EMERSON EXCHANGE 2025

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[3-1236] Enabling Advanced Automation for Pipeline Operations

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Spartan Controls Ltd.

Spartan Controls is the Emerson Impact Partner for British Columbia, Alberta, Saskatchewan, Northwest Territories, and Yukon.

Experience industrial innovation at Spartan Controls—the recognized leading provider of industrial automation solutions in Western Canada.

For over 60 years, Spartan has provided high performance automation solutions, industry expertise, lifecycle support, and technical training to deliver exceptional value to our customers.

AGENDA

SYED	Pembina Pipeline Background (3 mins)
SYED	Pembina Pipeline Operations and Challenges (5 mins)
KAMAAL	Advanced Automation – Motivations for APC and Procedure Automation (3 mins)
KAMAAL	Advanced Automation Opportunity Assessment for Pembina (2 mins)
SYED / KAMAAL	Advanced Automation Project Examples Incl. Results and Value Delivered to Pembina (15 mins)
SYED	Conclusion (2 mins)
SYED / KAMAAL	Questions (10 mins)

Pembina Pipeline

Core Business, Operations, and
Challenges around Process Automation

Pembina Pipeline Core Business

- **Pipelines**
  - Operates an extensive network of pipelines that transport crude oil, natural gas liquids (NGLs), and natural gas across Canada and the U.S.
  - Focus on connecting energy producers with key markets.
- **Facilities**
  - Provides natural gas processing, fractionation, and storage services.
  - Operates gas plants, storage terminals, and other midstream infrastructure.
- **Marketing & New Ventures**
  - Engages in commodity marketing and logistics.
  - Invests in renewable energy and low-carbon initiatives to support energy transition.
- **Utilities**
  - Offers propane distribution and related services to residential, commercial, and industrial customers.

Founded: 1954

Headquarters: Calgary, Alberta, Canada

Industry: Energy Infrastructure

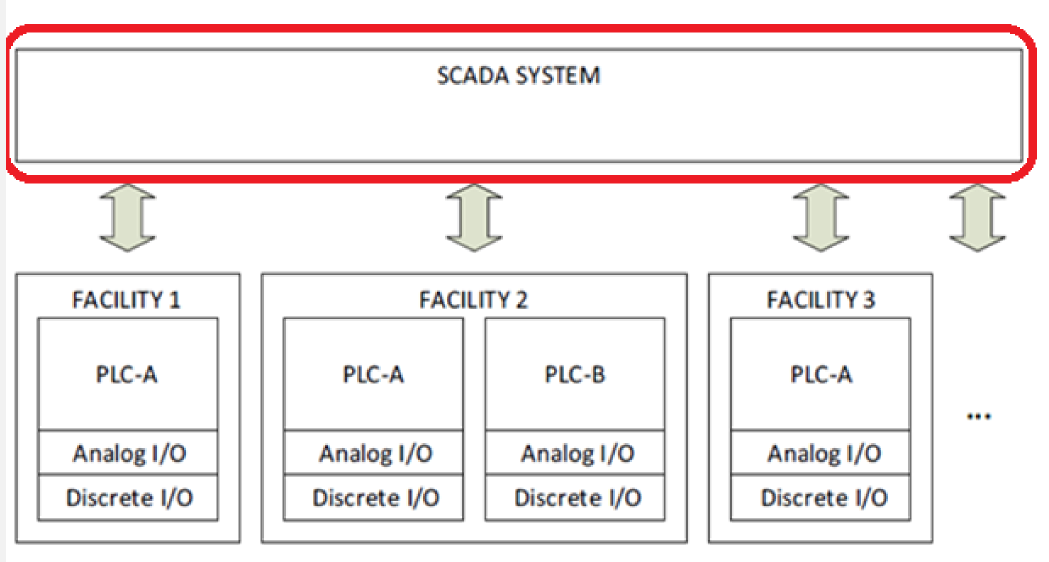
Pembina Pipeline is a leading energy transportation and midstream service provider in North America. The company has a long history of safely and reliably delivering energy products to customers and markets.

A Look into Pipeline Control Center

- **Supervisory Control and Data Acquisition (SCADA)**
  - SCADA systems by design are geared to handle batch tracking, leak detection, communications to the field and manual operations of control elements (pumps and valves).
  - Local PLCs deal with automation tasks in their current location and are not completely aware of upstream and downstream process conditions.

- **Operator Focus**
  - Monitoring pressure profiles for leak detection.
  - Managing tank swings on terminal sites.
  - Responding to phone call from field around maintenance activities.
  - Managing delivery schedules.

Basic Control System Architecture



Process Automation Challenges in SCADA

SCADA system not inherently designed to implement direct real time control.

They excel as a universal means of remote access to various local controllers (PLCs) and provides the means to monitor process and issue commands from a central location.

Lack of capability to create complex sequences for automation.

Absence of automation tools to help manage setpoints for various operations like product blending, dynamic pressure, and DRA adjustments; resulting in repeated manual operations.

