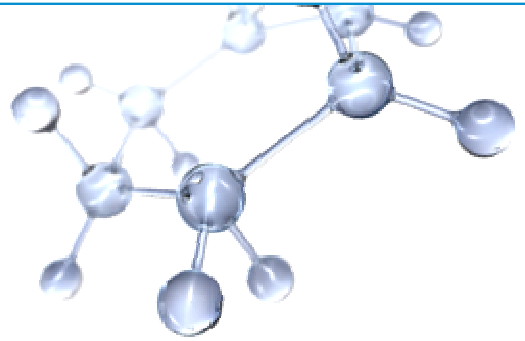
ExxonMobil Chemical

Advanced Process Control in ExxonMobil Chemical Company: Successes and Challenges



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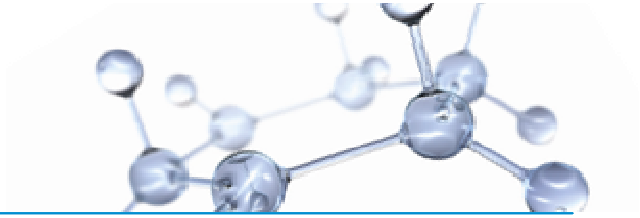
Session 10B01: In Honor of Tom Edgar's 65 Birthday II

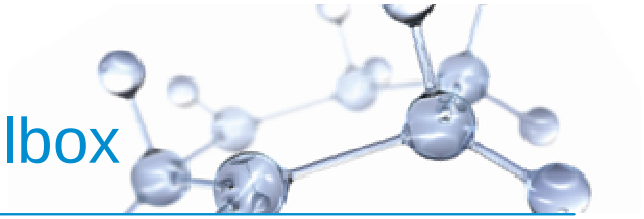
2010 AIChE Annual Meeting
Salt Lake City, UT
November 7-12, 2010

