Shaping Tomorrow's Engineers in Process Optimization and Control using Aspen DMC3

aspentech

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Today's Discussion

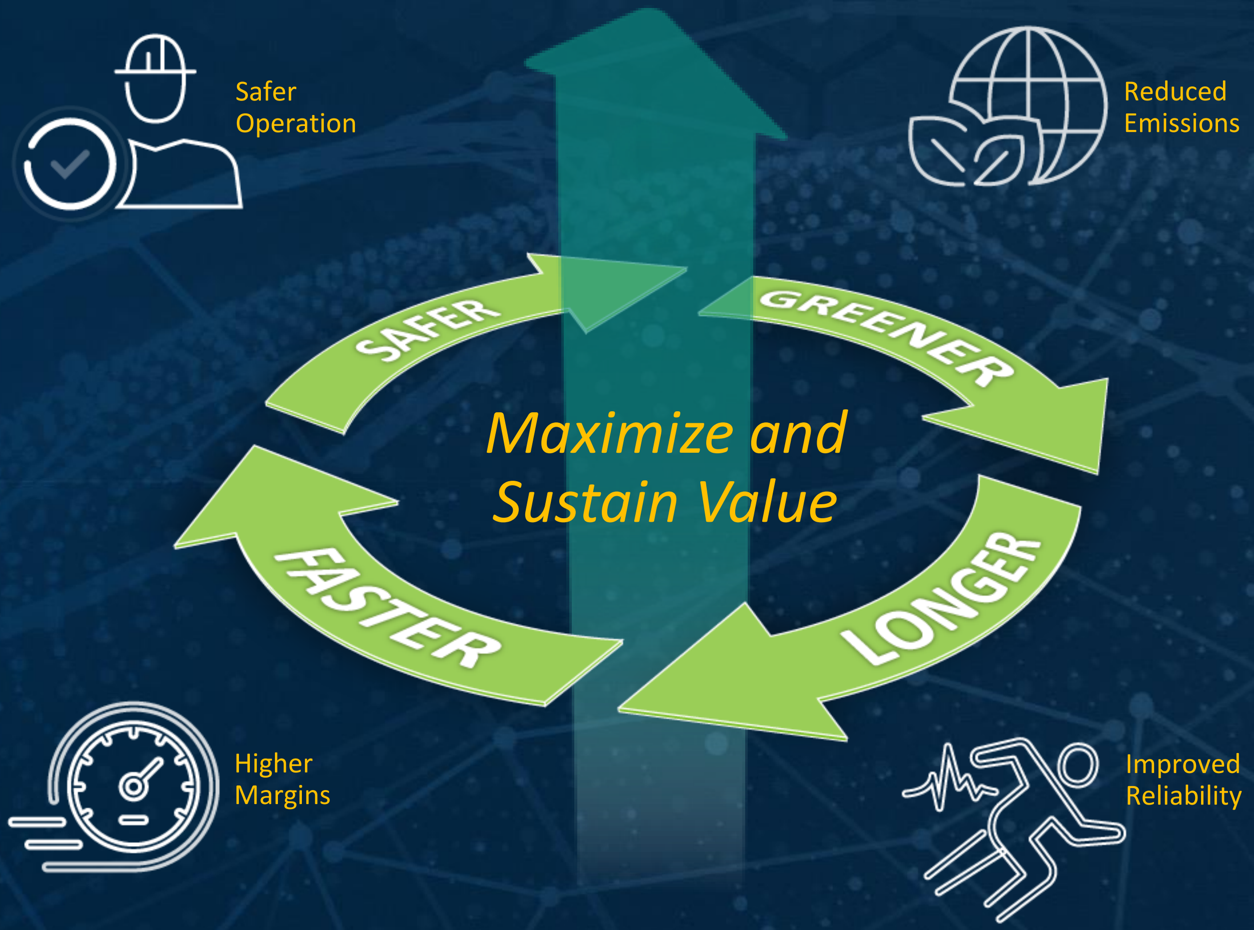
AGENDA

1. AspenTech Overview
2. Introduction to AspenTech APC
3. AspenTech DMC3 in Academia
4. Q & A

AspenTech Overview

AspenTech Mission

Accelerate the digital transformation of the industries we serve by optimizing their assets to run safer, greener, longer and faster



AspenTech – A History of Innovation

40+ YEAR JOURNEY

MIT ASPEN Project

Process Modeling & Simulation

Process Optimization

Asset Optimization

New Offerings
- Asset Performance Management
- Industrial AI
- Sustainability Models

New Vertical
- Pharma

Industrial Software Leader

New AspenTech
- Emerson Relationship
- Expanded Solutions & Expertise
- Sustainability Imperative
- Self-Optimizing Asset

New Offerings
- Digital Grid Management
- Subsurface Science & Engineering
- Enterprise Data Management

1970 1980 1990 2000 2010 2015 2020 2025 2030

EMERSON

inmation integrating success

Organic and Inorganic growth over the years.

Asset Optimization — Extending the Lifecycle

DESIGN — Pushing the Boundaries of What's Possible

OPERATE — Running to the Limits of Performance

MAINTAIN — Driving Uptime Through Actionable Insights

Performance Engineering

Manufacturing & Supply Chain

Asset Performance Management

Subsurface Science & Engineering

Digital Grid Management

Industrial Data Management

Introduction to AspenTech APC

Production Optimization: APC is the Foundation of Digital Transformation

Supply and

Production Constraints

Planning/Scheduling

Optimize Production

Satisfy Market Demand

Month/Weeks/ Days

Maintain Scheduling Targets

Coordinate Multiple APCs

Dynamic Optimization

Align Planning & Scheduling objectives to actual operations

Maximize More Profitable Products

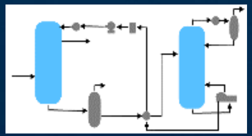
Minimize Product Giveaway

Maximize Yields/Conversion

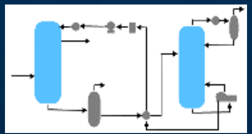
Push Process Constraints

Maintain Unit Targets

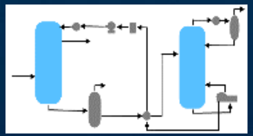
DMC3



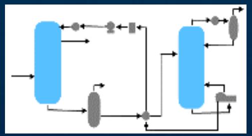
DMC3



DMC3



DMC3



Increase Throughput

Reduce Energy

Improve Unit Yields

Realtime

Running to the Limits of Performance – 24x7, minute-by-minute

Aspen APC Innovation Timeline

40 EST. 1981
YEARS OF INNOVATION

80s
- [DMC]

90s
- DMCplus

1998
- Performance Modeling
- Inferential Modeling

2000
- Aspen Inferential Qualities

2002-'05
- Automated Testing
- Smart Step
- Collinearity Detection & Repair

2006
- Modern Integrated Platform

2009
- Adaptive Modeling
- Model Quality Analysis – MQA
- Auto Slicing
- Auto ID

2010
- Nonlinear APC in the Builder
- DMCplus Engine Enhancements

2012
- DMC3
- Calibrate Mode
- Composite in the Platform

2016
- Structured Model ID
- Robust Control
- Smart Tune
- DMC3 Builder
- Variable dynamics & deadtime
- Nonlinear DMC3

2020
- AI: Maestro for DMC3
- AI: Deep Learning
- Batch APC
- APC Centralized Monitoring