Local PLCs work individually to automate their respective site. As a result, there is no centralized controller looking at the pipeline as a single entity. This leads to missed optimization opportunities.

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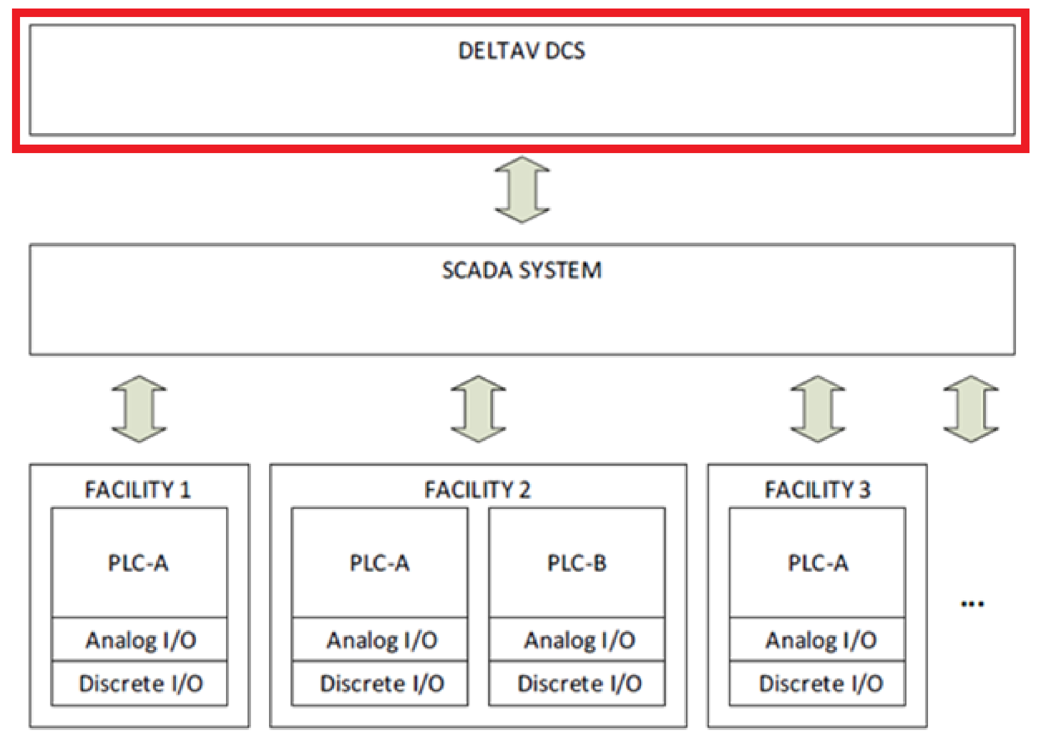
DeltaV Solution in SCADA Environment

- **DeltaV DCS as an APC Platform**
  - A DCS system like DeltaV is built to handle process control challenges. A centralized programming database provides necessary tools to handle the big picture.
  - An interface with current SCADA system will give DCS visibility into the entire pipeline network and automation projects encompassing multiple assets along a pipeline can be taken on.
  - DeltaV comes embedded with advanced control functions blocks like Model Predictive Control and State Based Sequencing.

- **Additional Tools for Operators**
  - Complex sequencing for pipeline operations.
  - Automated setpoint management based on process conditions and pipeline hydraulics.
  - Conditional alarms looking at the entire pipeline.

