

Setting the Standard for Automation™



Industrial Perspectives on Research to Predict and Diagnose Abnormal Situations

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Presenter

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Staff Scientist, Applied Mathematics R&D

American Air Liquide

Newark, DE

- Ph.D. in Chemical Engineering - University of Connecticut
- B.S. in Chemical Engineering – Virginia Tech
- Air Liquide project manager for:
 - Alarm Management
 - Human-Machine Interface Design
 - Fault Detection & Analysis
 - Bulk Distribution Optimization



World leader in gases for industry, health, and the environment.



Well-Established Research Programs at U. of Pennsylvania & Drexel U.



- **Fault Detection / Bayesian Networks (Drexel)**

- Mehranbod, N., M. Soroush, M. Piovoso, and B. A. Ogunnaike, 2003, A Probabilistic Model for Sensor Fault Detection and Identification, *AIChE J.*, 49(7), 1787-1802
- Mehranbod, N., C. Panjapornpon, and M. Soroush, 2005, A Method of Sensor Fault Detection and Identification, *J. of Process Contr.*, 15(3), 321-339.

- **Bayesian Analysis of Event Trees (Penn)**

- Oktem, U. G., W. D. Seider, M. Soroush, and A. Pariyani, May 2013, Improve Process Safety with Near-Miss Analysis: On the Horizon, *CEP*, 20-27.
- Pariyani, A., W. D. Seider, U. G. Oktem, and M. Soroush, 2012a, Dynamic Risk Analysis using Alarm Databases to Improve Safety and Quality: Part I – Data Compaction, *AIChE J.*, 58, 3, 812-825.
- Pariyani, A., W. D. Seider, U. G. Oktem, and M. Soroush, 2012b, Dyn. Risk Analysis using Alarm Databases to Improve Safety and Quality: Part II – Bayesian Anal., *AIChE J.*, 58, 3, 826-841.
- Meel, A., W. D. Seider, and M. Soroush, 2006, Game Theoretic Approach to Multi-Objective Designs: Focus on Inherent Safety, *AIChE J.*, 52, 1, 228-246.

