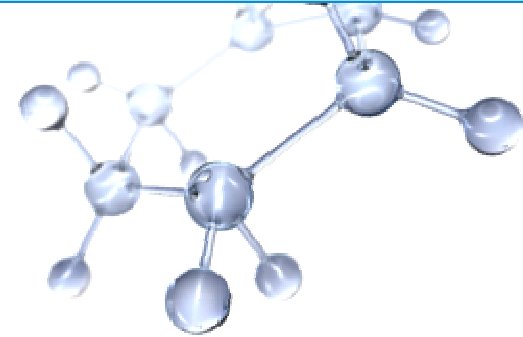

Advanced Process Control in ExxonMobil Chemical Company: Successes and Challenges



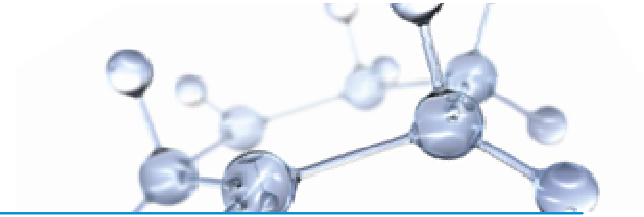
Tyler A. Soderstrom PhD.

Yang Zhang PhD.

John Hedengren PhD.

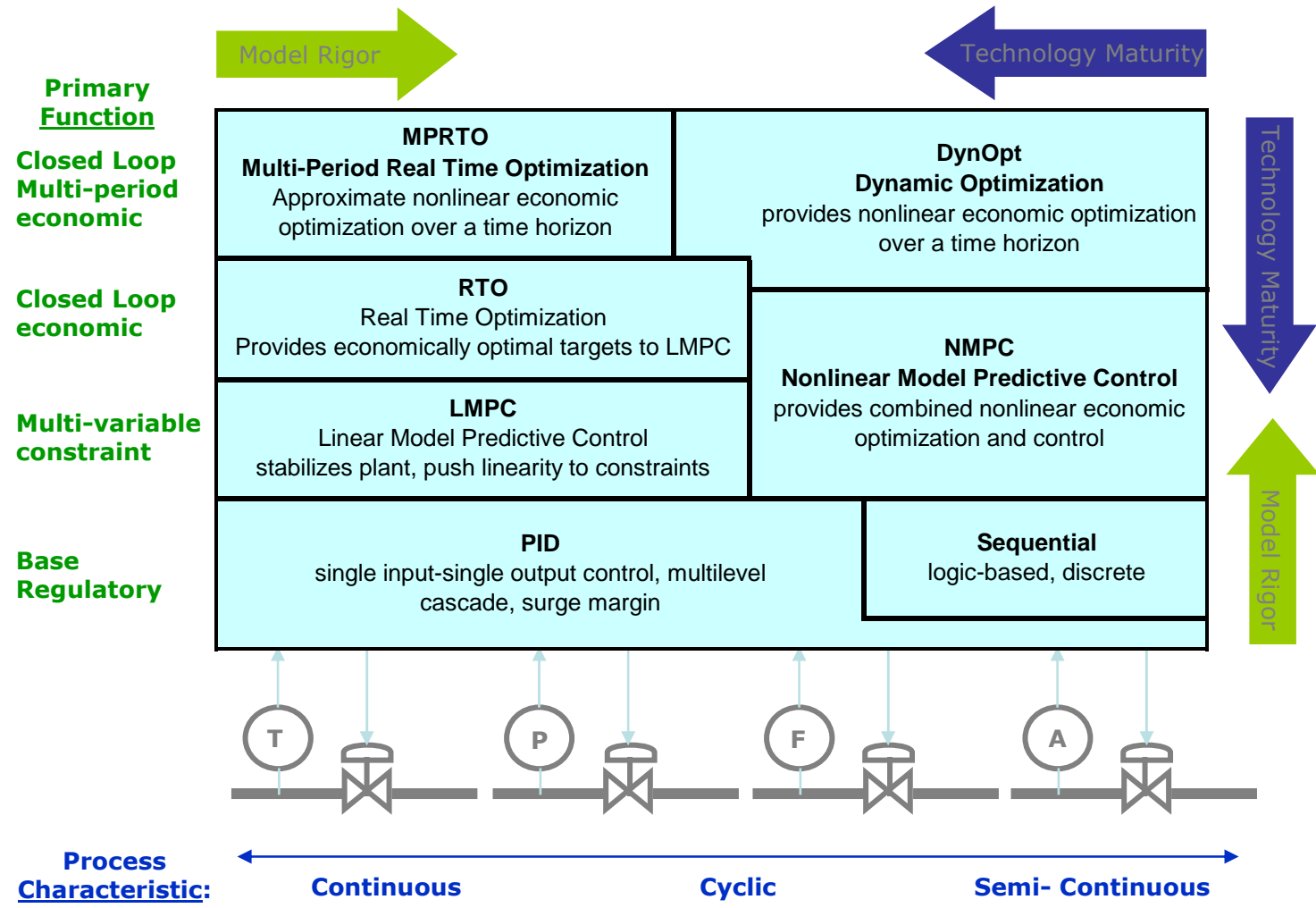
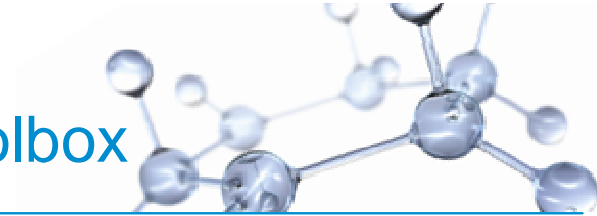
Session 10B01: In Honor of Tom Edgar's 65 Birthday II