Advanced Control System Architecture



DeltaV DCS system provides a robust solution for industrial automation

Advanced Automation

Motivations for Advanced Process Control and Procedure Automation

The Process Control Pyramid

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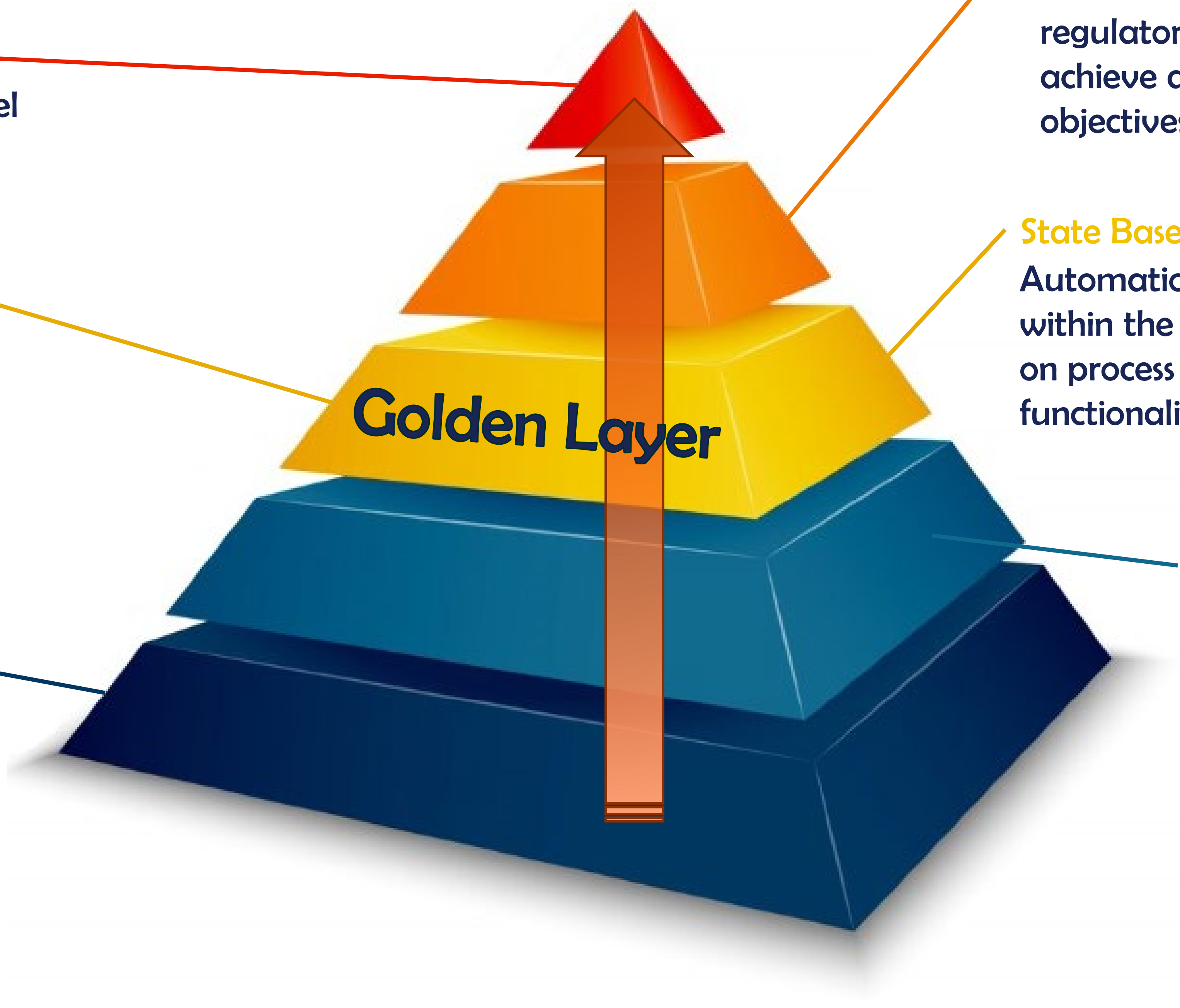
Enterprise Optimization
Optimization at the highest level driven down through the individual RTO layers.

Advanced Process Control
Supervisory layer on top of the regulatory control. Responsible for coordinating and/or optimizing complex equipment or processes.

Instrumentation, Actuation, Control System
Interface between the process and control. Provides information on the current state of operation and allows automation to enact changes.