2022
- AVA for DMC3
- APC Gateway
- Hybrid Models for DMC3

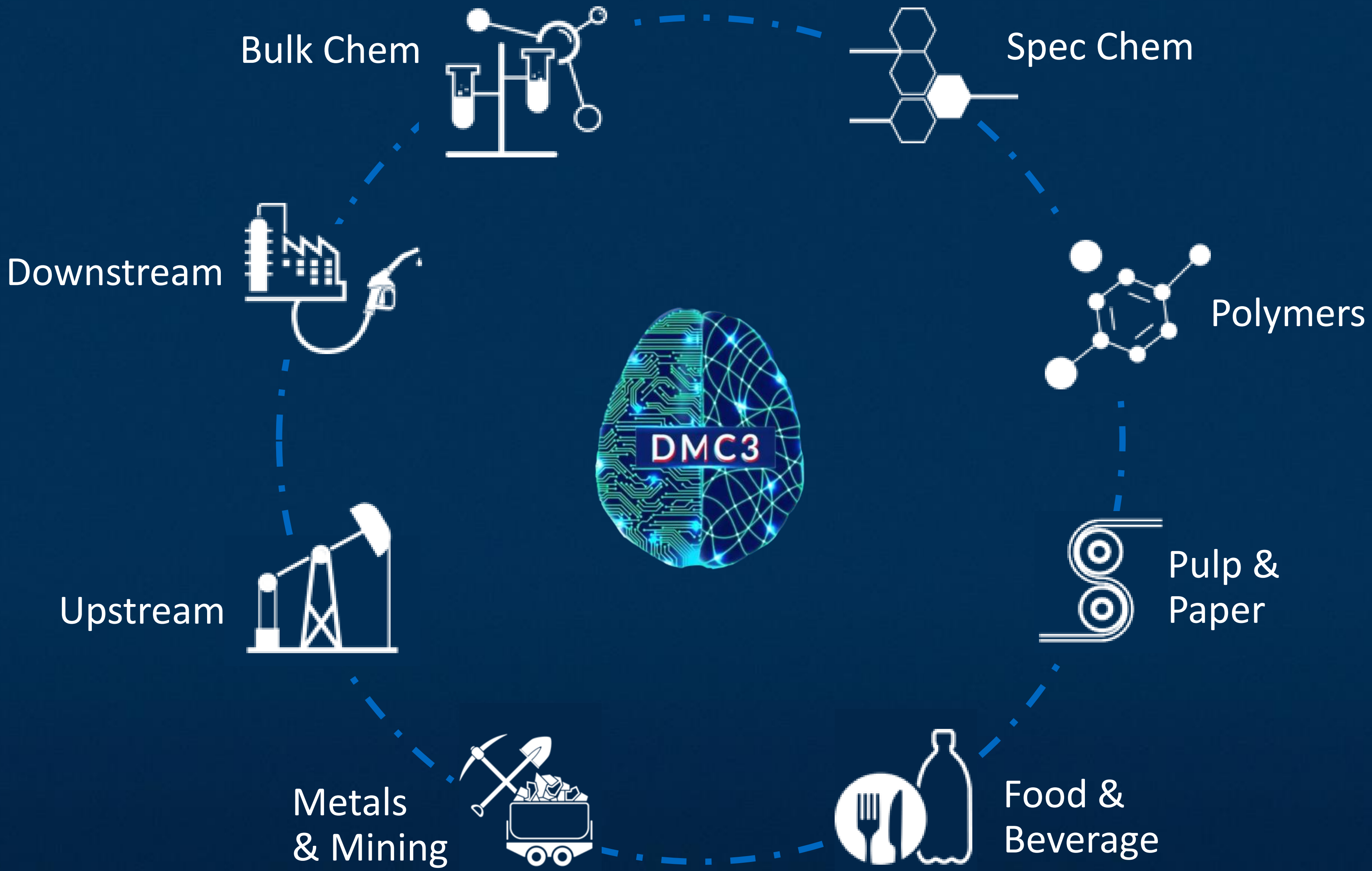
AI

Adaptive control

Maintain benefits and implement more efficiently

Increase process profitability with Aspen APC

APC Versatility: Broad Industry Use Cases



Examples of Customer Benefits – AspenTech APC

SUCCESS STORIES

rompetrol

$45 Million in benefits over 5 years

Achieved $3.8 Million/year
Savings In high capacity FCCU APC application

ESSAR

SINOPEC 中国石化

$1.5M benefits from increased yield on a single refinery unit

2-5% increase in reactor yield Using AspenTech APC

EVONIK POWER TO CREATE

LG Chem

$4M in operational benefits from APC in ethylene plant

€ 2.1 million/year benefits from reduced fuel gas usage and venting

RM Raffineria di Milazzo S.C.p.A.

* May not apply in VUCA environment. Still relevant during ramp-up.

Viewer Poll

What are the primary challenges you face when integrating process control concepts into your courses?

a) Difficulty in finding relevant and up-to-date teaching materials

b) Time constraints to adapt curriculum

c) Insufficient training

AspenTech DMC3 in Academia

AspenTech APC Solution

Definition of Terms

- Advanced Process Control (APC)
- Model Predictive Control (MPC)
- Dynamic Matrix Control (DMC)

APC Goals: Improved Operations & Profitability

- Achieving stable control of the unit in the presence of disturbances
- Maximizing unit throughput (feed flow)
- Maximizing production of the most profitable products
- Minimizing the cost of utilities (fuel gas, steam, cooling water, electricity)
- Achieving the best possible product quality to meet specifications

Examples of Process Units

- Crude Distillation unit in a refinery
- Ethylene furnaces (reactors) in a petrochemical plant

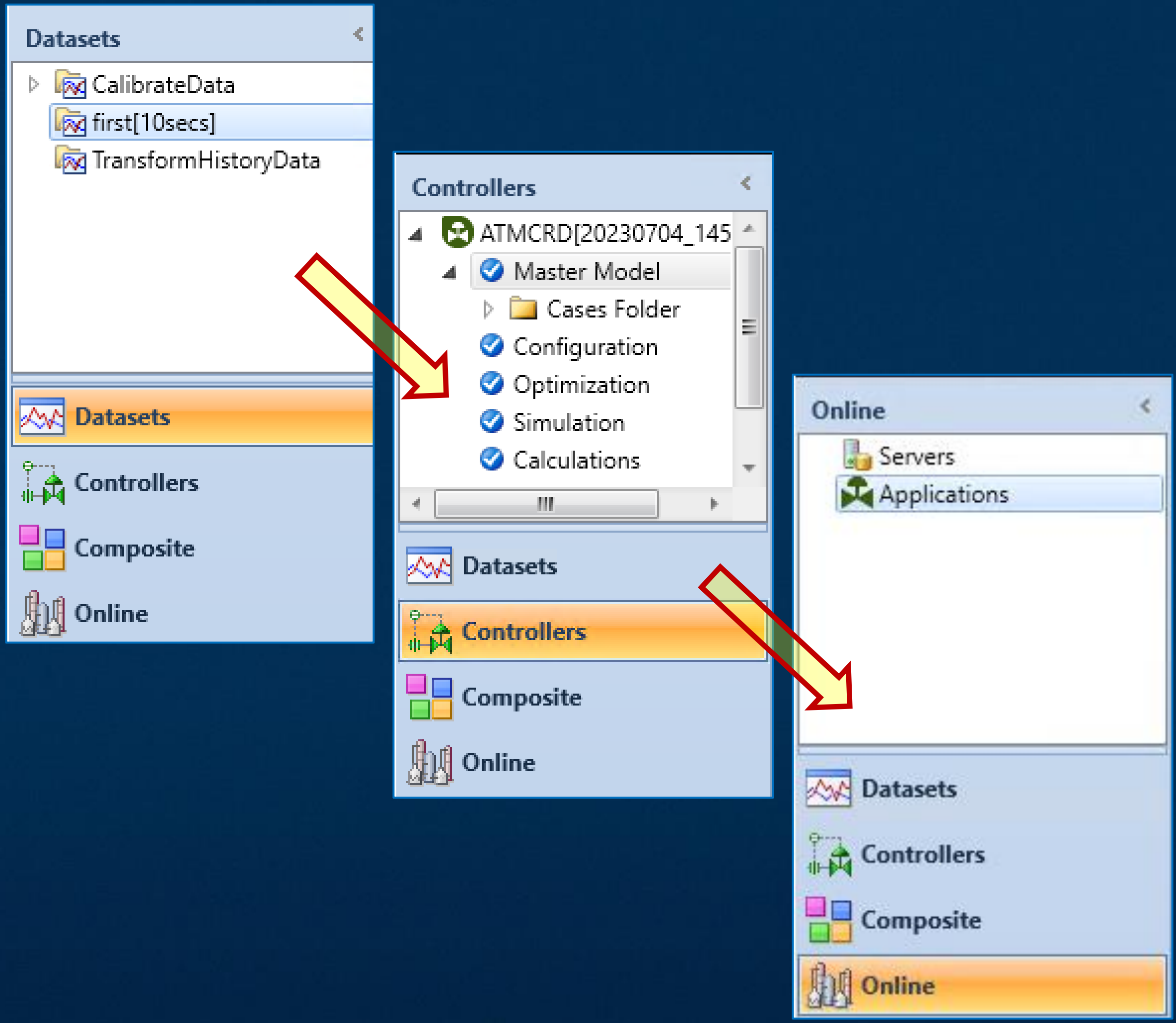
APC Project Overview

- **Project Definition and Scope**
  - Project benefits, costs, schedule
- **Preliminary Design**
  - APC objectives, scope
  - Optionally create skeleton model and connections
- **Preliminary Plant Test**
  - Start collecting live data
  - Initial steps to check system (PID, Instrumentation, etc.)
  - Generate seed model
- **Plant Step Test**
  - Generate dynamic data
  - Collect steady-state data for property estimators
- **Detailed Design and Analysis**
  - Develop dynamic models
  - Develop property estimators
  - Develop online calculations
  - Offline simulation and tuning
- **Commissioning**
  - Install and evaluate property estimators
  - Operator and engineer training
  - Closed-loop commissioning
  - Final project documentation
- **Sustained Performance**
  - Controller monitoring and enhancement
  - Maintain on-going training