Outline

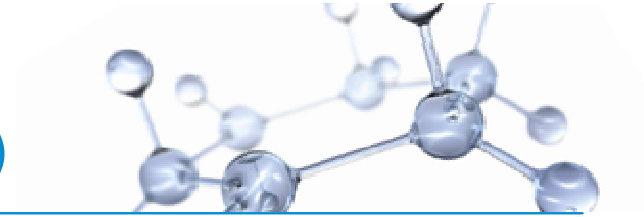


- Process Industries Advanced Control Toolbox
- ExxonMobil Chemical's Advanced Control Experience
- Engineering Specialists: Process Control
- Advanced Control Improvement Needs
- Tom Edgar's Impact
- Summary & Conclusions

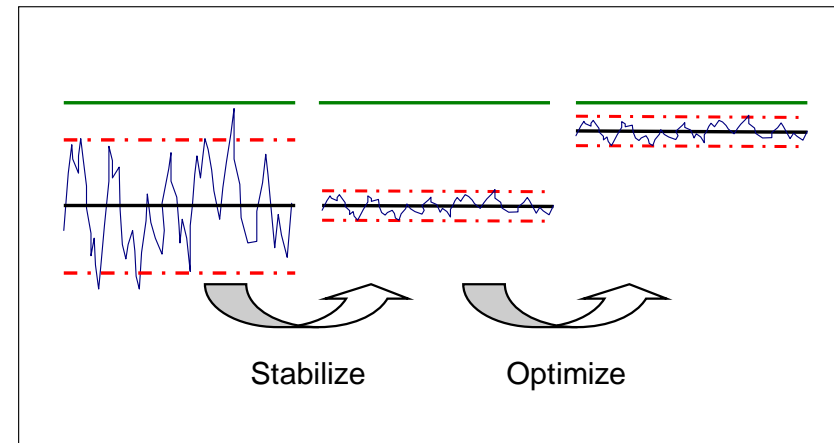
Process Industries Advanced Control Toolbox



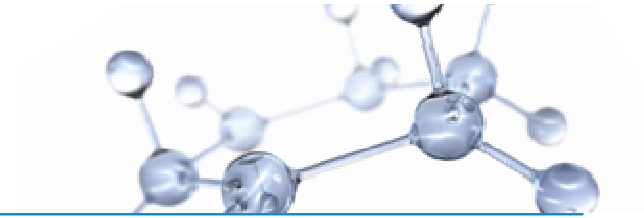
Linear Model Predictive Control (LMPC)