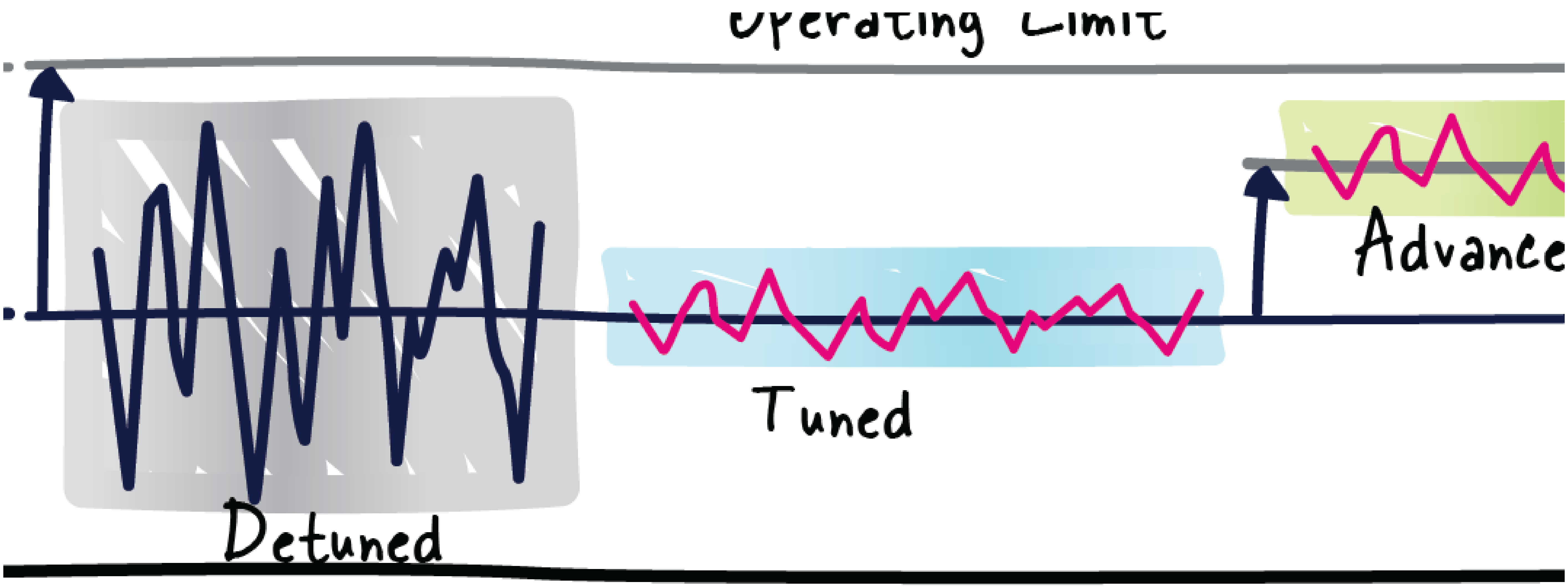


Real Time Optimization (RTO)
Coordination of multiple APC, SBC, and regulatory control applications to achieve area or site-wide optimization objectives.

State Based Control & Procedural Automation
Automation of operational procedures within the DCS, or control procedures based on process states used to drive automatic functionality. Based on ISA-106.

Regulatory Control
Standard process control loops, typically PID. Focused primarily on maintaining stability in the process.

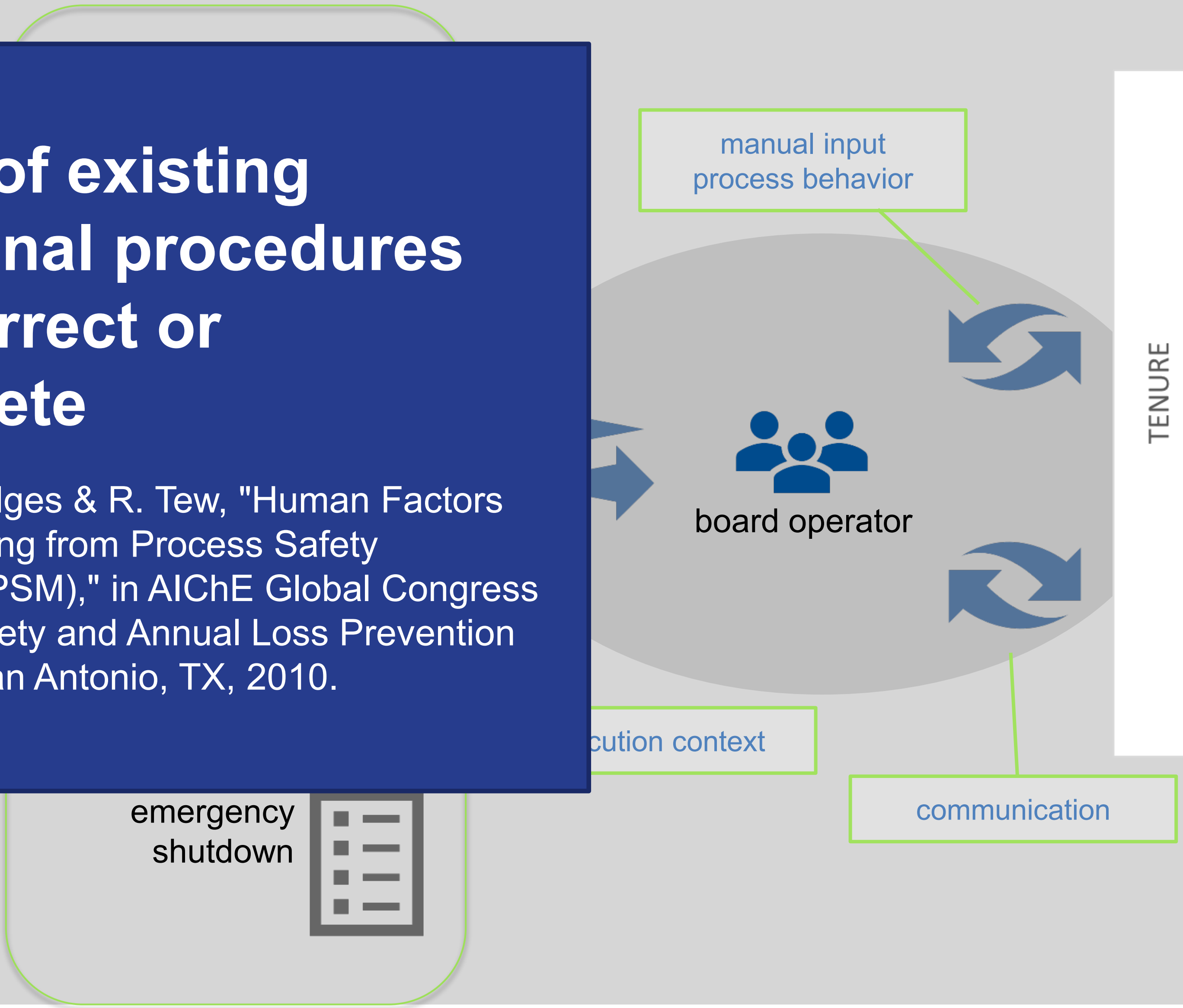
Advanced Process Control Motivation & Goal