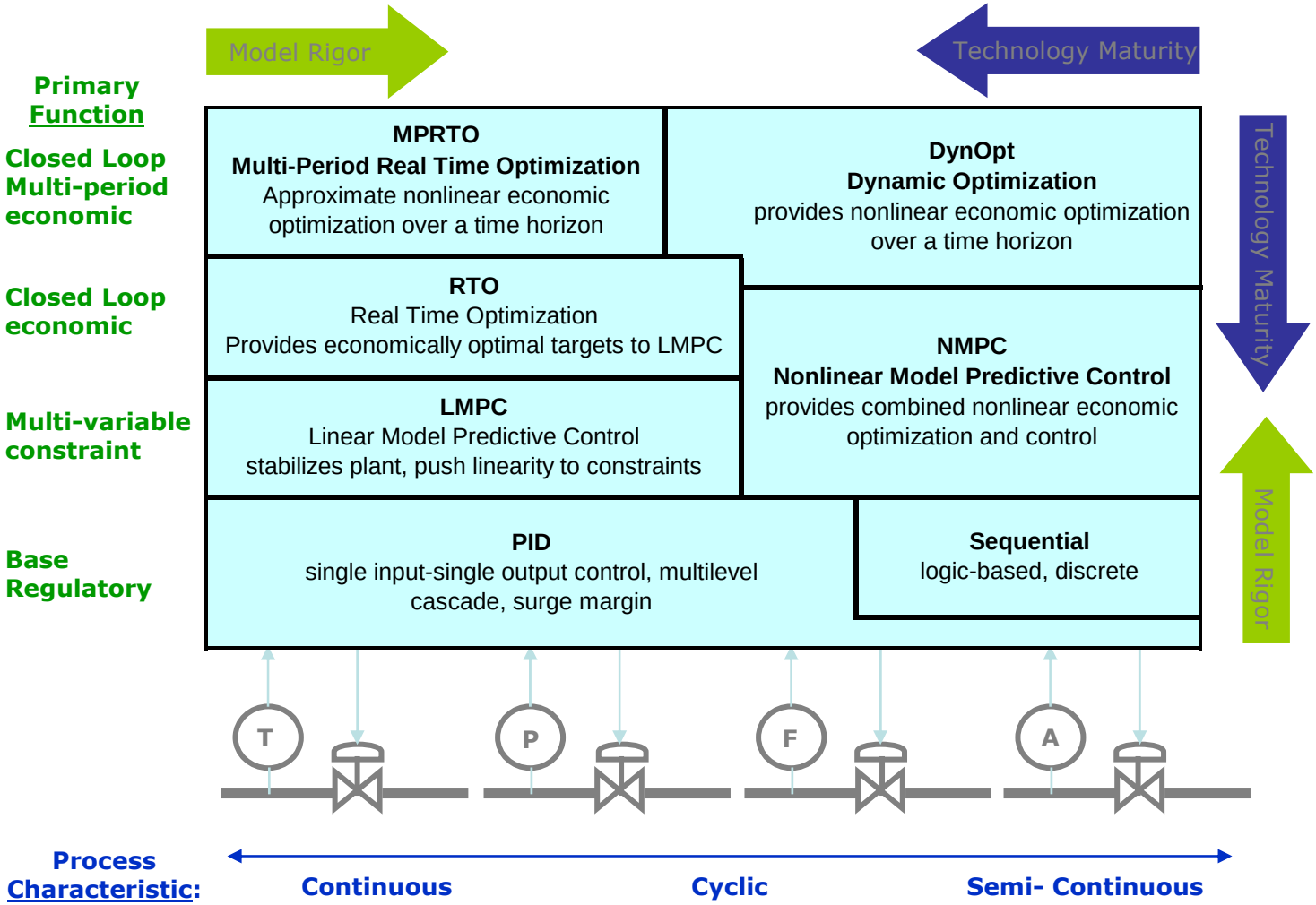
Outline



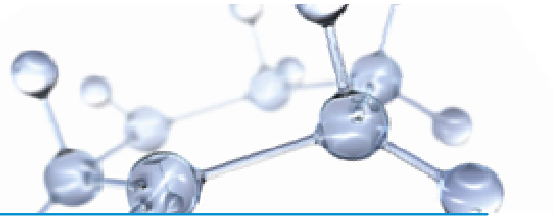
- Process Industries Advanced Control Toolbox
- ExxonMobil Chemical's Advanced Control Experience
- Engineering Specialists: Process Control
- Advanced Control Improvement Needs
- Tom Edgar's Impact
- Summary & Conclusions

Process Industries Advanced Control Toolbox

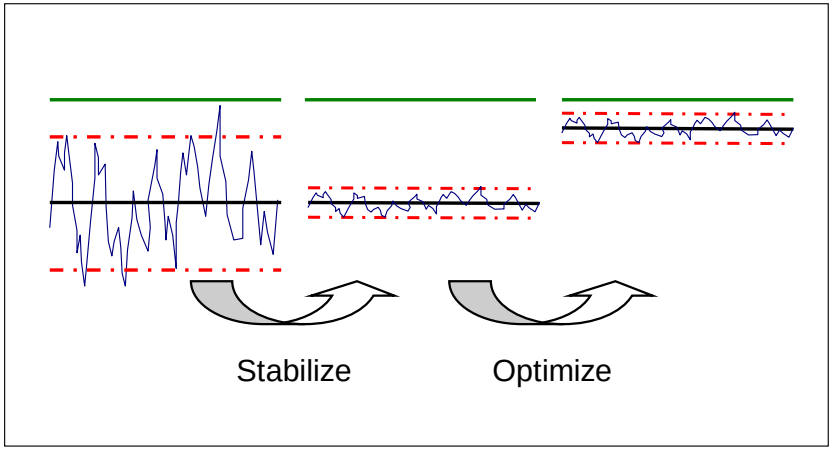




Linear Model Predictive Control (LMPC)