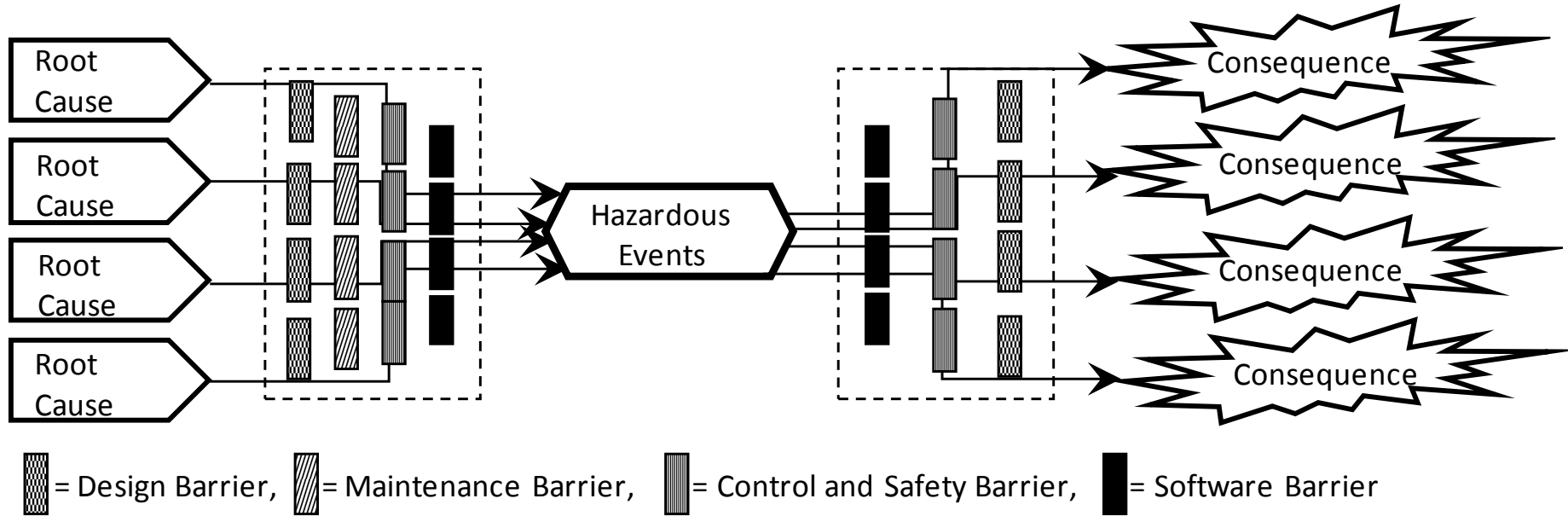
Background

NSF GOALI Project



- National Science Foundation (NSF)-funded Grant Opportunities for Academic Liaison with Industry (GOALI) project [Apr 2011 - Mar 2014]
 - **U. of Pennsylvania** (Prof. Seider, Prof. Oktem, I. Moskowitz)
 - **Drexel University** (Prof. Soroush, T. Mohseni)
- Industrial (Air Liquide) contribution
 - Review of research to provide required industrial insight and feedback
 - Provide researchers with process data and information to facilitate the development of relevant techniques
 - Promote open and collaborative feedback to ensure relevance to Industry (in general) and Air Liquide (in particular)
 - Periodic update / review of research to internal stakeholders (memos: Q2 & Q4)