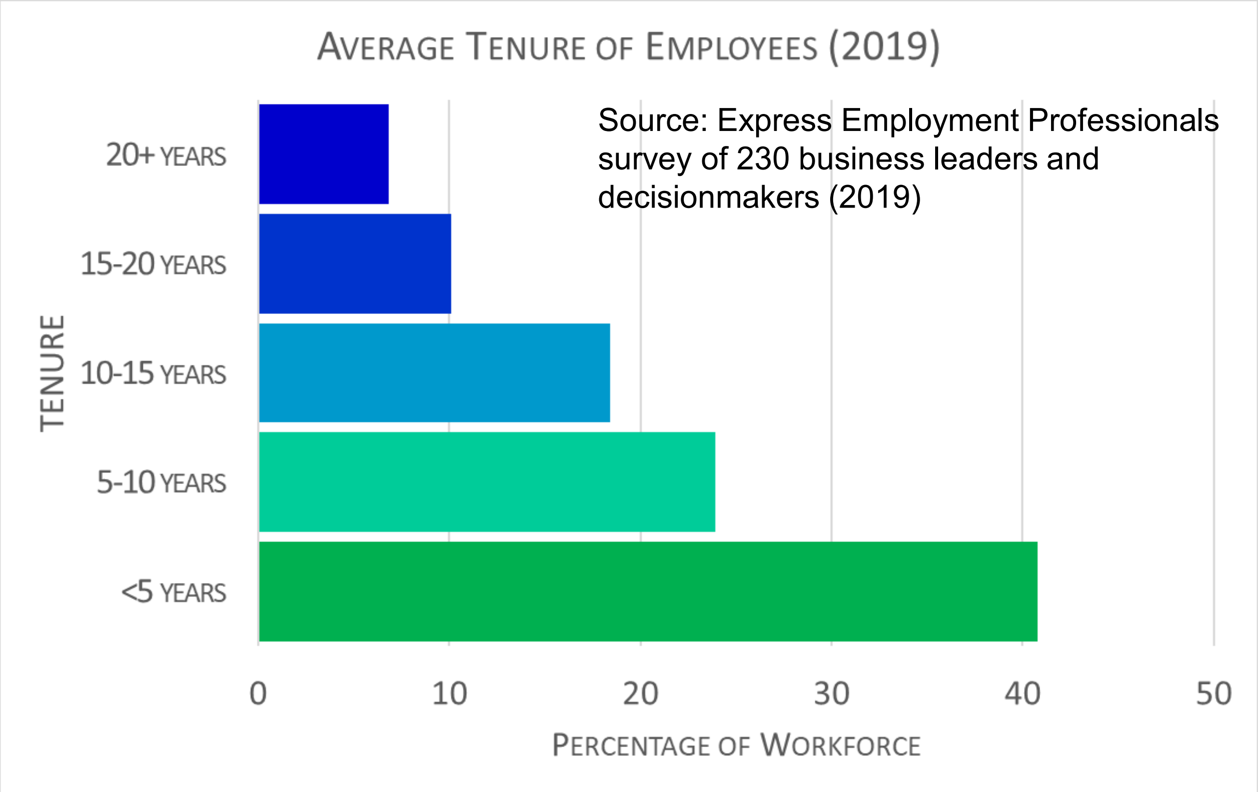


Procedure Automation

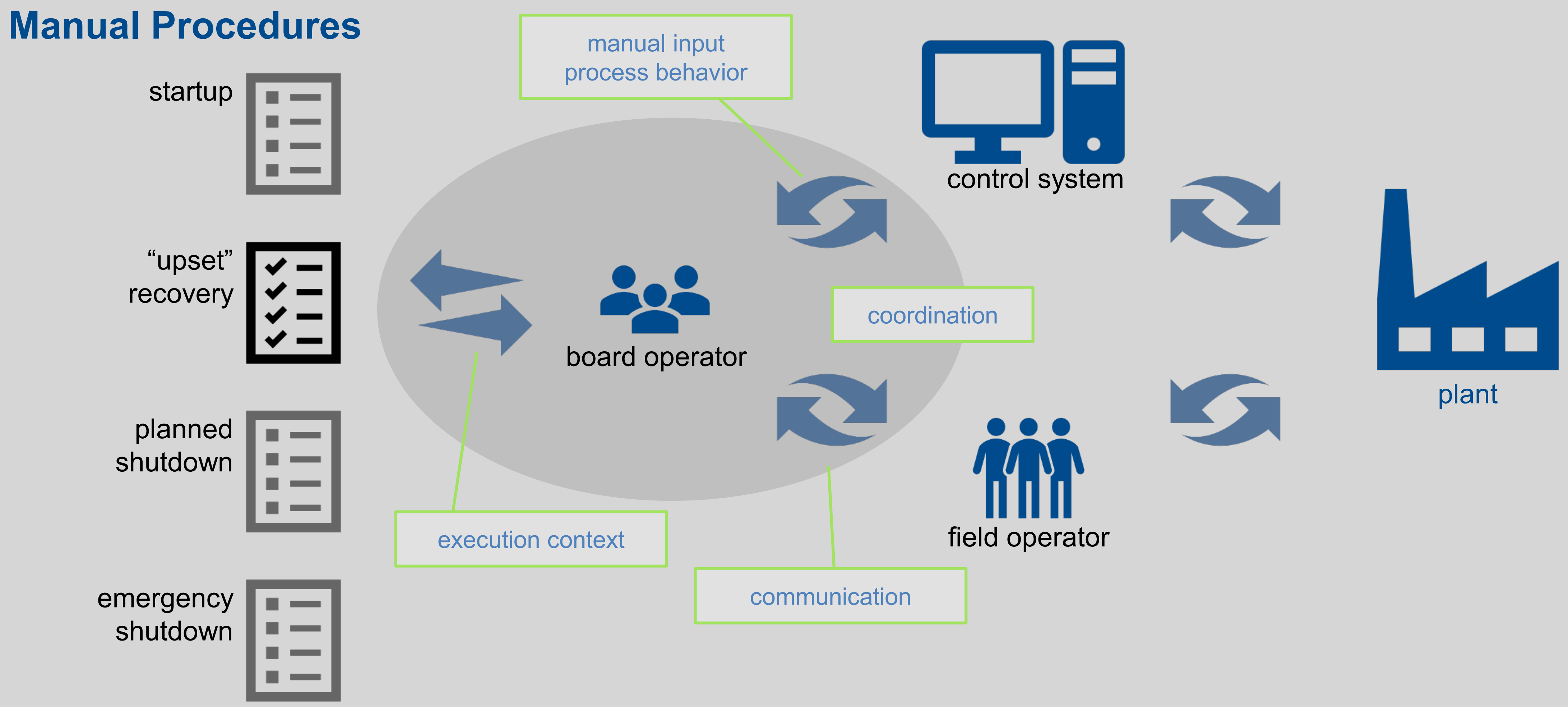
70-85% of existing operational procedures are incorrect or incomplete

Source: W. Bridges & R. Tew, "Human Factors Elements Missing from Process Safety Management (PSM)," in AIChE Global Congress on Process Safety and Annual Loss Prevention Symposium, San Antonio, TX, 2010.