DMC3 Builder is used for developing the DMC3 controller Model under the Detailed Design and Analysis step

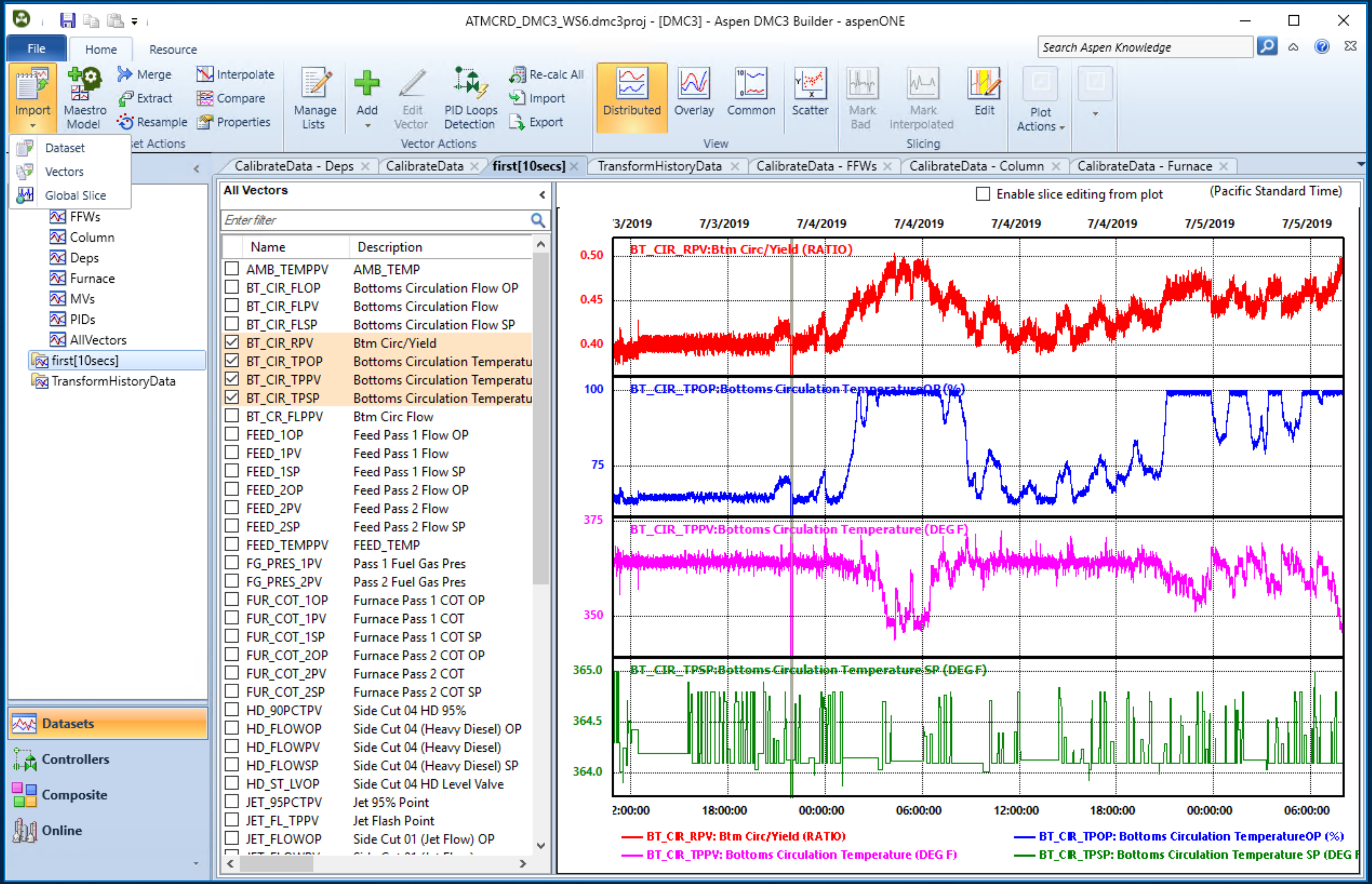
Aspen DMC3 Builder - Overview

- The DMC3 controller application is developed in DMC3 Builder
  - Part of the Detailed Design step
- Step by step work process guides the user
  - **Datasets:** import and condition the process data
  - **Controllers:** DMC3 model identification, configuration and simulation without deploying the controller online
  - **Composite:** coordinates the optimization functions of multiple DMC3 controllers
  - **Online:** Configure and test DCS connections and deploy the controller online



