AspenTech Advanced Process Control
DMC3 – 3rd Generation of Adaptive APC Technology

Aspen Technology, Inc.

Alex Kalafatis, Sr. Director, Product Management
Lucas Reis, Sr. Product Manager, Product Management
Production Optimization

**Forecast & Plan**
Balance supply & demand

**Inform the plan**
VALUE CHAIN OPTIMIZATION

**PRODUCTION OPTIMIZATION**

1. **Plan & Schedule**
   Optimize feed, processing & products
2. **Control & Optimize**
   Maximize quality & performance
3. **Assess Reliability**
   Minimize risk
4. **Prescriptive Maintenance**
   Avoid unplanned downtime

**What can the plant produce?**

- **Plant Digital Twin**
  Optimize OPEX by mirroring asset
- **Design & Debottleneck**
  Optimize CAPEX and time to market

**What's the condition of the plant or process?**

**Actionable Insights & Automated Execution**
Collect, visualize, analyze, automate

**Operate**

**MAINTAIN**

**OPERA**
Optimize product distribution

**DESIGN**

**VALUE CHAIN OPTIMIZATION**
Produce to demand

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Production Optimization
APC is the Foundation of Digital Transformation

Supply and Production Constraints

Unified Planning/Scheduling

Optimize Production
Satisfy Market Demand

Dynamic Optimization
Align Planning and Scheduling objectives to actual operations

Maximize More Profitable Products
Minimize Product Giveaway
Maximize Yields/Conversion

DMC3

Maximize Yields/Conversion

Push Process Constraints
Maintain Unit Targets

Maintain Scheduling Targets
Coordinate Multiple APCs

Increase Throughput
Reduce Energy
Improve Unit Yields

Running to the Limits of Performance – 24x7, minute-by-minute
Aspen APC Innovation Timeline

- **80s**: Performance Monitoring, Inferential Modeling, DMC
- **90s**: Colinearity Detection and Repair, Nonlinear Control, Modern Integrated Platform
- **2000**: Automated Testing, Multivariable Step Testing, State Space Controller
- **2002**: Nonlinear Inference Modeling, DMCplus Engine Enhancements
- **2003**: Composite in the Platform
- **2005**: Nonlinear APC in the Builder
- **2006**: Adaptive Modeling
- **2008**: DMCplus in the Platform
- **2009**: Adaptive Model ID, Calibration Mode, Model Quality Analysis - MQA, Auto Slicing, Auto ID
- **2010**: DMCplus Engine Enhancements, Composite in the Platform
- **2012**: Model Quality Analysis – MQA, Auto Slicing, Auto ID
- **2016**: Structured Model ID, Robust Control, Smart Tune, DMC3 Builder, Variable Dynamics, Variable Deadtimes
- **2020**: Batch APC, APC Centralized Monitoring, Nonlinear DMC3, KPIs for inferentials

**Key Features**
- Maintain Benefits and implement more efficiently
- Increase Process Profitability with Aspen APC

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Why DMC3 Adaptive Process Control?

Actual plant performance changes overtime, APC Models need to adapt

- Equipment performance change (e.g. fouling, catalyst life etc.)
- Unit turnarounds, Process modifications
- Operating or economic conditions change and many more..

Lost Benefits $$
Why do companies choose Aspen DMC3 – *Adaptive Process Control*

- Keeping models up to date
- Adaptive Process Control enables continuous background maintenance
- Testing is disruptive and difficult to schedule
- Optimizing while testing in the background
- Too few/experienced APC resources
- Lower APC footprint leading to low benefits
- Minimal maintenance efforts and rapid deployment enables footprint expansion
- Ease of use, powerful tools, simplified tuning

**Ease of use, powerful tools, simplified tuning**

**Too few/experienced APC resources**

**Minimal maintenance efforts and rapid deployment enables footprint expansion**

**Lower APC footprint leading to low benefits**

**Testing is disruptive and difficult to schedule**

**Optimizing while testing in the background**
Adapt to New Operating Conditions in an VUCA Environment

VUCA: (Volatility, Uncertainty, Complexity, Ambiguity)

- Significant changes to product demand necessitate production rate drops & ramp-ups to be managed safely
- Need for agility with product mix changes
- Updating nonlinear APC models in a new operating environment is very challenging
- Work-force shifting to remote and essential-only due to pandemic risk
- Specific energy reduction still a key objective
- Need for sustainability of APC applications benefits
Adapt to New Operating Conditions – Why Now?