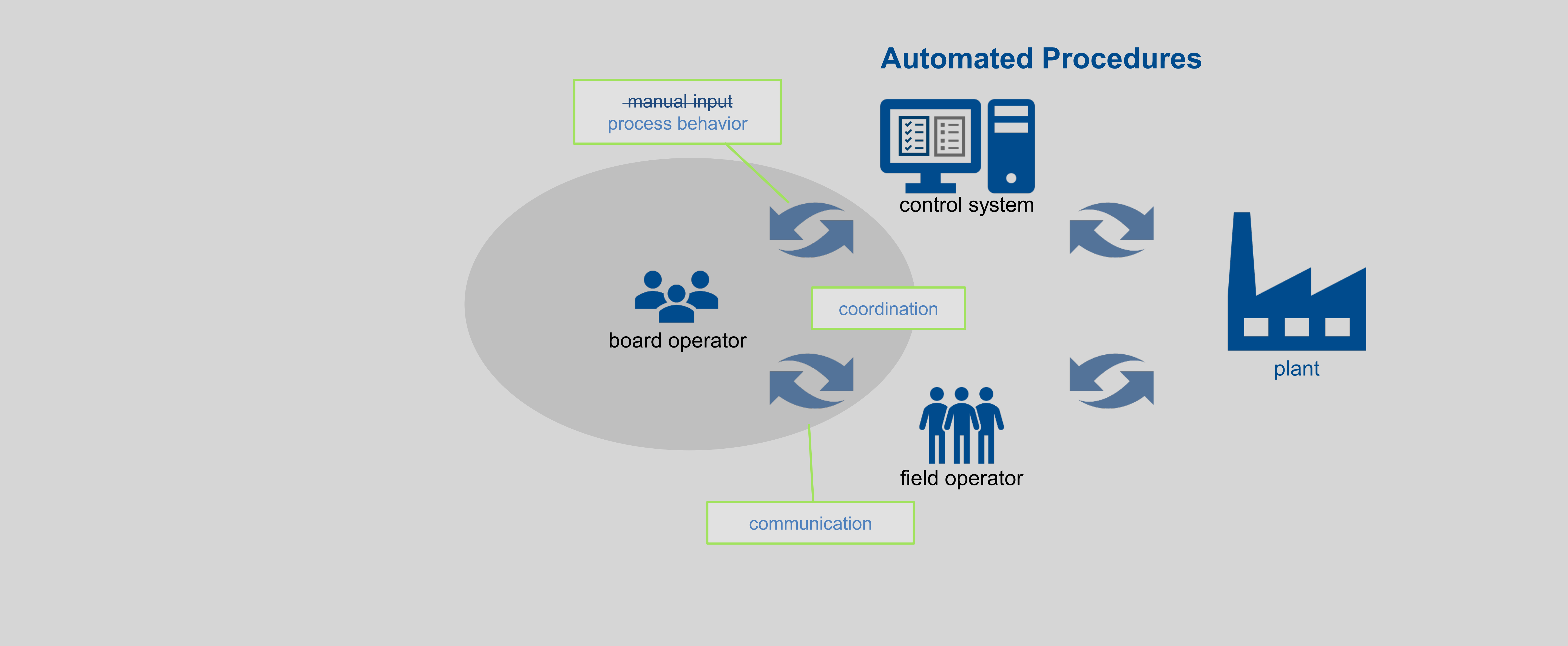




Procedure Automation



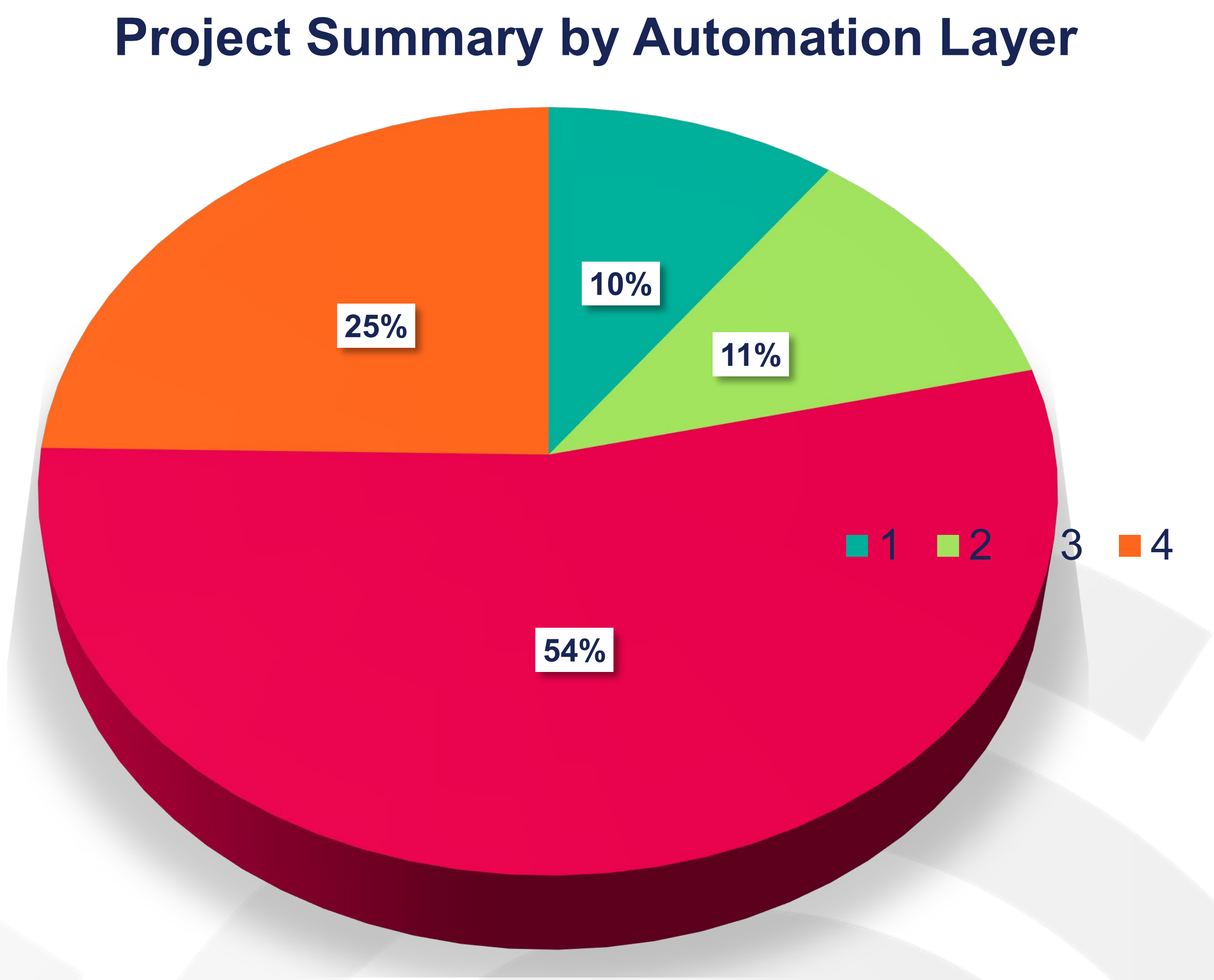
Procedure Automation



Advanced Automation Opportunity Assessment

Results from the APC Study

- 8-Day Site Interview and Audit
  - Interviews with Console Operators, SCADA Team, Hydraulic/Optimization/Control Engineers
  - Analyzed Historical Process Data
  - **100+ Individual Opportunities** through Advanced Automation identified
  - **$15 M per year** in total quantified **revenue** increase
  - Significant **un-quantified savings** through operational improvements, process stability, operator workload reduction, minimization of failed start-ups and stream-lined procedures