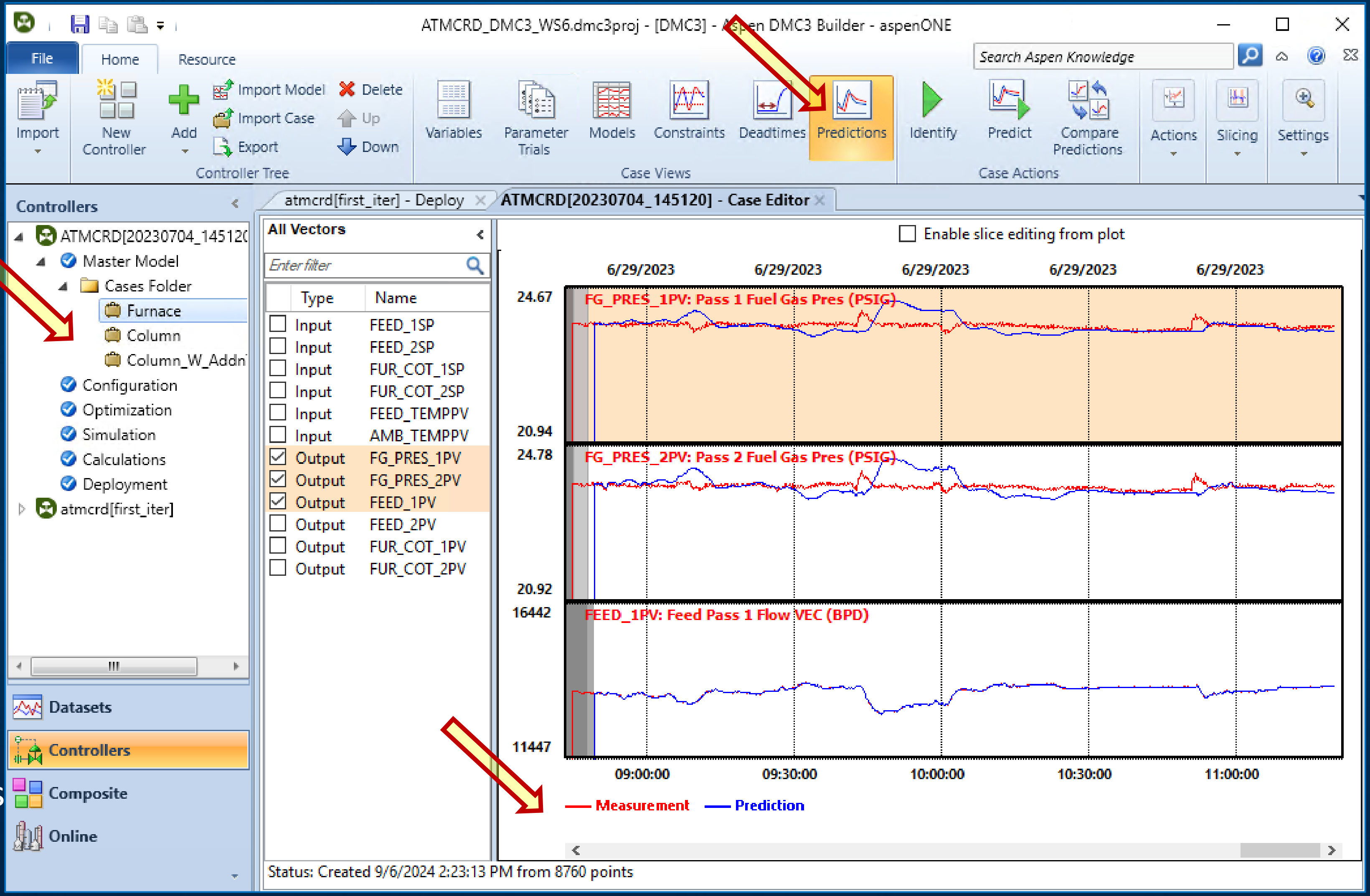
Aspen DMC3 Builder - Datasets

- Use the Import function to bring process data into DMC3 Builder
- View the data information and plots
- Use the top ribbon to condition the data and remove (slice) inappropriate data
  - For example, data spikes, flat lines, valve saturation are not suitable for model identification



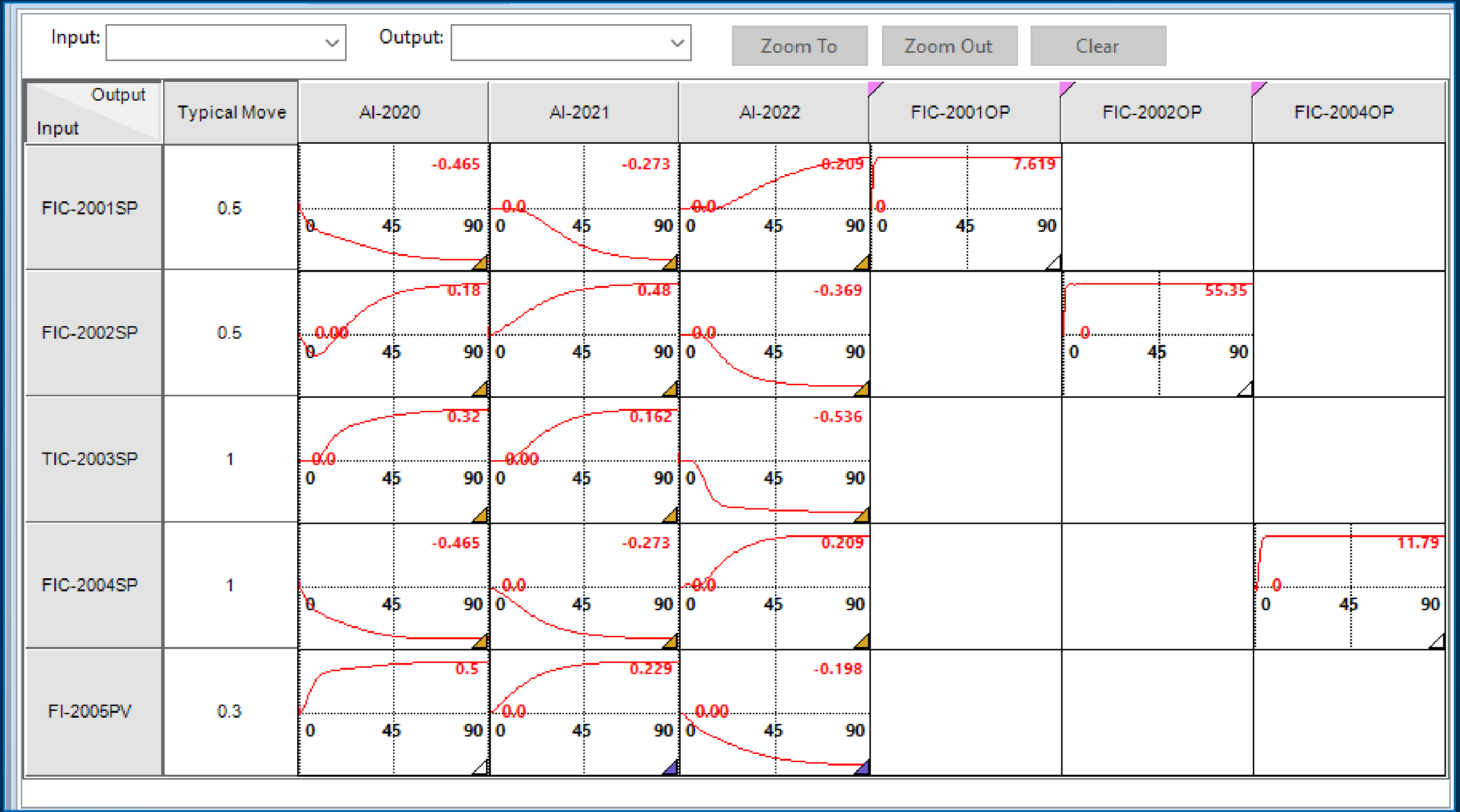
Aspen DMC3 Builder – Controllers (1)

- Model identification:
  - Run subset of the total model in cases, assemble the cases to build the final (master) model
- Algorithms available:
  - FIR and Sub-Space for linear processes
  - Deep Learning for non-linear
- Model evaluation:
  - View model predictions
  - View frequency uncertainty plots



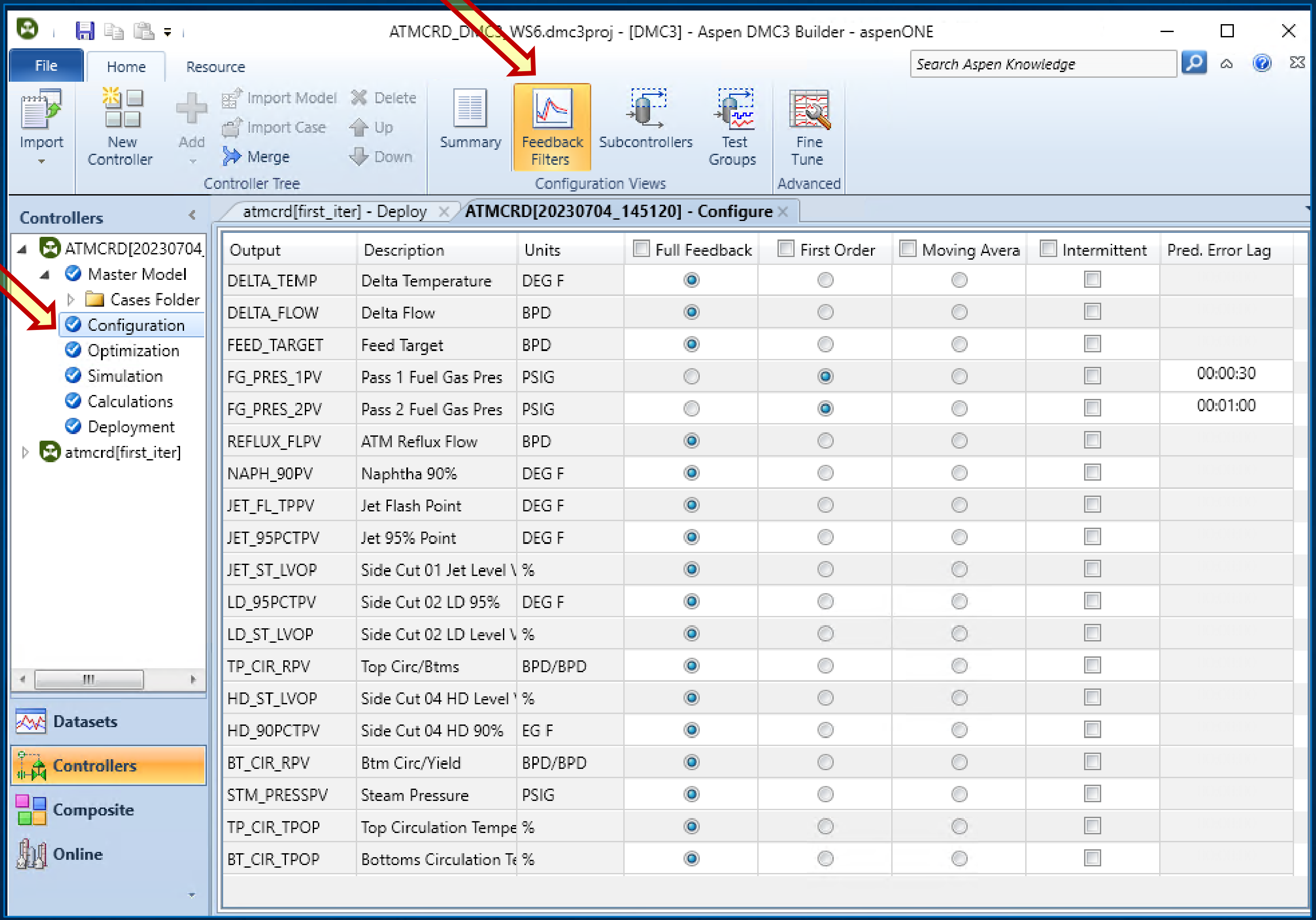
Aspen DMC3 Builder – Controllers (2)