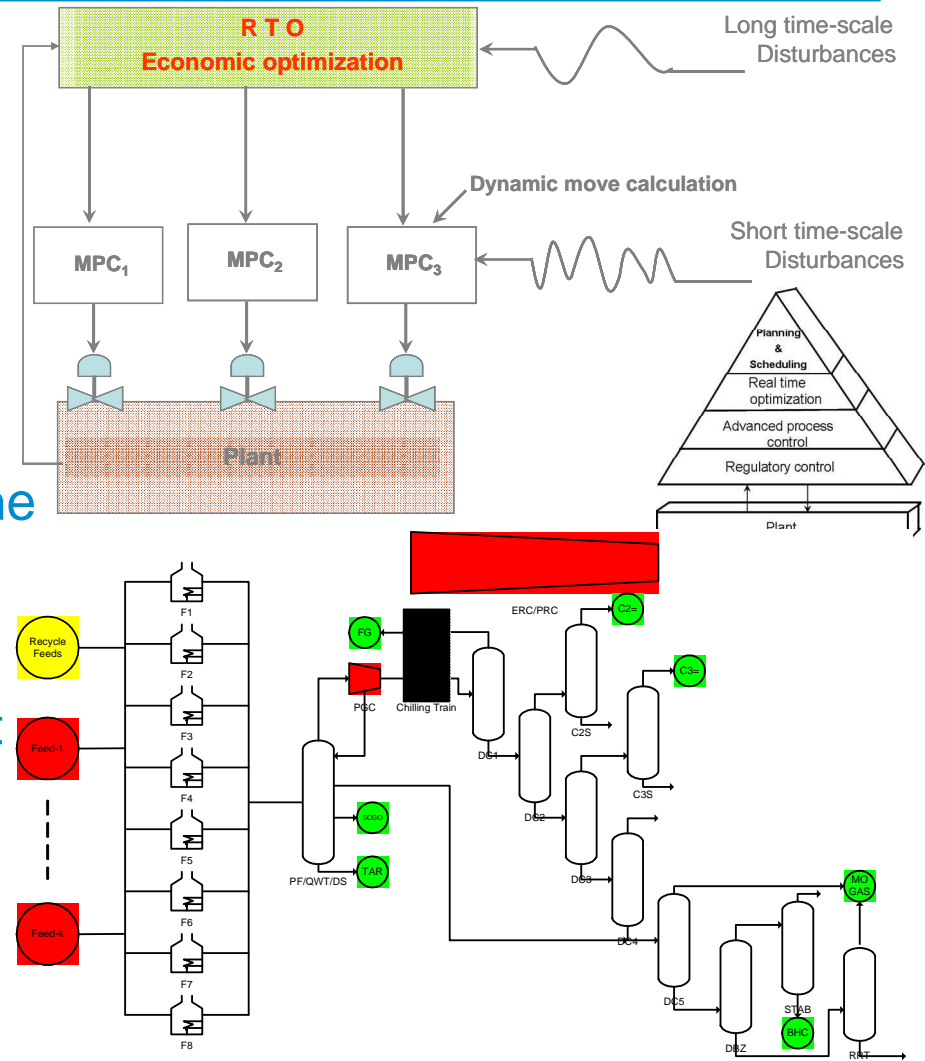
- LMPC is the most widely used advanced control technology
 - Medium Size application routinely delivers significant energy savings as well as additional production
 - Example: Butadiene Recovery Unit, Baton Rouge Chemical Plant
 - 40 Manipulated Inputs, 50 Controlled Variables
 - Reduced steam consumption 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



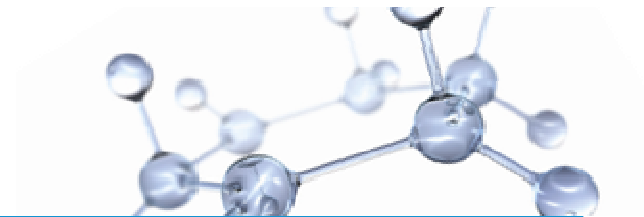
Real Time Optimization (RTO)