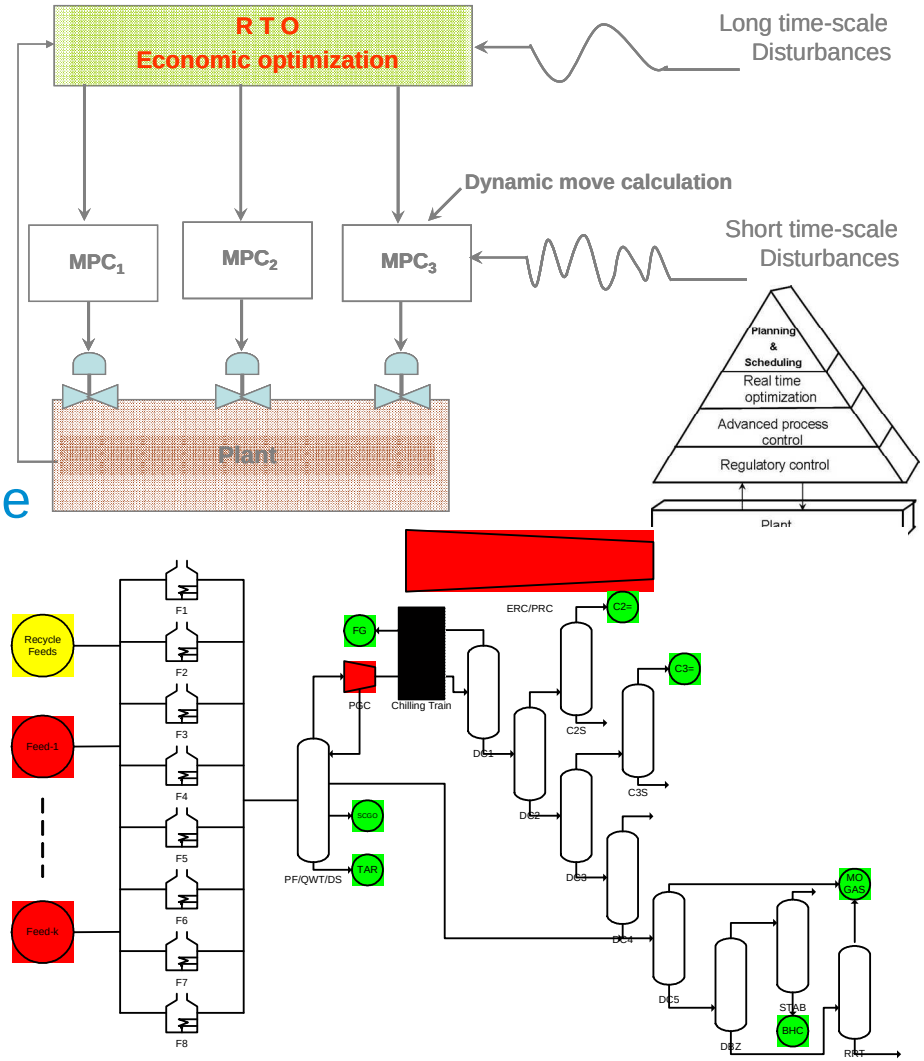


- LMPC is the most widely used advanced control technology
  - Medium Size application routinely delivers significant energy savings as well as additional production
  - Example: Butadiene Recovery Unit, Baton Rouge Chemical Plant
    - 40 Manipulated Inputs, 50 Controlled Variables
    - Reduced steam consumption 12MBTU/hr ($800k/yr)
  - Example: “Typical” Ethylene Plant
    - 77 Manipulated Inputs, 189 Controlled Variables
    - 109 Additional Feed Forward Inputs
    - Energy Reduction / Feed Increase on similar scale

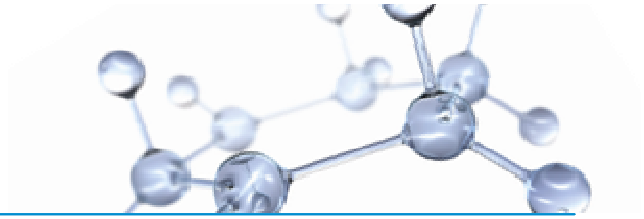


Real Time Optimization (RTO)

- Optimize the plant automatically on hourly basis by setting the underlying MPC setpoint
- Utilize real time price / cost information and plant constraints
- Cover all key unit operations in the plant
- Utilize rigorous thermodynamics and reaction kinetics to represent plant steady-state behavior
- Plant wide scope provides substantial benefits

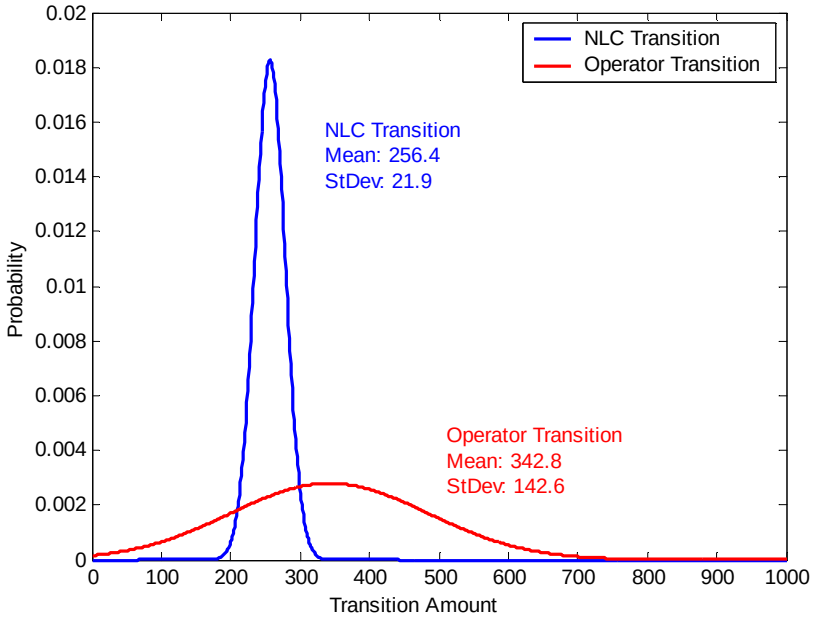


Nonlinear Model Predictive Control



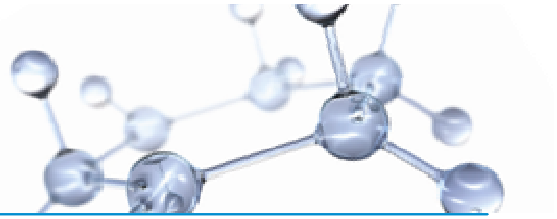
- Most ExxonMobil Chemical Company applications are first-principles based with some empirical elements
- Largest penetration of technology in polymers area
- Consistent control of properties through grade transitions is significant benefit of applications
- Modeling and parameter estimation require significant effort
- Little (if any) plant testing required