- Master Model graph shows:
  - Controlled Variables (CVs)
  - Manipulated Variables (MVs)
  - Deviation Variables (DVs)
  - Steady state gain for each one
  - Settling time (Time to Steady State, or TTSS)



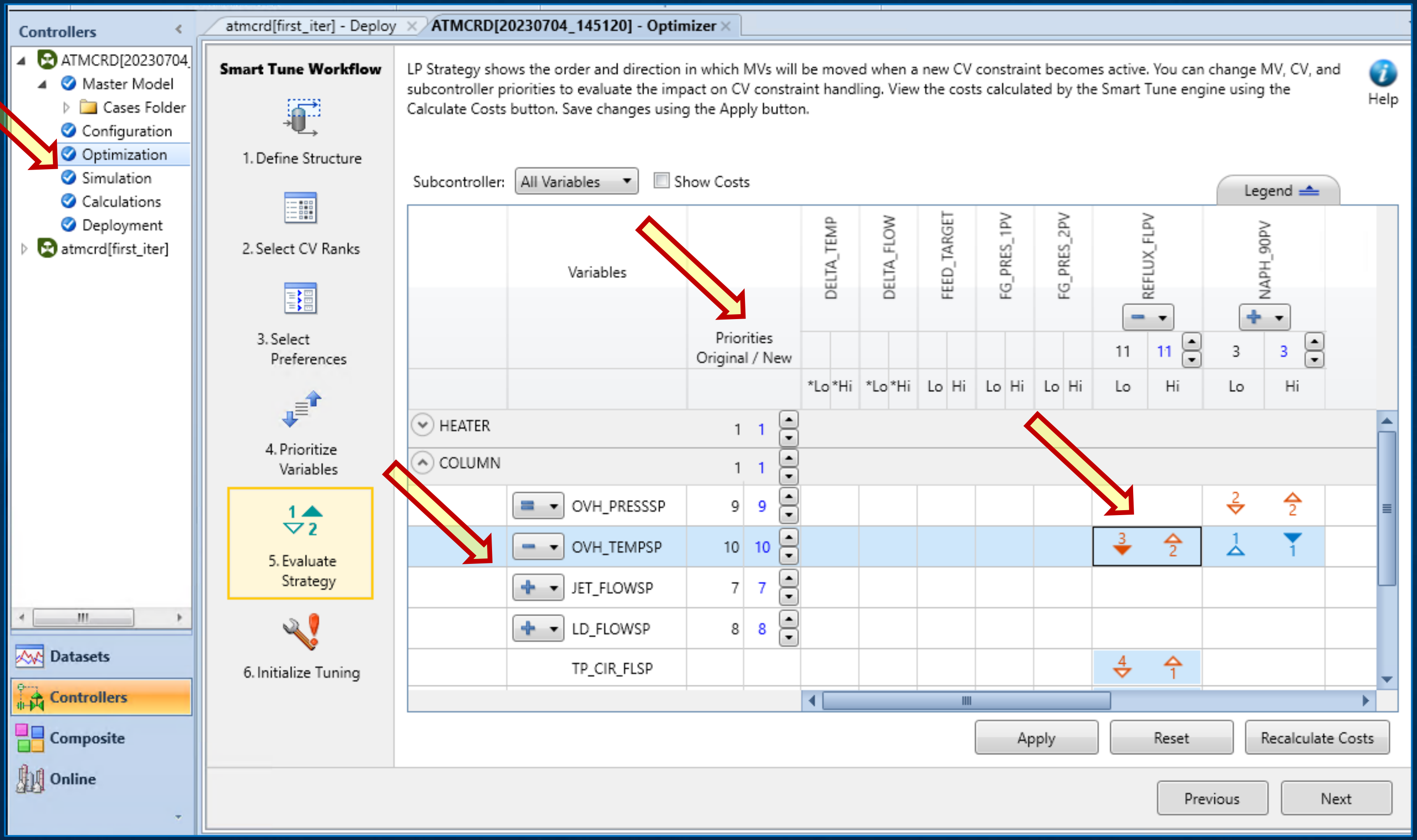
Aspen DMC3 Builder – Controllers (3)

- Configuration:
  - Set controller-wide settings
  - Feedback filters
  - Define intermittent variables
  - Sub-controllers
  - Test groups



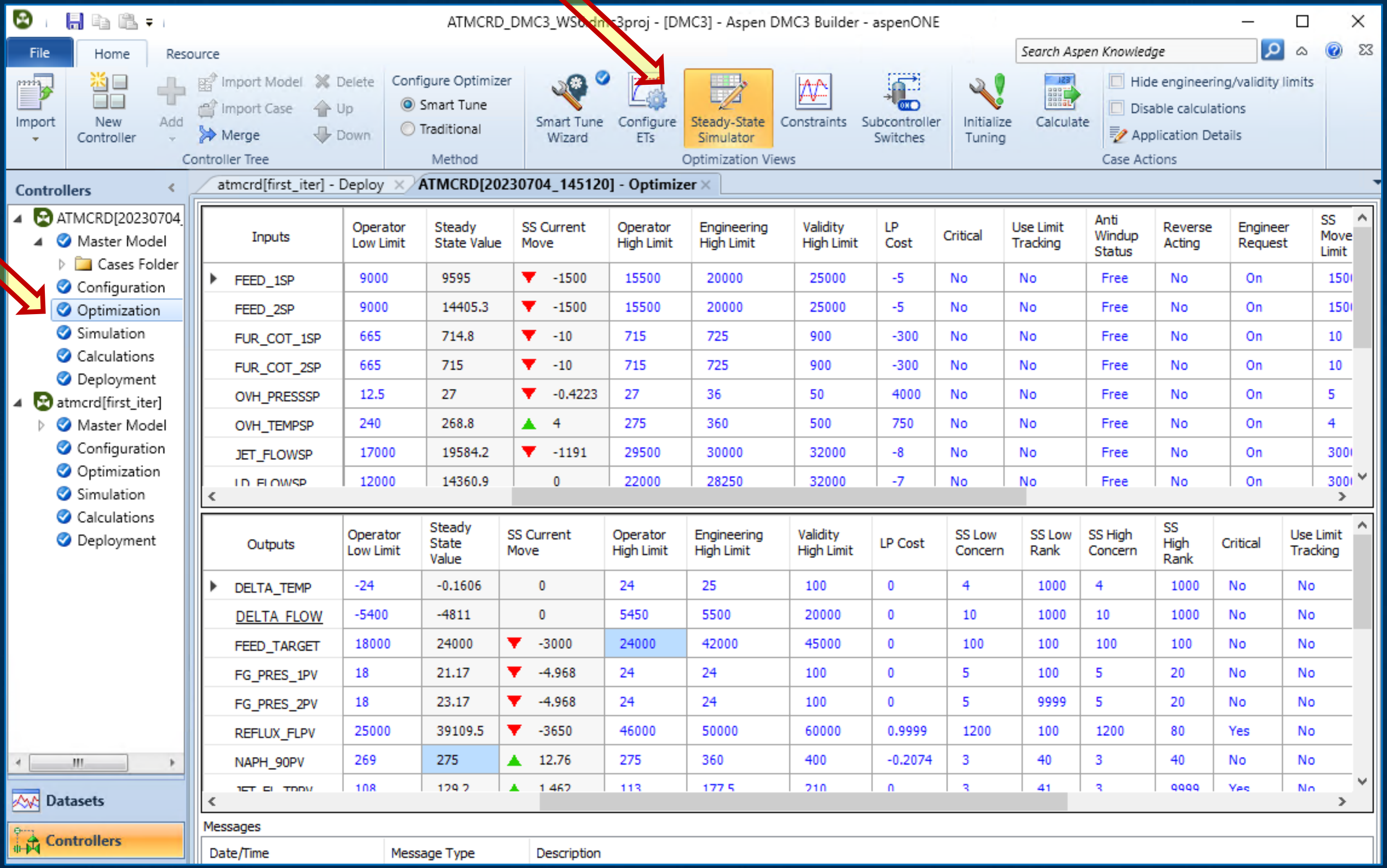
Aspen DMC3 Builder – Controllers (4)

