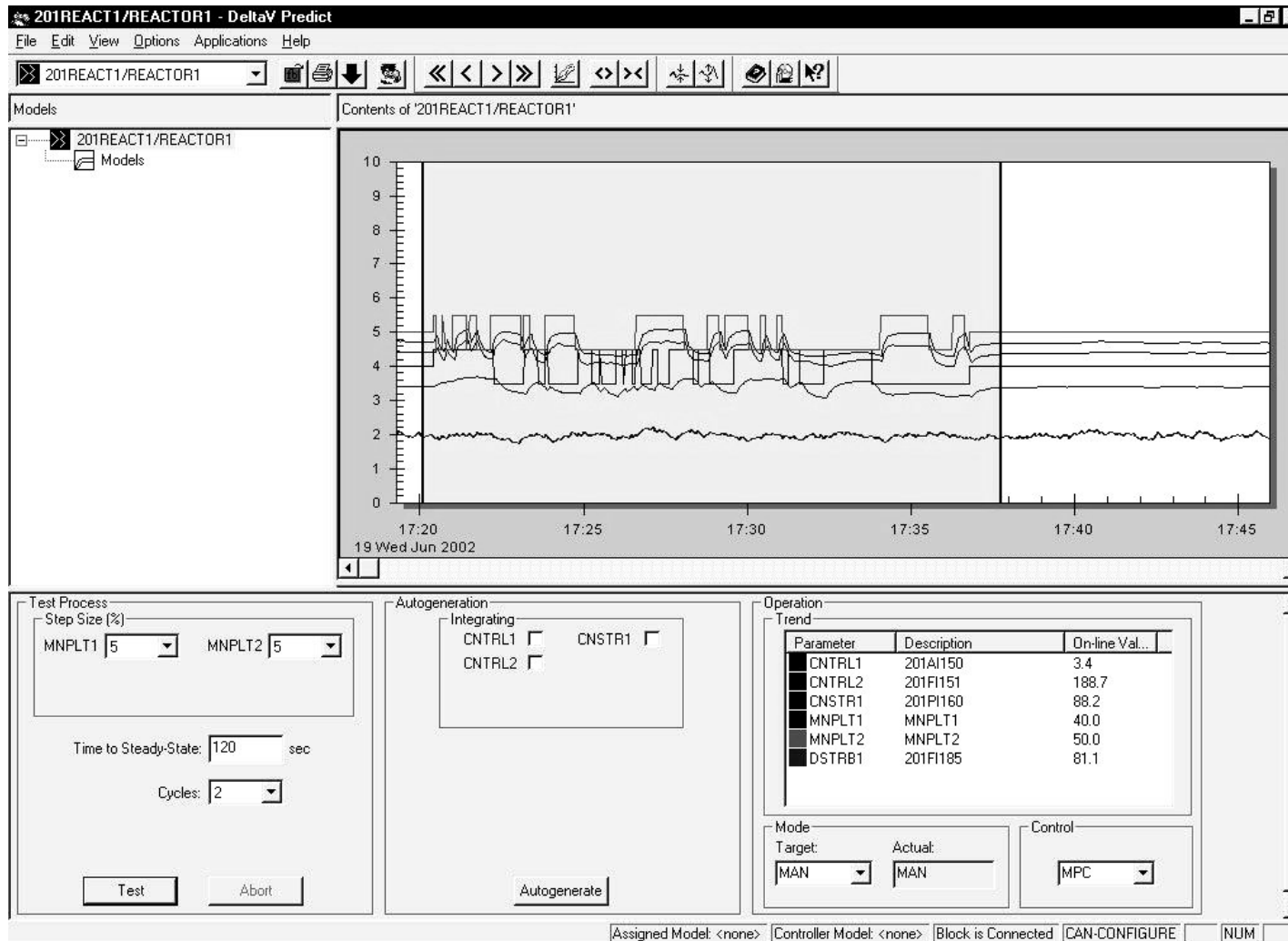
# Distillation Tower, Step Response Model for MPC Development