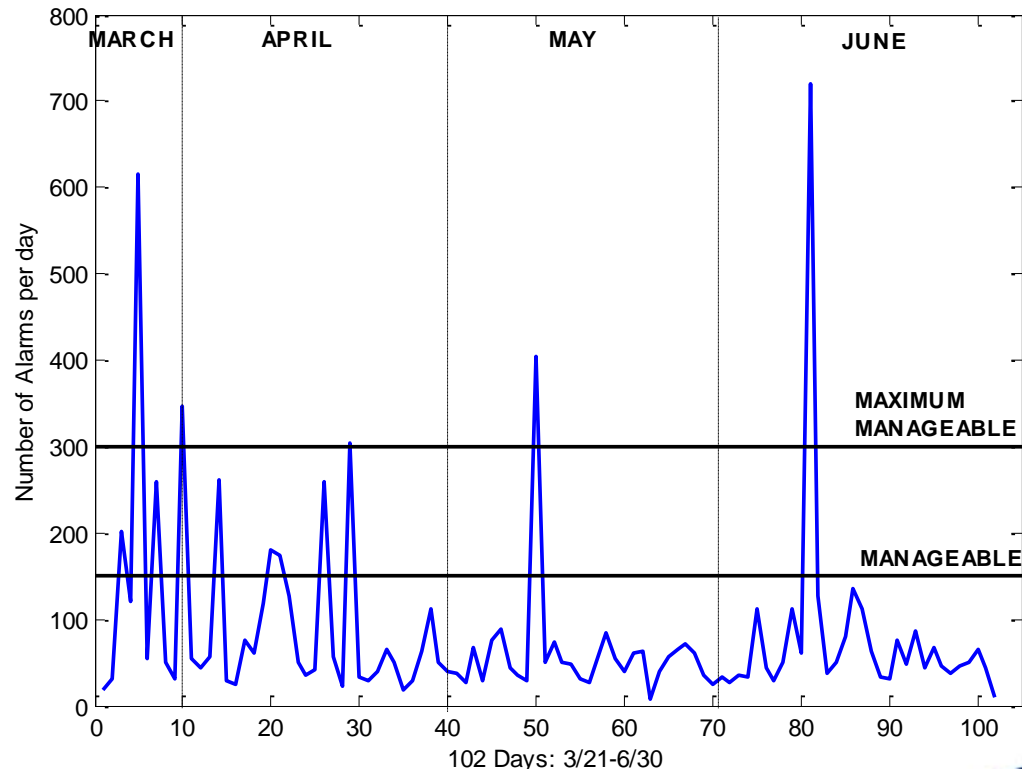
In the Context of a Bow-Tie Diagram



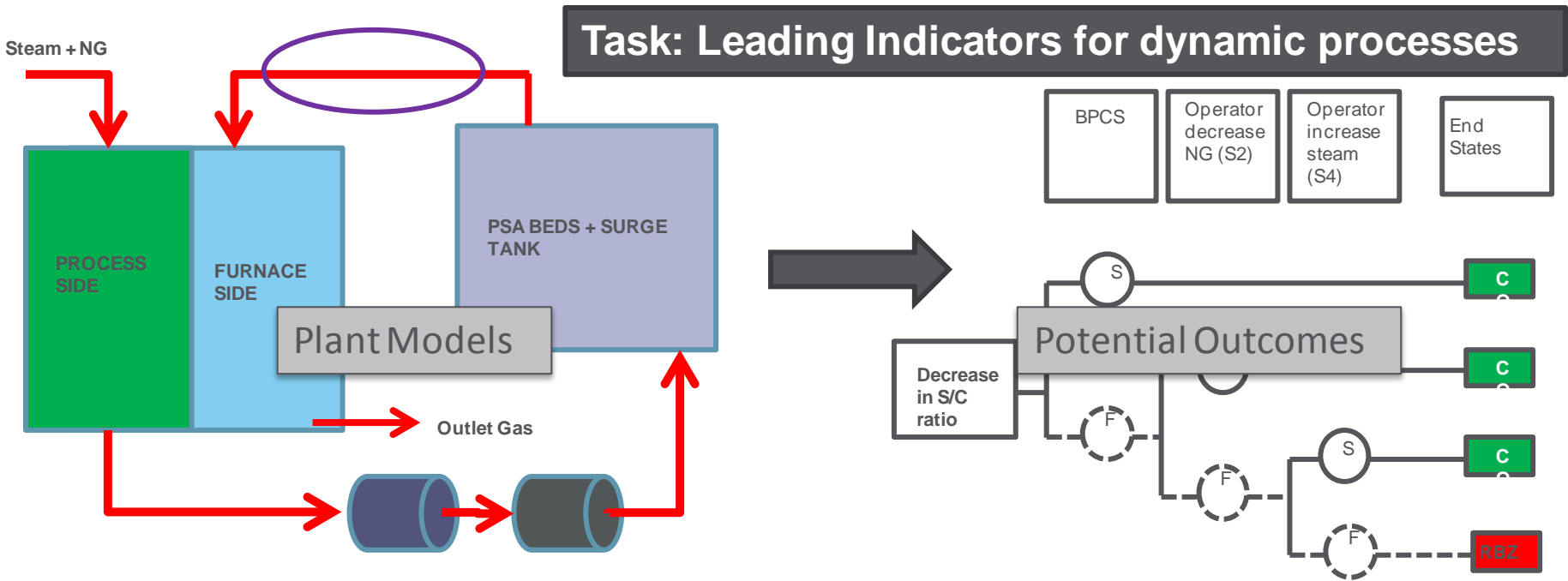
Roots of Our Effort: Alarm Management (e.g., ANSI/ISA-18)

- Average number of alarms per day = 84
- Percentage of days having alarm frequency
 - >150* (manageable value) = 11%
 - >300* (maximum manageable value) = 5%

Much lower than manageable value of 150



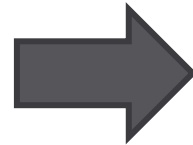
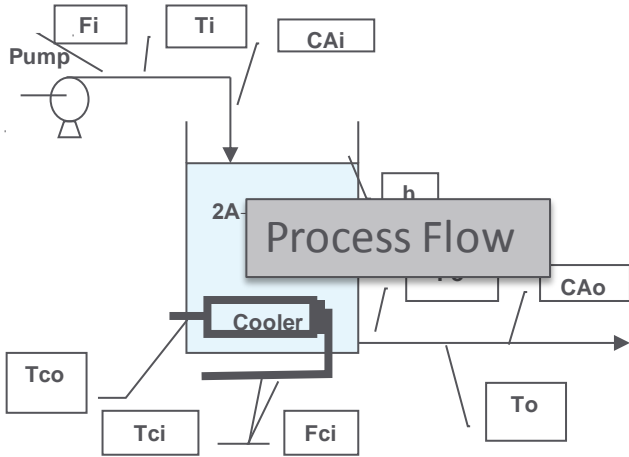
* Proposed by EEMUA