- Optimization objectives:
  - Stepwise workflow guides through the optimization steps
  - Defines the optimization requirements, such as
  - Variables to maximize (+)
  - Variables to minimize (-)
  - Priorities of each
  - Criteria for relaxing constraints



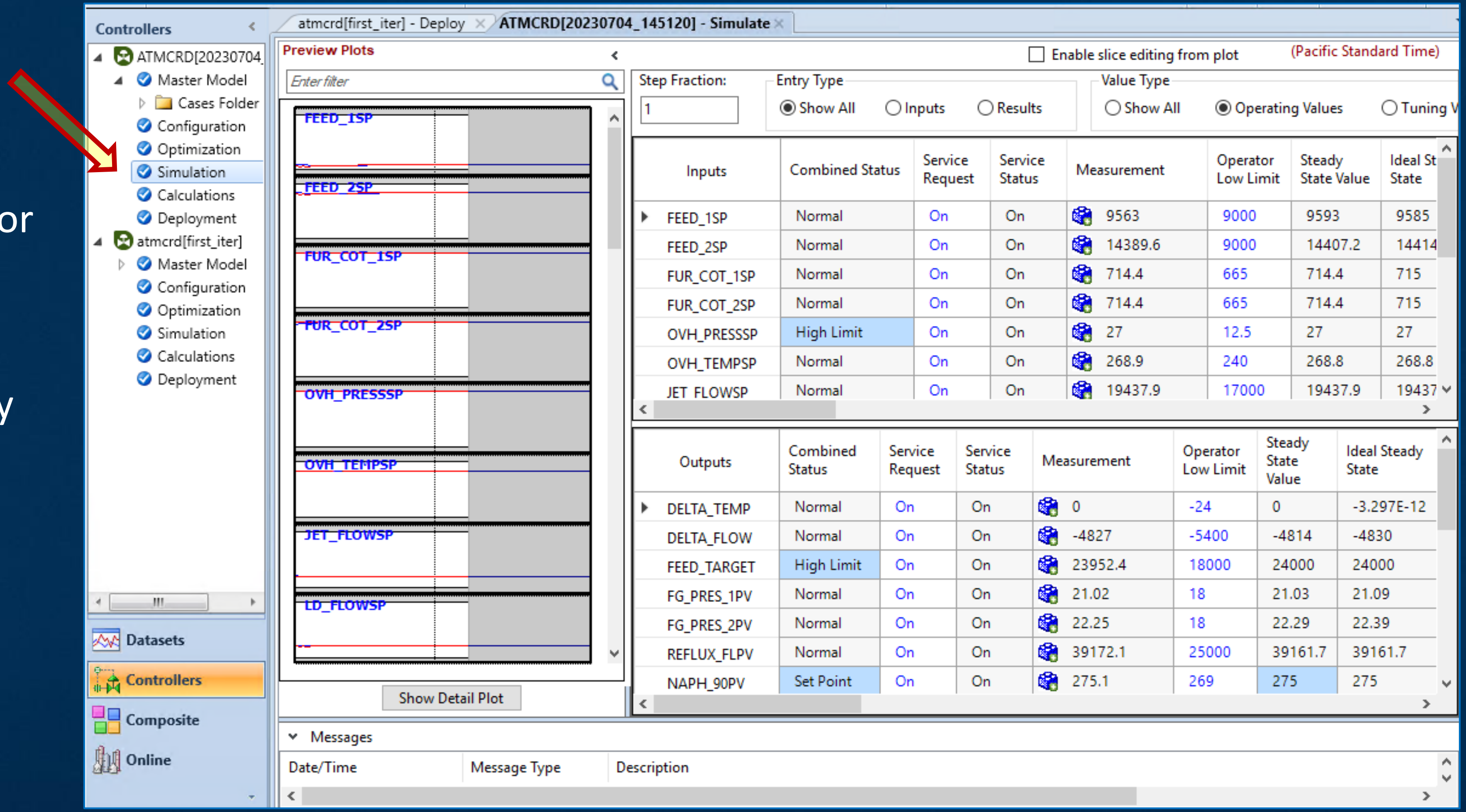
Aspen DMC3 Builder – Controllers (5)

- Steady State Simulation:
  - Optimization workflow step
  - Simulator tests controller behavior
  - Computes optimization targets
  - Is used for finalizing optimization tuning parameters
  - Various process conditions are tested to check the controller response prior to deploying it online



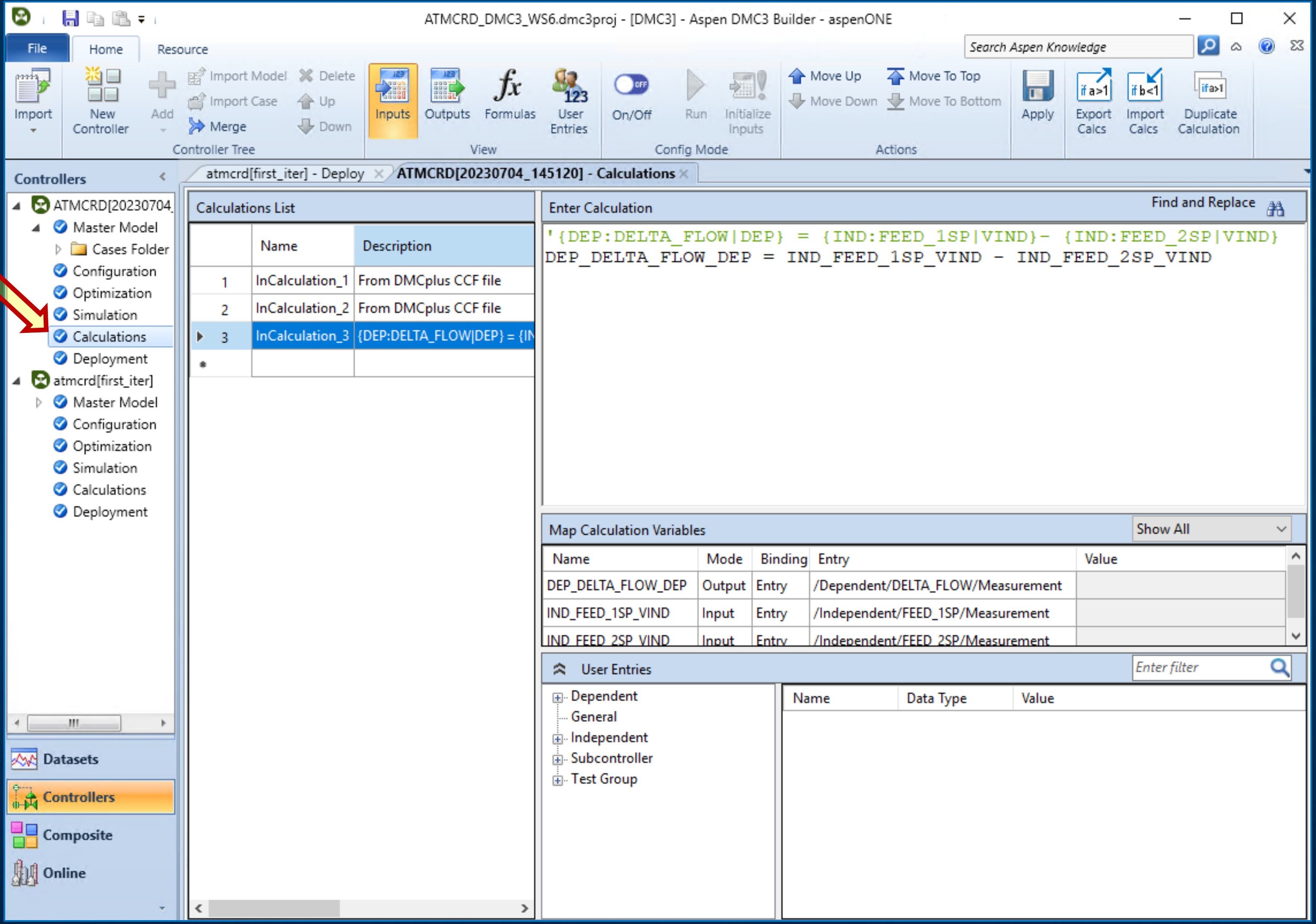
Aspen DMC3 Builder – Controllers (6)