|                   |                         | Manipulated           |                    |                     | Disturbance              |
|-------------------|-------------------------|-----------------------|--------------------|---------------------|--------------------------|
|                   |                         | FC 1-3<br>Reboil Rate | TC 1-2<br>Top Temp | FC 1-1<br>Feed Rate | PT 1-3<br>Steam Pressure |
| <b>Controlled</b> | AT 2-2<br>A btms comp   |                       |                    |                     |                          |
|                   | AT 1-2<br>A ovhd comp   |                       |                    |                     |                          |
|                   | FEED TGT<br>A ovhd comp |                       |                    |                     |                          |
| <b>Constraint</b> | FC 1-2<br>Reflux rate   |                       |                    |                     |                          |
|                   | TT 1-4<br>Reflux temp   |                       |                    |                     |                          |
|                   | TT 1-5<br>Tower A temp  |                       |                    |                     |                          |
|                   | DP 1-1                  |                       |                    |                     |                          |
|                   | Delta P                 |                       |                    |                     |                          |

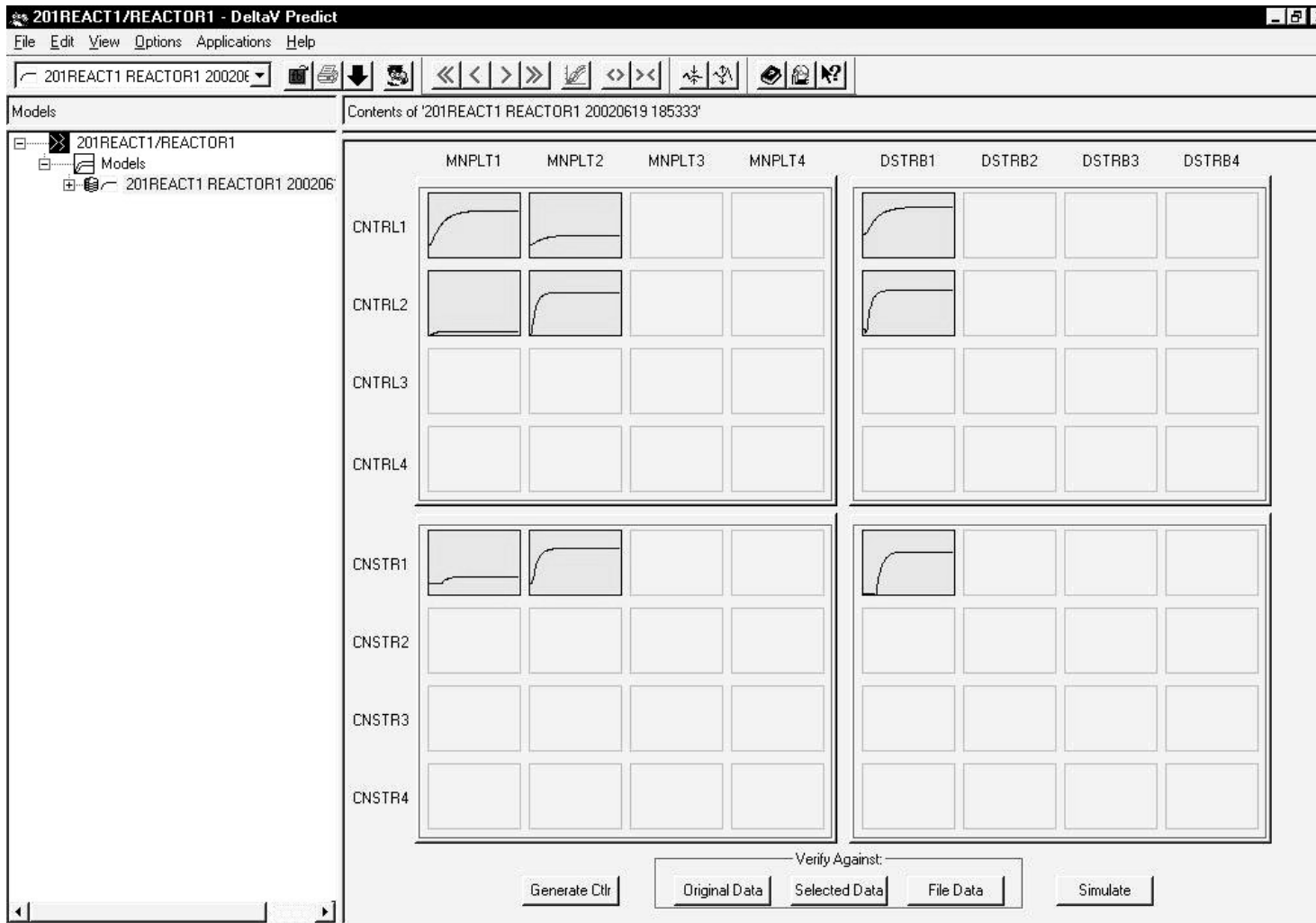
# Configuration of MPC Strategy



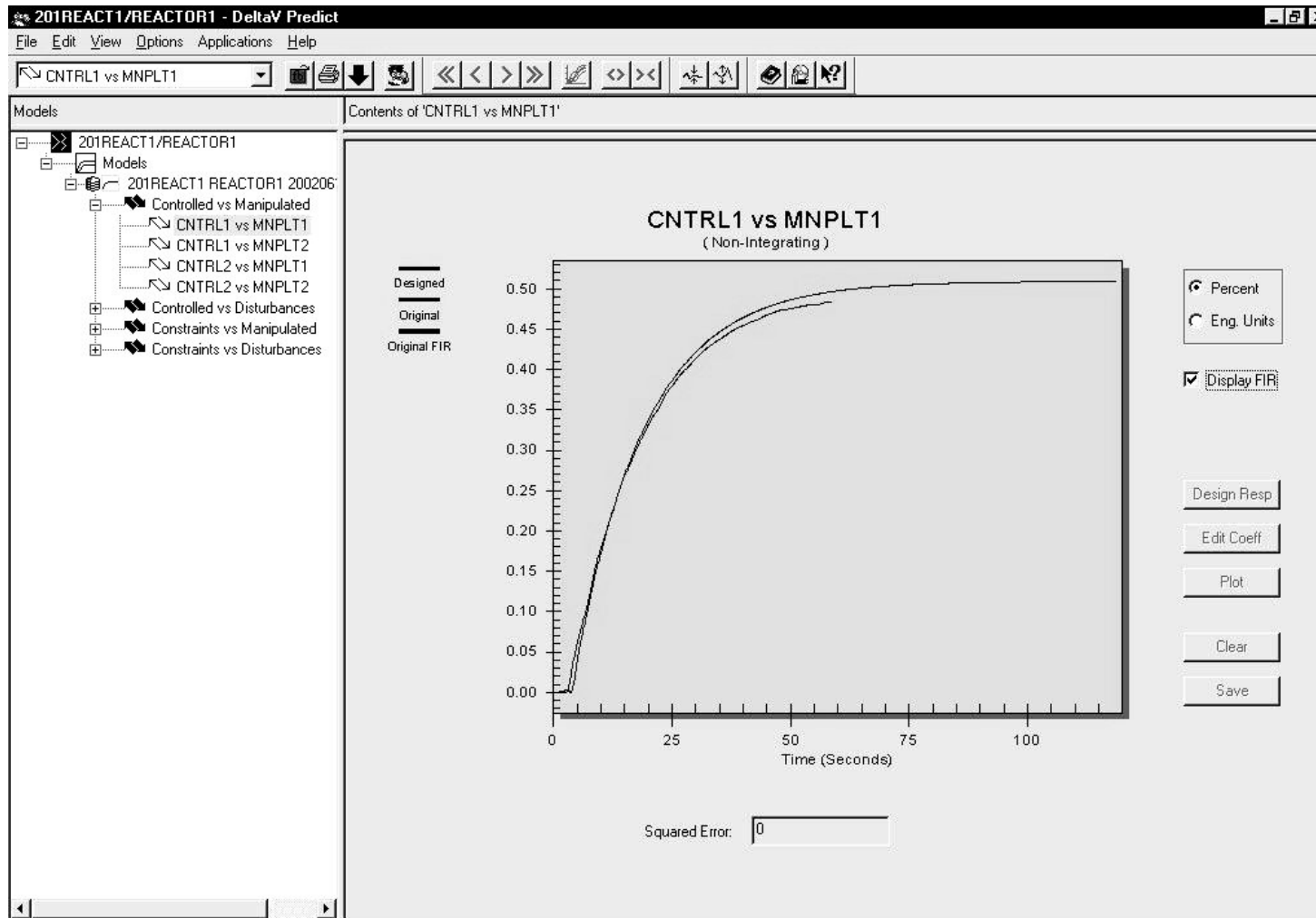
# Automated process testing to identify the process model