- 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

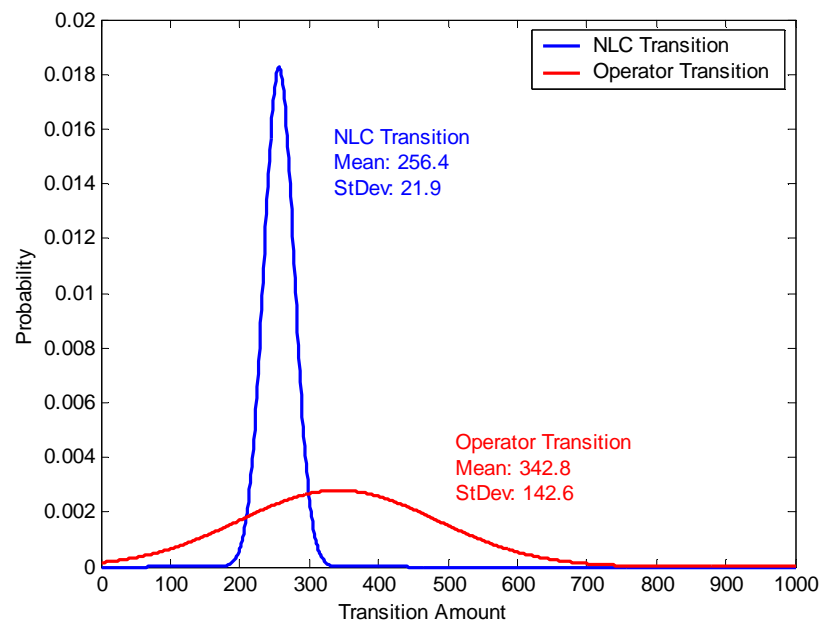


Nonlinear Model Predictive Control

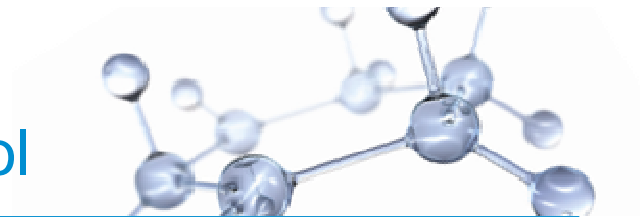


- Most ExxonMobil Chemical Company applications are first-principles based with some empirical elements
- Largest penetration of technology in polymers area
- Consistent control of properties through grade transitions is significant benefit of applications
- Modeling and parameter estimation require 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 |

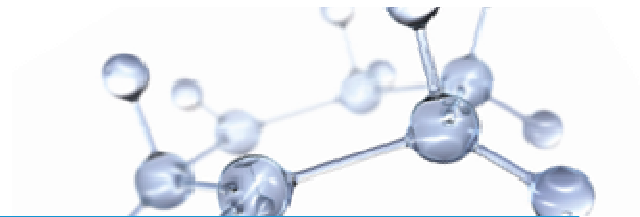


Engineering Specialists: Process Control



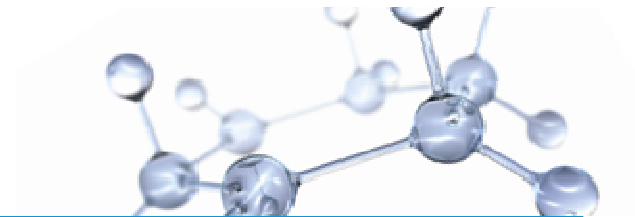
- Relatively small central group
- Maintain expertise in supported technologies
- Support site projects and initiatives
- Provide higher level support for applications worldwide
 - Sites maintain significant expertise in supported technologies
 - Central group facilitates application updates, troubleshoots 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



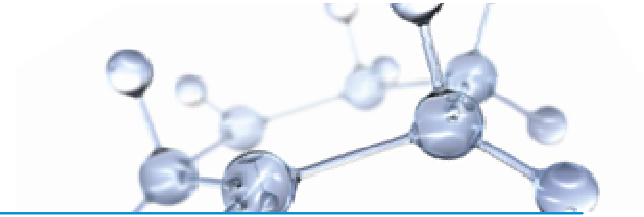
- Actively contribute to professional societies
- Actively participate in joint academic / industry consortia
- Maintain a fresh perspective
 - Seminars from visiting professors
 - Support graduate student internships
- Actively participate in vendor user groups
- Collaborate with colleagues internally

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



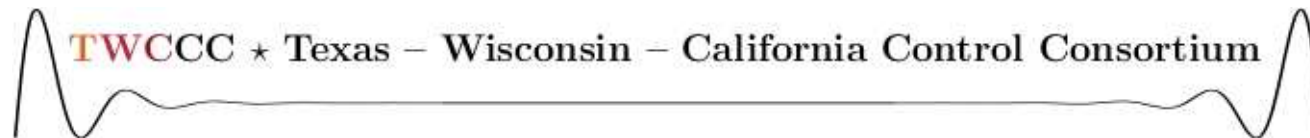
- **Education**

- 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**

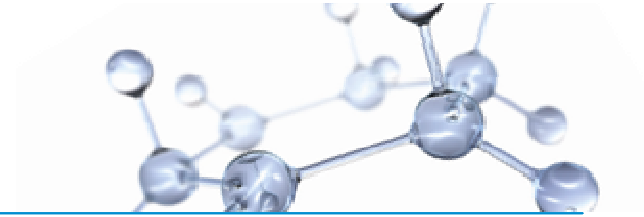
- More than 250 refereed journal articles and significantly more conference publications

- **Industrial Collaboration**

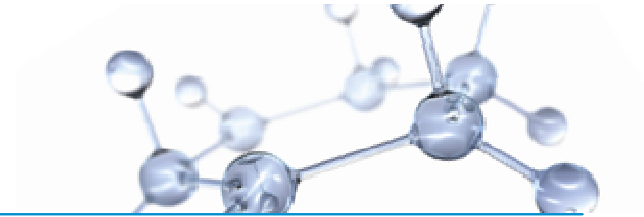


- Making students available for internships and to work directly on problems of interest to industry

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.



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