- Dynamic Simulation:
  - Optimization workflow step
  - Simulator tests controller behavior in the dynamic sense
  - Predicts the controller dynamic response for achieving the steady state optimization targets
  - Is used for finalizing the dynamic tuning: response aggressiveness, constraint violations and similar
  - Various process conditions are tested to check the controller response prior to deploying it online



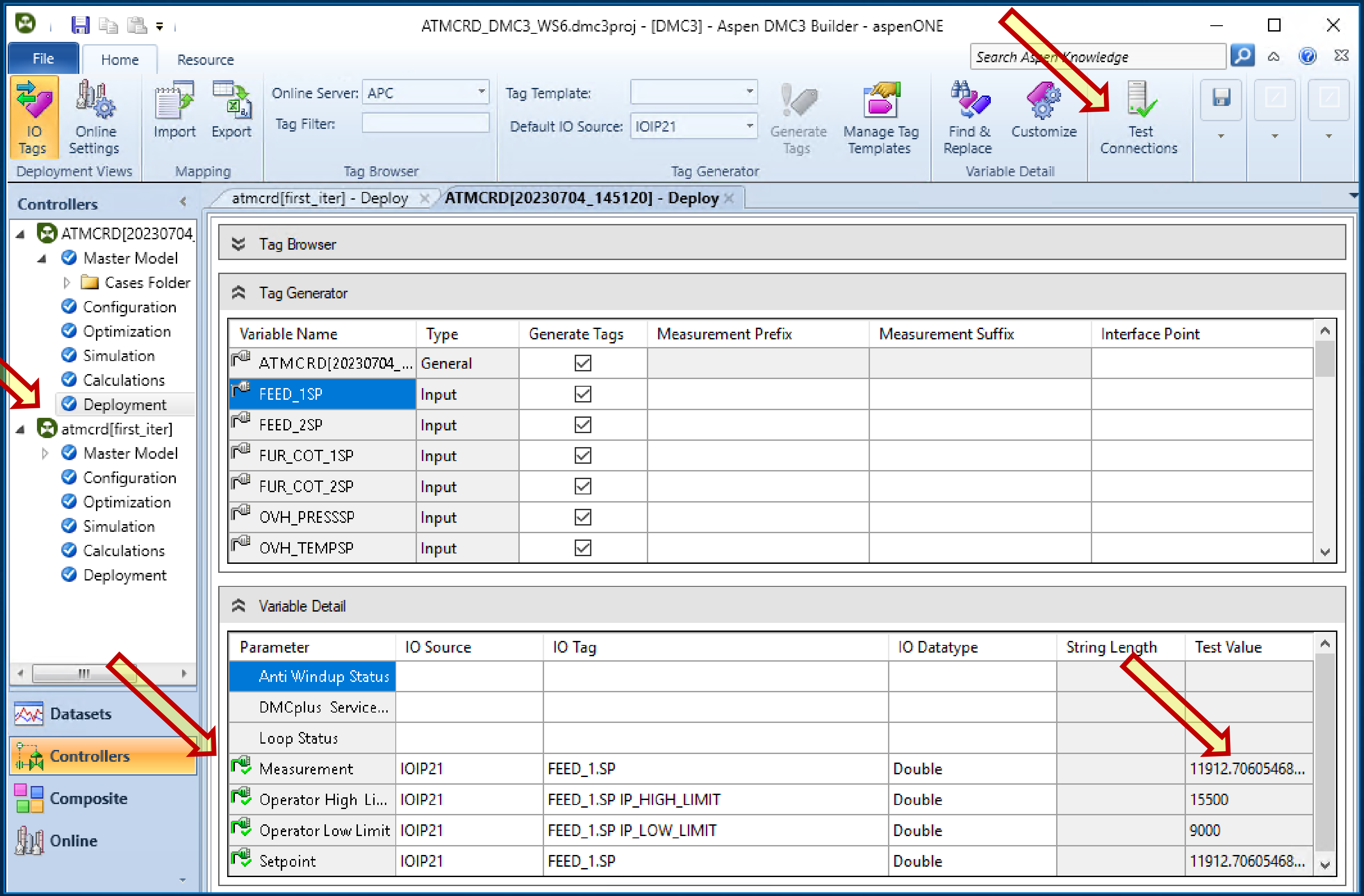
Aspen DMC3 Builder – Controllers (7)

- Custom Calculations:
  - Tool for addressing special needs
  - Calculating controller variables from other process inputs
  - Modifying controller parameters under certain process conditions
  - For example, when feed makeup changes, disable a CV and enable another
  - Can be tested offline prior to deployment
  - Defined for controller inputs (MVs) and outputs (CVs)



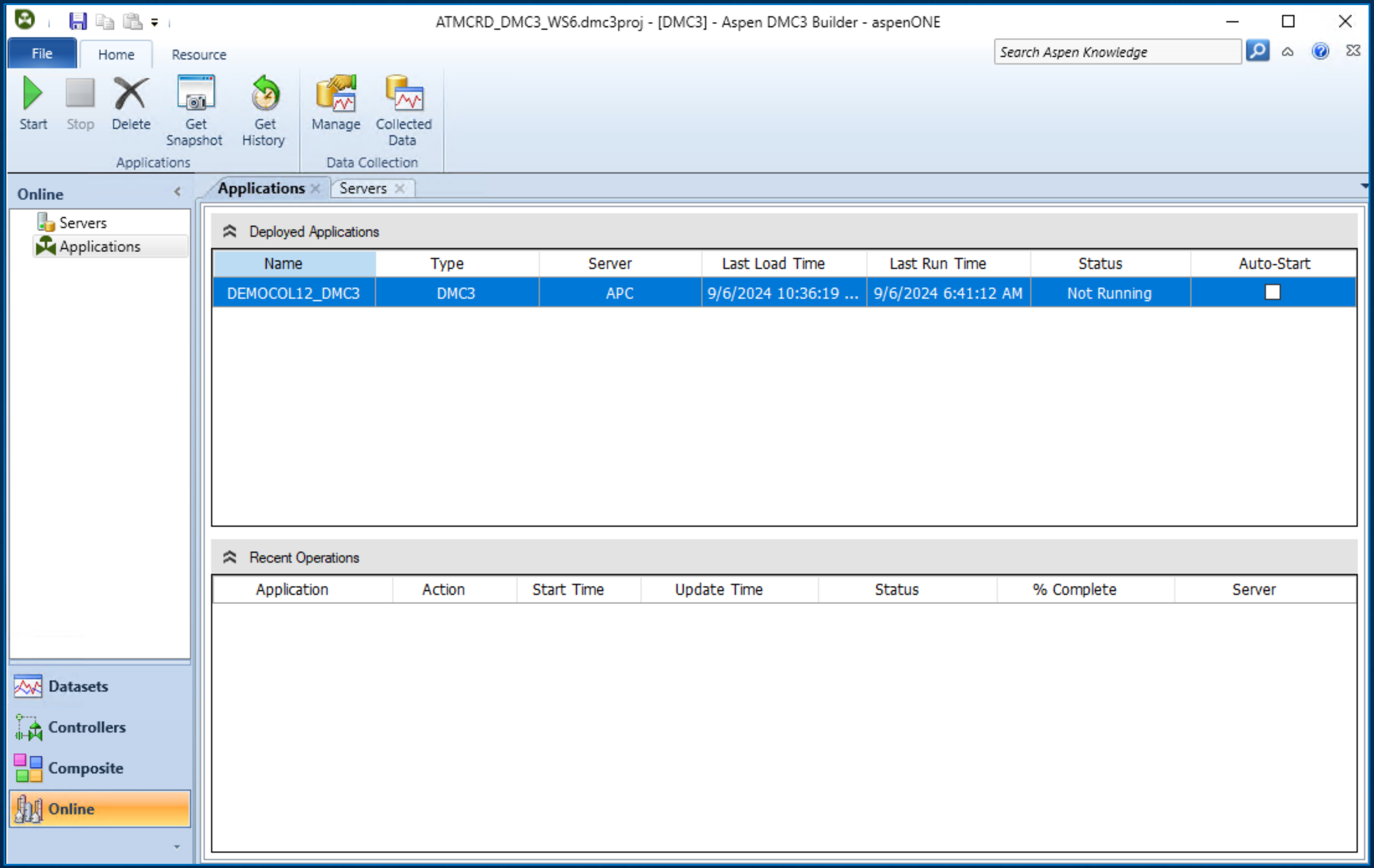
Aspen DMC3 Builder – Controllers (8)