Process	DAE	CV	MV	FF
LDPE-1	21	2	2	3
LLDPE	42	8	5	7
PP-1	128	4	4	22
LDPE-2	21	2	2	16
PP-2	2300	6	3	31



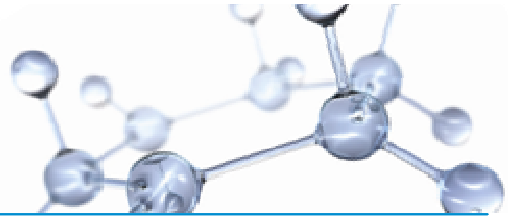
ExxonMobil Chemical

Engineering Specialists: Process Control



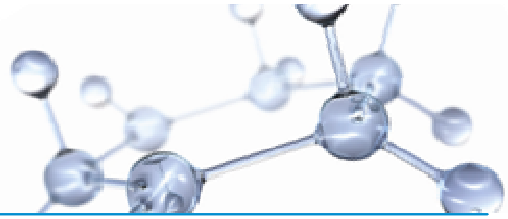
- Relatively small central group
- Maintain expertise in supported technologies
- Support site projects and initiatives
- Provide higher level support for applications worldwide
  - Sites maintain significant expertise in supported technologies
  - Central group facilitates application updates, troubleshoots modeling and technology issues
- Keep up to date with “State of the Art Technology”
  - Collaboration with academic researchers to deliver proof of concept applications
  - Work with vendors to drive technology improvements to address issues discovered at manufacturing sites

Importance of Industrial Participation



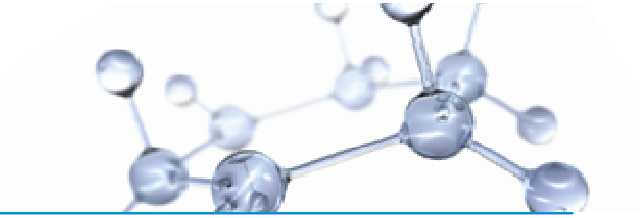
- Actively contribute to professional societies
- Actively participate in joint academic / industry consortia
- Maintain a fresh perspective
  - Seminars from visiting professors
  - Support graduate student internships
- Actively participate in vendor user groups
- Collaborate with colleagues internally

Advanced Control Improvement Needs



- Linear MPC
  - Better control infrastructure design
  - Model consistency and closer integration to RTO
  - Identification tools that systematically enforce relationships between variables
- Real Time Optimization
  - Better NLP & MINLP solvers and parallel computing to handle large scale, mix-integer, and complementarity problem
  - Better understanding of distributed optimization & control
- Nonlinear MPC
  - Improved state / disturbance estimation methods
  - Parameter estimation
  - Improved integration of first principals and empirical models
  - Evolution to dynamic optimization

Tom Edgar's Impact

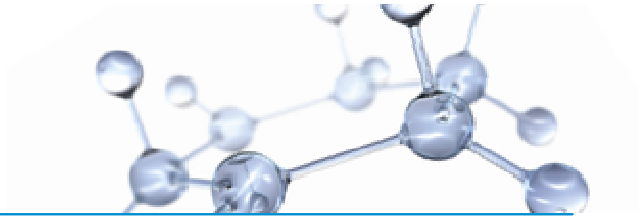


- Education
  - Undergraduate – embraced new technology for course organization, teaching concepts, and working problems
  - Graduate – direct research of and maintain funding for a substantial research group
  - ExxonMobil has directly benefited from the quality of graduates produced
- Research
  - More than 250 refereed journal articles and significantly more conference publications
- Industrial Collaboration

TWCCC ⋆ Texas – Wisconsin – California Control Consortium

  - Making students available for internships and to work directly on problems of interest to industry

Summary & Conclusions



- Advanced control has been extremely successful applied to industrial problems.
- Advanced control is not a “solved problem”, many research challenges still exist.
- Ongoing academic and industrial collaboration is needed.
- Maintaining capability to sustain applications is an ever-present challenge.
- Educators such as Tom Edgar are key to supplying the next generation of engineers with understanding of the technology and its capability.