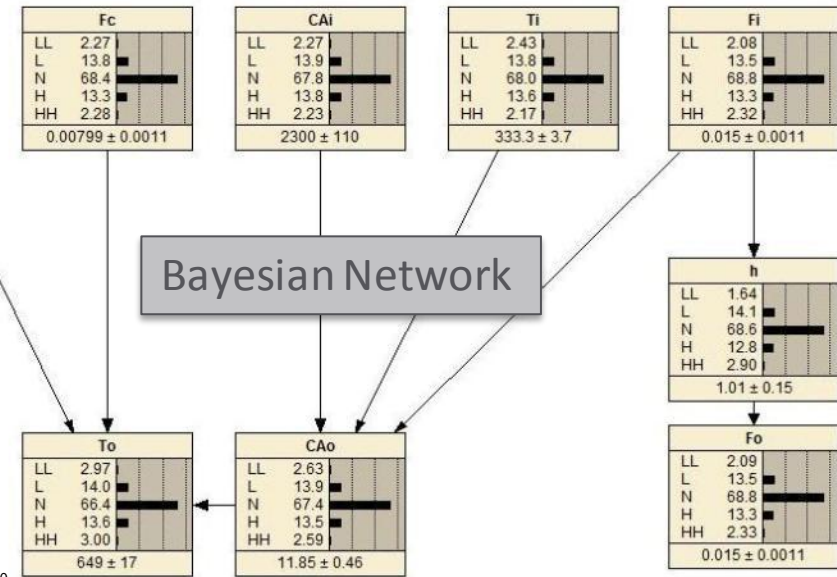
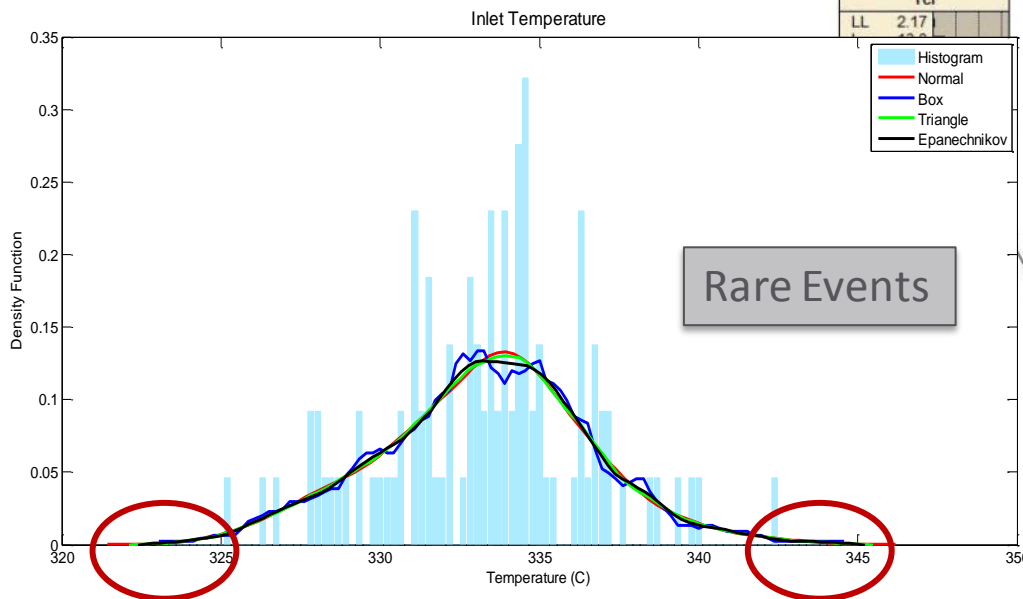
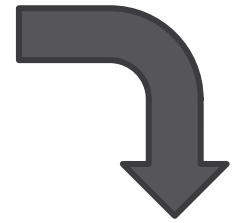
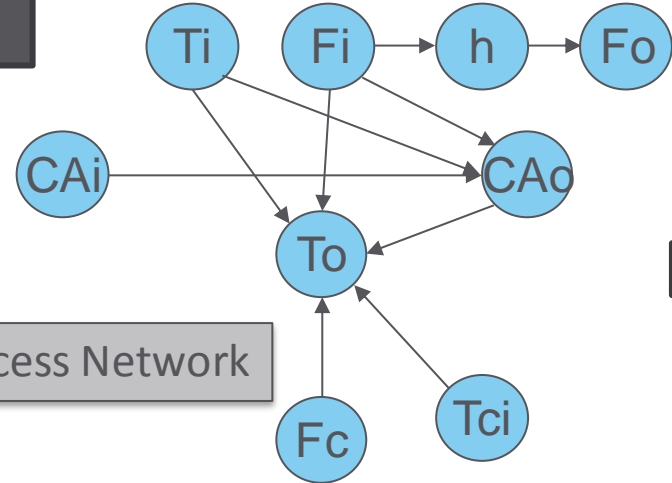
Potential outcomes:

1. Tool to simulate plant disturbances and study effect
2. Tabulation of possible outcomes with likelihood probability
3. Determination of rules to setup advanced tools to monitor plant reliability

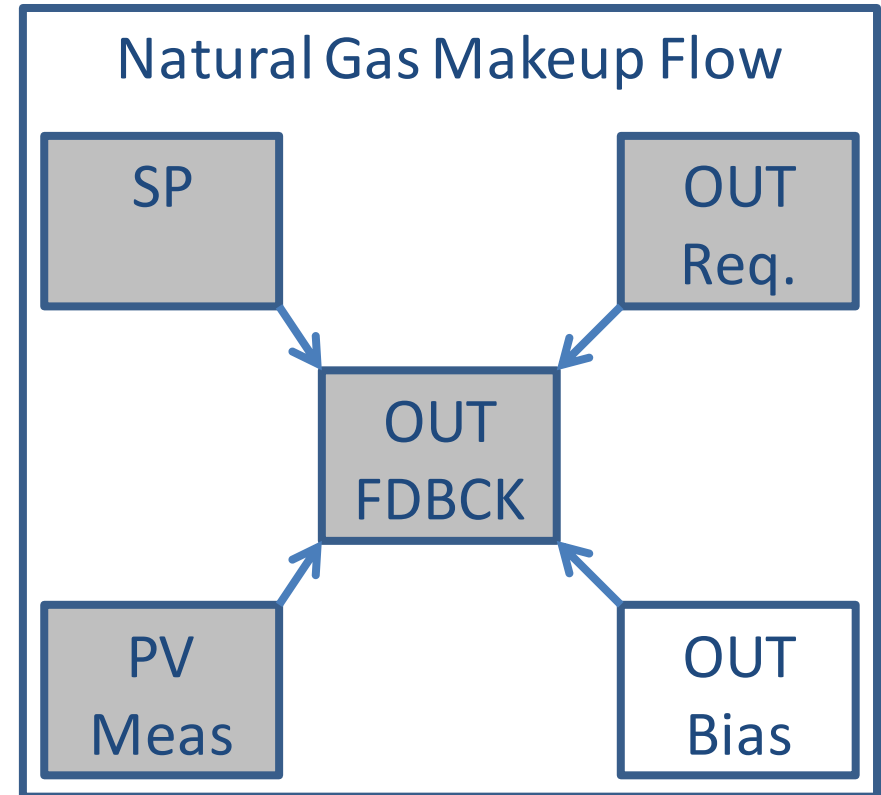
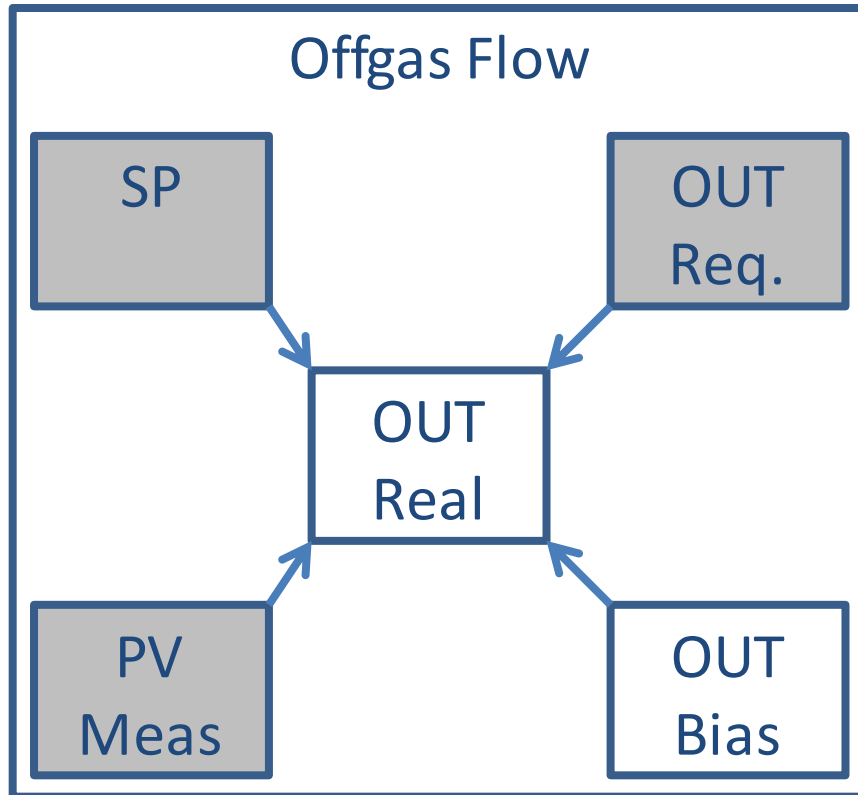
Task: Automatic Root Cause Analysis