Production Agility

Quickly adapt to significant changes in process unit operating points
State-of-the-art adaptive process control solution to enable non-disruptive testing in the background to build & adapt controller models to new operating conditions

Capabilities

▪ Easily calibrate model adaptation to new operating conditions
  ▪ **Sharp changes in production rates**

▪ Continuously optimize processes to ensure preferred product yields
  ▪ **Significant shifts in product mix**

▪ Easily account for severe process nonlinearities
  ▪ **New operating environments**

▪ Remotely monitor performance with secure data access
  ▪ **Lean Operations, Remote Workers**
Adaptive Process Control
Aspen DMC3™

Sustain Peak Plant Performance and Enable Rapid Deployment

Automatically Adapt and Optimize to Ever Changing Plant Conditions
Maintain and expand APC benefits achieved through production increases, energy reductions, & yield improvements with patented Adaptive Process Control technology

Challenges with APC

- Sustaining APC Benefits
- Few Experienced Resources
- Low APC Footprint
# AspenTech APC – Key Differentiators Vs Competition

## Executive Summary

<table>
<thead>
<tr>
<th>Feature</th>
<th>AspenTech</th>
<th>Competitor</th>
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<tbody>
<tr>
<td>1. Optimizing Control while Calibrate testing</td>
<td>Patented</td>
<td>Absent</td>
</tr>
<tr>
<td>• Enables Background Model Updates &amp; Rapid Deployment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Model Quality Analysis</td>
<td>Patented</td>
<td>Absent</td>
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<tr>
<td>• Real-time Monitoring and Predictive Maintenance</td>
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<td>3. Ease of Tuning and Optimization</td>
<td>Patented</td>
<td>Absent</td>
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<tr>
<td>• Explicitly specify variable priorities and optimization direction for objective function</td>
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<td>4. Robust Control with Economic Relaxation</td>
<td>Patented</td>
<td>Absent</td>
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<tr>
<td>• Make the controllers more resilient to model quality issues and process disturbances</td>
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<td>5. Closed-loop Capable Model ID</td>
<td>Full Capability and Proven</td>
<td>Partial</td>
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<tr>
<td>• Very robust algorithm to unmeasured disturbances</td>
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<td></td>
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<tr>
<td>• Can handle MV-Cross Correlations</td>
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<tr>
<td>• Can handle up to 80% closed loop data</td>
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DMC3 Adaptive Technology: Some Recent Innovations

Specific Technologies

- Calibration mode
- Model Quality Analysis
- Robust Control with Economic Relaxation
- Closed-loop Capable Model ID
- Automatic Data Slicing
- Constrained Identification
- Online Model Assembly
- Collinearity analysis and optimal repair

Patents

- **US 7,209,793 B2**: Automated Closed Loop Step Testing of Process Units
- **US 8,560,092 B2**: Apparatus and Method for Model Quality Estimation and Model Adaptation in Multivariable Process Control
- **US 9,715,221 B2**: Online Control Calculation for Models Containing Near Collinearity and Uncertainty
- **US 10,082,773 B2**: Formulating Steady-State Targets Using Prioritized Objective Functions
- Provisional App: Apparatus and Method for Automated Data Selection in Model Identification and Model Adaptation in Multivariable Process Control
Calibrate: Enables Background Model Updates & Rapid Deployment

Optimizing Control while testing

**Background Testing**

A single parameter to adjust trade-off between optimal control and step testing

No Operator Intervention

Test (CR=1)  Control (CR=0)
Aspen DMC3 Deployment and Maintenance Lifecycle

Traditional Work Flow

Pre-Test → Step Test → Model ID → Build Controller → Commission → Sustain

3 - 4 Months

Start Getting Benefits

Aspen DMC3 Work Flow

Pre-Test → Calibrate Mode → Reduce Calibration Ratio → Model ID → Update Controller → Continuous Improvement

3 - 4 Weeks

Start Getting Benefits

Traditional Work Flow vs. Aspen DMC3 Work Flow

- Traditional Work Flow:
  - Pre-Test
  - Step Test
  - Model ID
  - Build Controller
  - Commission
  - Sustain
  - 3 - 4 Months
  - Start Getting Benefits

- Aspen DMC3 Work Flow:
  - Pre-Test
  - Calibrate Mode
  - Reduce Calibration Ratio
  - Model ID
  - Update Controller
  - Continuous Improvement
  - 3 - 4 Weeks
  - Start Getting Benefits
Adaptive for New Projects
Faster Benefits Accrual
Real-time Monitoring and Predictive APC Maintenance

Visualize, analyze, monitor and access real-time controller KPIs to gain key insights into controller performance.