- Deployment:
  - Define connections to the control system (DCS)
  - Test the connections to ensure the controller can read process values
  - Press the Deploy button to begin the deployment process for online operation

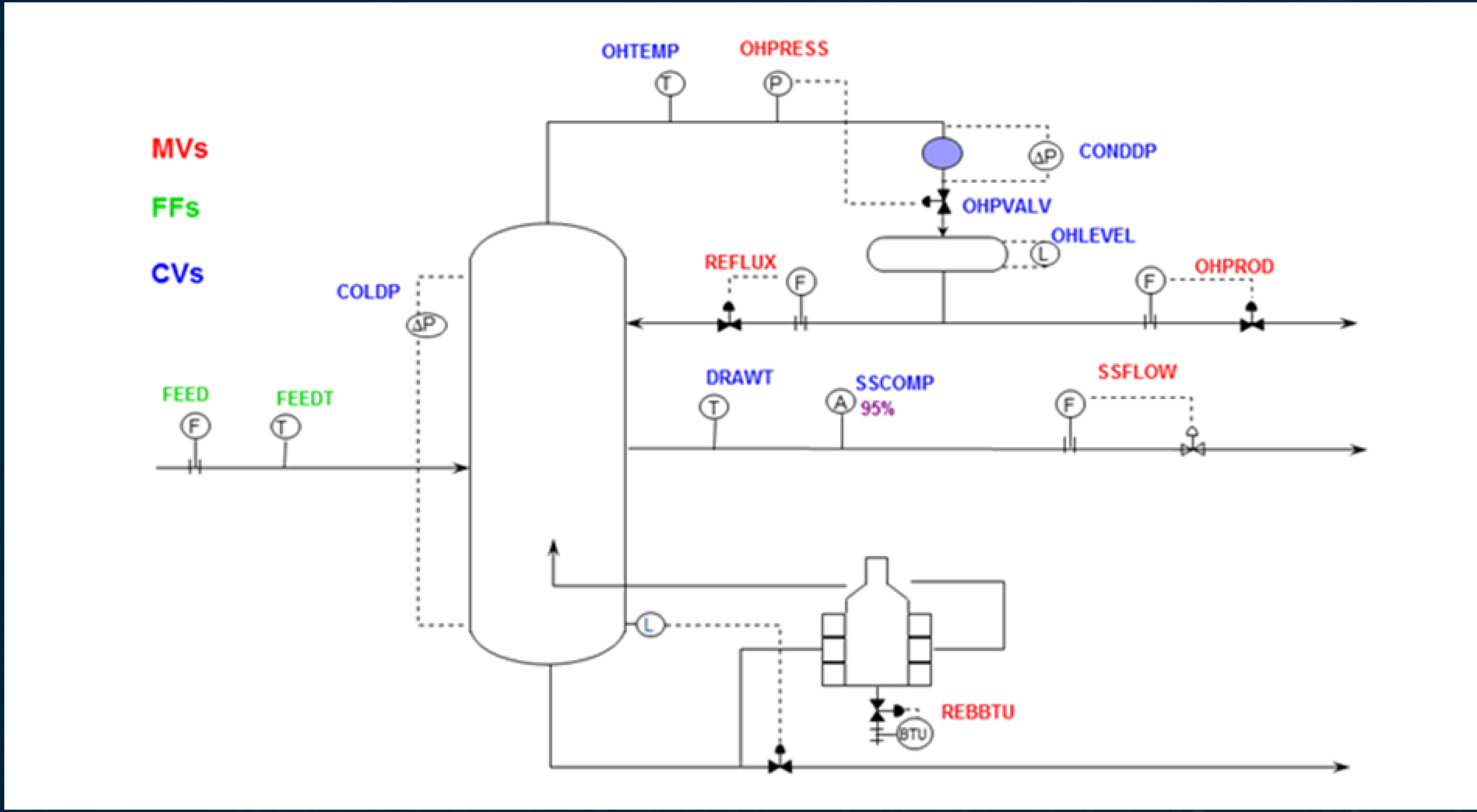


Aspen DMC3 Builder – Online

- Complete the deployment:
  - Complete the connection definitions
  - Deploy and start the controller
  - Once this step is complete the controller will be displayed on the operator web screens
  - At this point, the controller is visible but has not been started
  - It will be started once the operators are confident it is ready to begin controlling
- DMC3 Controller Demo



Simulated Distillation Column - Demo



DEMO

Viewer Poll

Which of the following topics do you currently teach in your process control classes?

a) Optimization

b) Modeling for Control

c) Automation Technology

d) Feedback control

e) Model Predictive Control

f) Control System Programming

g) Adaptive Control

h) Stability

From Research to Industry:
A Career in Control Engineering

1980

Research
- Coventry Polytechnic
- British Gas

1990

Consulting
- Cambridge Control
- AspenTech

2000

Advanced Control Services
- Applied Manufacturing Technologies
- APC in refining & chemical industries

2010

Leadership at BP
- Led APC and optimization globally
- Developed global control and automation capability

2024

Academia
- Coventry University

An Industry Perspective

- Acute shortage of APC engineers
- Difficulty for graduates to link control with process and operations
- Lack of appreciation for the depth required in control engineering
  - Systems hardware and networks
  - Human machine interfaces
  - Instrumentation and valves
  - Designing and debugging control strategies
  - Tuning
  - Commissioning

The Value of DMC3 in Process Control Curriculum

- **Industry- standard:** DMC3 is well-established and widely used industrial tool
- **Comprehensive Functionality:** Incorporates key control theory concepts, including:
  - System identification and modeling
  - State-space analysis and uncertainty management
  - Deep Learning
  - Inferential soft sensors
  - Optimization using linear and quadratic programming
  - Non-linear control strategies
- **Integration Expertise:** Requires a solid understanding of system integration:
  - IT vs OT, digital security
  - Safe communication with PAS control blocks
  - Human machine interface, interacting with complex automation

The Value of DMC3 in Process Control Curriculum

- **Extensive Experience:** DMC3 methodology is based on decades of real-world engineering experience
- **Broader Perspective:** Understanding this methodology helps students grasp the broader context of control problems:
  - Integrating operations, human factors, and safety considerations
  - Appreciating the role of instrumentation and process actuation
  - Understanding the development of control schemes and strategies
  - Recognizing the exciting and rewarding nature of control engineering

Leveraging DMC3 in Academia

Teaching

- Bridging Theory and Practice
  - Use DMC3 to illustrate the hands-on application of control theory in practice.
- Real-World Examples:
  - Developing models by fitting plant test data
  - Addressing non-linear control challenges

Research

- Identifying Research Gaps
- Enhancing MPC Usability and Operability

Focus on:

- Improving visualization and interaction with complex MPC applications
- Using clear language to enhance situational awareness
- Strengthening the connection between the MPC layer and the PID layer for better system adaptability

Questions & Answers

Next Steps: Access to Relevant Resources

Get started with key resources

DMC3 Builder: This video series offers a comprehensive introduction to the Aspen DMC3 Builder interface. Learn how to efficiently manage datasets and deployments in a streamlined environment.

- How-to Video Series Part 1
- How-To Video Series Part 2

Learn more about AspenTech Academic Program

Visit our website: AspenTech Academic Program

AspenTech Academic Order: Form to submit your new order or renewal

Questions: If you have any questions email Cecilia.singh@aspentech.com


Thank You!
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