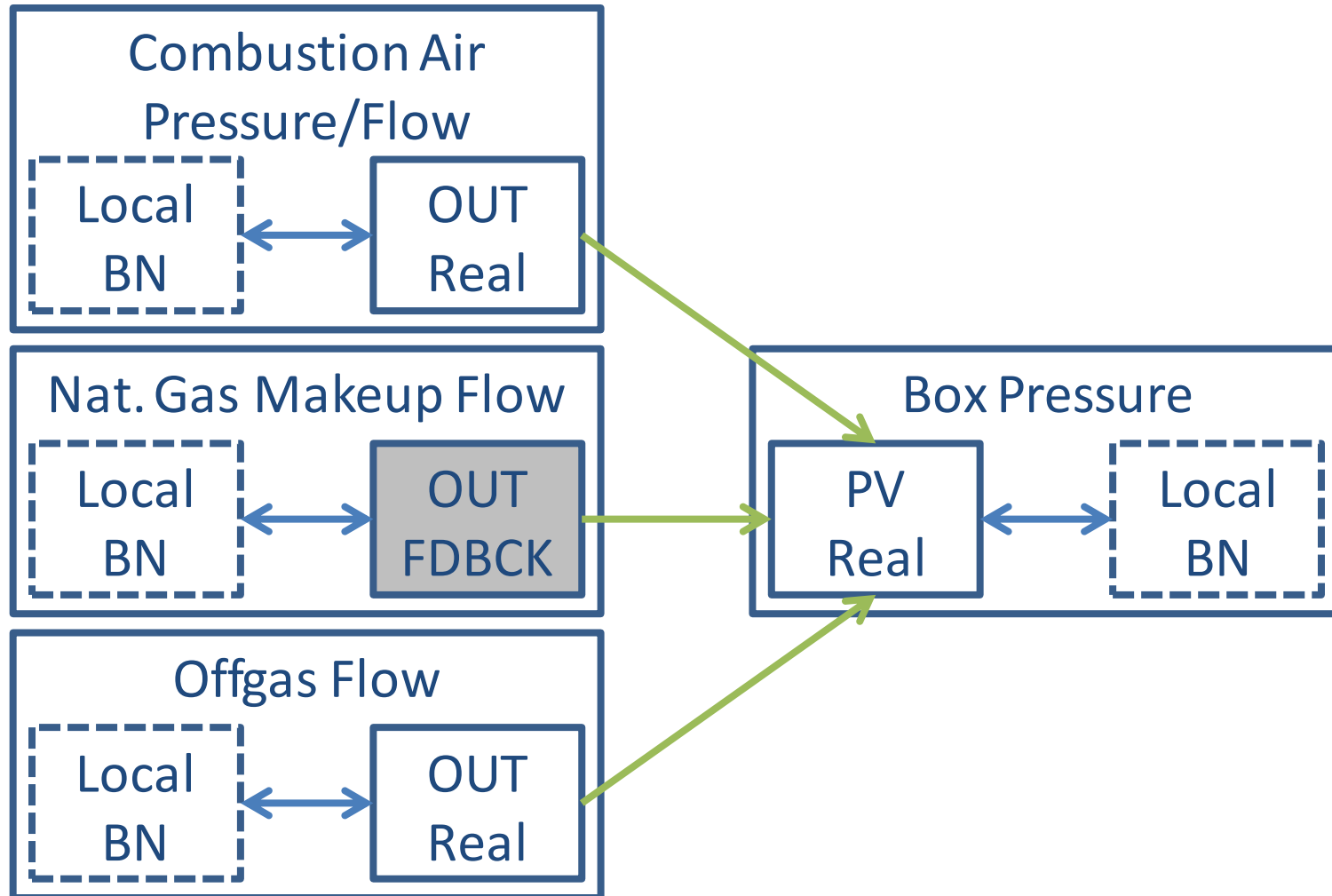
Process Network



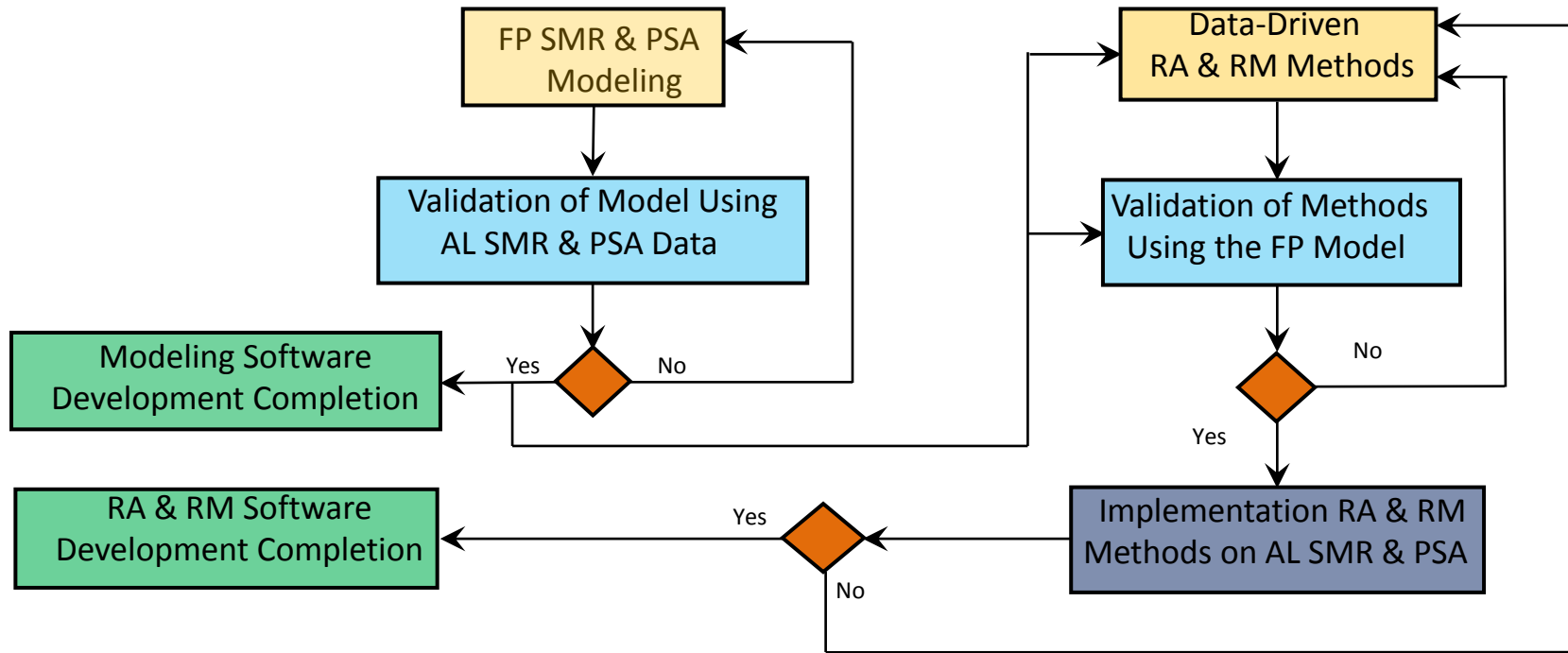
Application to Closed-Loop Systems toward Dynamic Bayesian Networks (1/2)



Application to Closed-Loop Systems toward Dynamic Bayesian Networks (2/2)



Schematic of Proposed Continuing Research



FP = First Principles
RA = Risk Assessment
RM = Risk Mitigation
AL = Air Liquide

- **Strong Academic Research on Safety & Reliability** here in the Delaware Valley (and elsewhere)
- NSF GOALI funding is a good way to **engage with universities** on generally applicable, topical research
- From an Academic Point of View
 - This research is focused on **safety** – preventing near misses (e.g., alarms) from turning into incidents
 - Develop **new mathematical techniques** to **analyze data**
- From an Industrial Point of View
 - This research is focused on **reliability** since automatic safety systems (e.g., ANSI/ISA-84) prevent safety/environmental consequences
 - Develop **systematic methods** to convert mathematical analysis into **industrial implementation** and **industrial insight**

Thank You! Any Questions?



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