# Step Response Model

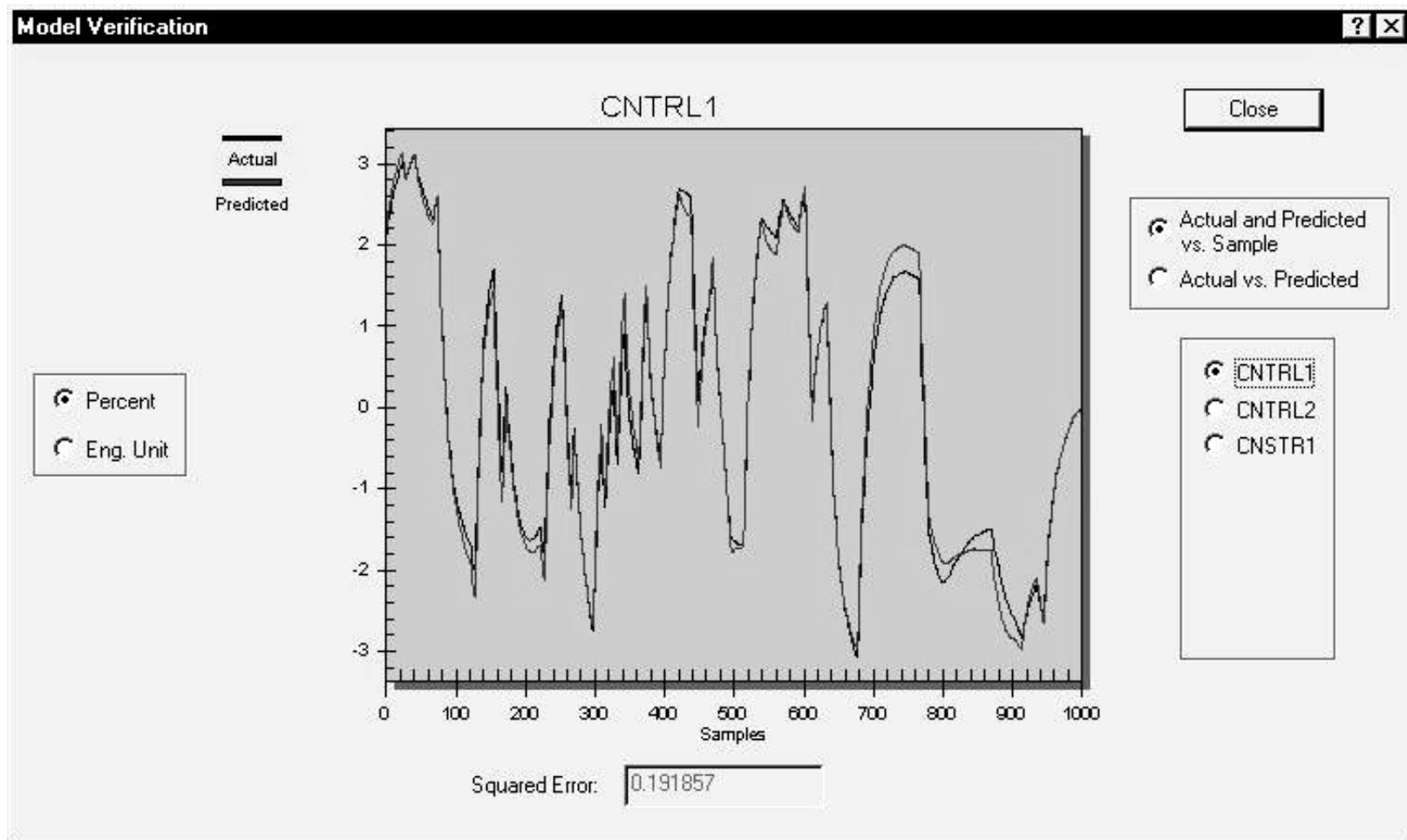


# Comparison of FIR and ARX Step Response Model





# Verification of identified model



# Testing of control using simulated environment

201REACT1/REACTOR1 - MPC Simulate

File View Trend Help

Simulating realtime

Contents of '201REACT1/REACTOR1'

Mode: AUTO, MAN, Simulate

Control: MPC, Local

1 100 History

120

19:17 19:18 19:19 19:20 19:21 19:22

19 Wed Jun 2002

| Parameter Reference          | Descriptor | Value  | Units    | Y-Scale Low | Y-Scale High | Timestamp          |
|------------------------------|------------|--------|----------|-------------|--------------|--------------------|
| 201REACT1/REACTOR1/CNTRL1.CV | 201AI150   | 4.26   | no units | 0.00        | 10.00        | 6/19/02 7:20:58 PM |
| 201REACT1/REACTOR1/CNTRL2.CV | 201FI151   | 187.26 | no units | 0.00        | 400.00       | 6/19/02 7:20:58 PM |
| 201REACT1/REACTOR1/CNSTR1.CV | 201PI160   | 92.17  | no units | 0.00        | 200.00       | 6/19/02 7:20:58 PM |
| 201REACT1/REACTOR1/MNPLT2.CV | MNPLT2     | 48.34  | no units | 0.00        | 100.00       | 6/19/02 7:20:58 PM |
| 201REACT1/REACTOR1/MNPLT1.CV | MNPLT1     | 47.49  | no units | 0.00        | 100.00       | 6/19/02 7:20:58 PM |
| 201REACT1/REACTOR1/SP1.CV    | SP 201A... | 3.89   | no units | 0.00        | 10.00        | 6/19/02 7:20:58 PM |

Mpc Block Status/Error Summary

Simulation is active (not connected to a real process)

201AI150 SP 10.0 4.3 3.9 no units

MNPLT1 100.0 47.1 47.1 no units

201PI160 200.0 92.2 no units

201FI185 400.0 84.5 no units

201FI151 SP 400.0 186.7 186.0 no units

MNPLT2 100.0 48.7 48.7 no units

Unmeasured Load Disturbance: OFF

Output Value: OFF

Bias: 0.0

Not Limited

Configured Model: 201REACT1 REACTOR1 20020619 185333 Simulation Model: 201REACT1 REACTOR1 20020619 185333 NUM Historical

# Operator interface to MPC



## ***Summary***

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- The advent of powerful and friendly integrated software has moved advanced process control (APC) from the realm of consultants into the arena of the average process control engineer
- Deficiencies in the measurement and final element can significantly reduce the improvement in process capacity and efficiency provided by APC.
- Advanced process control techniques may be implemented in stages. Most plants can justify the utilization of model predictive control.

# Questions

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- Questions from the Audience?
- Related Resources from ISA
  - Advanced Control Unleashed, available at [www.isa.org](http://www.isa.org)