- Pin point troubled areas for focused revamps and continuously measure performance
- Proactive controller monitoring
- Improve controller uptime and utilization
- Rapidly detect and diagnose performance issues
Smart Tune - Ease of Tuning and Optimization

Easily setup optimizer, Enable more engineers

Patented optimizer enables directly specifying controller objectives instead of tuning parameters

Eliminate complicated tuning by directly specifying objectives

No need to revisit tuning after model updates

Quickly adapt to changing economic objectives
Variable Deadtimes and Scalable Dynamics

Easily adjust model dynamics and deadtimes

Avoid switching models

Accurate models across operating range
Varying Model Parameters (in online PCWS)

- Gain Multipliers
- Time Constant Multipliers
- Variable Deadtime
Nonlinear APC Models in DMC3

Improve product yield & maintain tighter product quality

Benefits

- Model & optimize nonlinear variables by capturing the inherent complexity of such applications, while simplifying model development & deployment

- Democratize nonlinear control & reduce barrier for model development & deployment – an area previously limited only to a few experts

- Versatile solution, driving the optimum towards greater value for both linear & nonlinear models with one technology
Future Feedforward Trajectories

- Allows engineers to specify a future trajectory.
- Useful for processes where predictable feedforwards like fan switches.
- Controller performance can be improved as the controller can start taking action in advance.
Aspen Inferential Qualities (IQ)

- Aspen IQ is a tool to develop linear steady state-based inferential models based on process parameters
- Acts as Soft Analyzer(s) & helps augment existing lab instruments
- Reduces Reliance on Analyzers and Lab Samples
- Provides instant feedback to operators
Inferential Modeling in DMC3 Builder

- **Available Features:**
  - Integration between Aspen IQ and DMC3 Builder.
  - Leverage all data analysis tools in DMC3 Builder to build Steady-State inferentials.
  - Inferential objects are saved under datasets:
  - Export inferentials to files and load in Aspen IQConfig to deploy online.

- **Simple Workflow Wizard**
  - Available Features:
  - Integration between Aspen IQ and DMC3 Builder.
  - Leverage all data analysis tools in DMC3 Builder to build Steady-State inferentials.
  - Inferential objects are saved under datasets:
  - Export inferentials to files and load in Aspen IQConfig to deploy online.
Aspen IQ Watch

- Available Features:
  - Enable AW monitoring for individual IQ modules in Aspen IQConfig.
  - AW automatically recognizes inferentials with the AW monitoring flag enabled.
  - Standard KPI library available.
  - KPIs can be customized from AW Maker in PCWS.
  - X-Y plot enabled to monitor unbiased prediction versus lab/analyzer.

- KPI plots and trends

![KPI plots and trends diagram](image-url)
Aspen Centralized Monitoring
Monitor APC Benefits with Secure Remote Access

Improve operating margins (increase production rates, quality and energy efficiency) across enterprise with greater visibility into APC performance.

Key Capabilities
- Controller profit calculations
- Centralized web-based architecture
- Configurable workflows, mobility & packaged solutions

Benefits
- Maintain peak controller performance through better insights
- Highlight the current profit gap across the site or multiple sites
- Enable remote workers to collect data, easily monitor & share corporate wide APC performance
Aspen DMC3 Builder Platform – Powerful, Modernized & Easy to Use

One powerful integrated platform used to build and deploy controllers, from start to finish

Modernized Interface
Ribbon based, workflow oriented design

Collinearity Analysis
Integrated and powerful collinearity analysis & repair

Constrained Identification
Embed Process Knowledge on models and cases

Visual Transform
Simple and powerful way of defining transforms

Smart Slicing
Automatic bad data slicing enables easier pre-processing of data
Aspen DMC3: Automation of Workflows

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<tr>
<th>Role</th>
<th>Control/Process Engineer</th>
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<tr>
<td>Knowledge Work Activity</td>
<td>Automated model identification/ adaptation and controller configuration</td>
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<td></td>
<td>Automated maintenance and update of APC systems</td>
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<tr>
<td>Enabling Technologies</td>
<td>• Automated plant perturbation</td>
</tr>
<tr>
<td></td>
<td>• Model generation</td>
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<tr>
<td></td>
<td>• Controller configuration</td>
</tr>
<tr>
<td></td>
<td>• Performance monitoring and assessment</td>
</tr>
<tr>
<td></td>
<td>• Robust control</td>
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Automate complex analysis or workflow
Generate significant customer value
Reduce barrier to adoption or deployment

Assistants (wizards) based on best practices or heuristics
Summary of Aspen DMC3 Benefits

- Maximize APC benefits through continuous background maintenance
- Enable faster project implementation
- Expand APC footprint to more units
- Enable more Engineers
- Significantly affect the cash curve!
Thank You