Advanced Automation Applications

SYED

APC and Procedure Automation Applications
- Crude Blending Model Predictive Control
- Automated Pipeline Startup/Shutdown
- Automated Pipeline Flow Mode Procedure Automation

KAMAAL

Soft Sensor Applications
- Kalman Filter - Reid Vapour Pressure
- Line Scraper Tracking and Automated Asset Shutdown

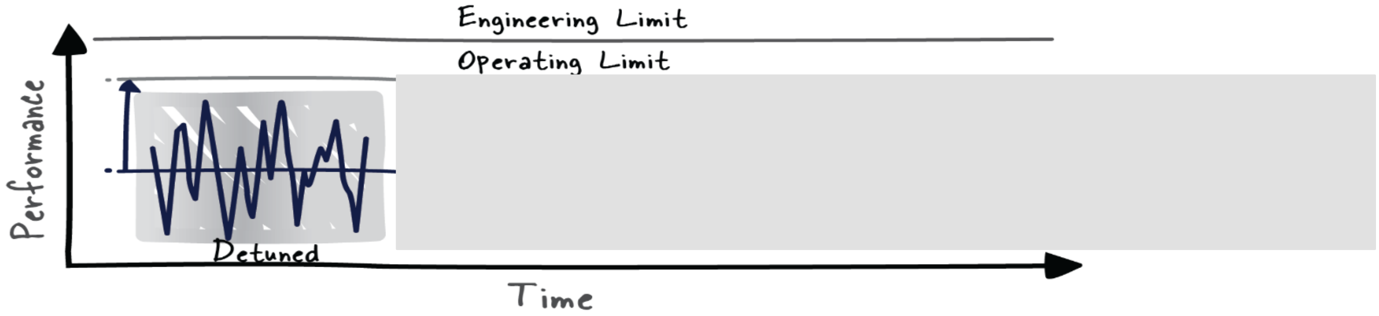
KAMAAL

Future Application
- Real-time Optimization of Pressure Profile

1 - Crude Blending Model Predictive Control

Challenges:

- Lack of advanced automation resulted in **reduced blending capabilities**
    - Basic process control has difficulty with maximizing RVP while respecting minimum density constraint
    - **Long RVP sampling times** require basic process controllers to be "de-tuned" to maintain control stability
    - De-tuned controllers in-turn lead to **long time to steady state** and **poor disturbance rejection** when conditions change

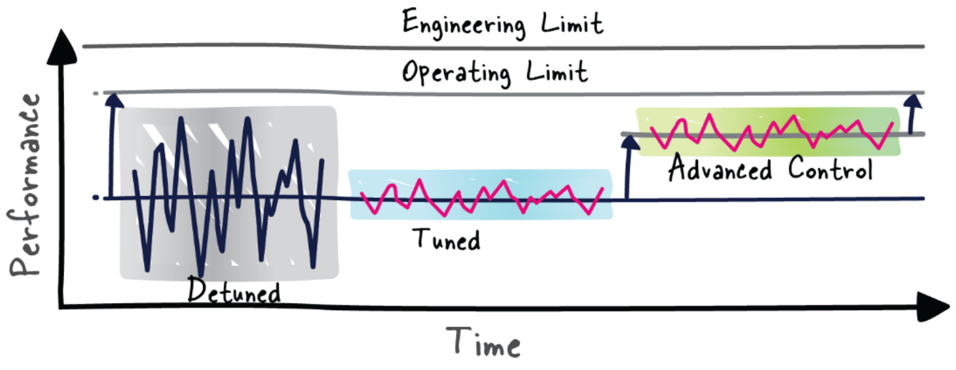


As a result, **significant time was spent by operators** micromanaging blending flow rates manually to meet RVP Targets for the different customers and product

1 - Crude Blending Model Predictive Control

Solution:

- Implement **Model Predictive Control in DeltaV**
  - A Model Predictive Controller (MPC) was deployed to automate the crude blending with the goal of maximizing RVP to the target while respecting minimum density specifications
  - Model based **Multi-Variable Control** (RVP, Density, Feed disturbances)
  - **Dynamic Optimization** (continuously maximize blending opportunity)



Value:

100

Operator Workload

Significant reduction in operator workload. 75-100 less commands per day

34%

Process Variability

Reduced process variability by 34%

98%

Mean Error

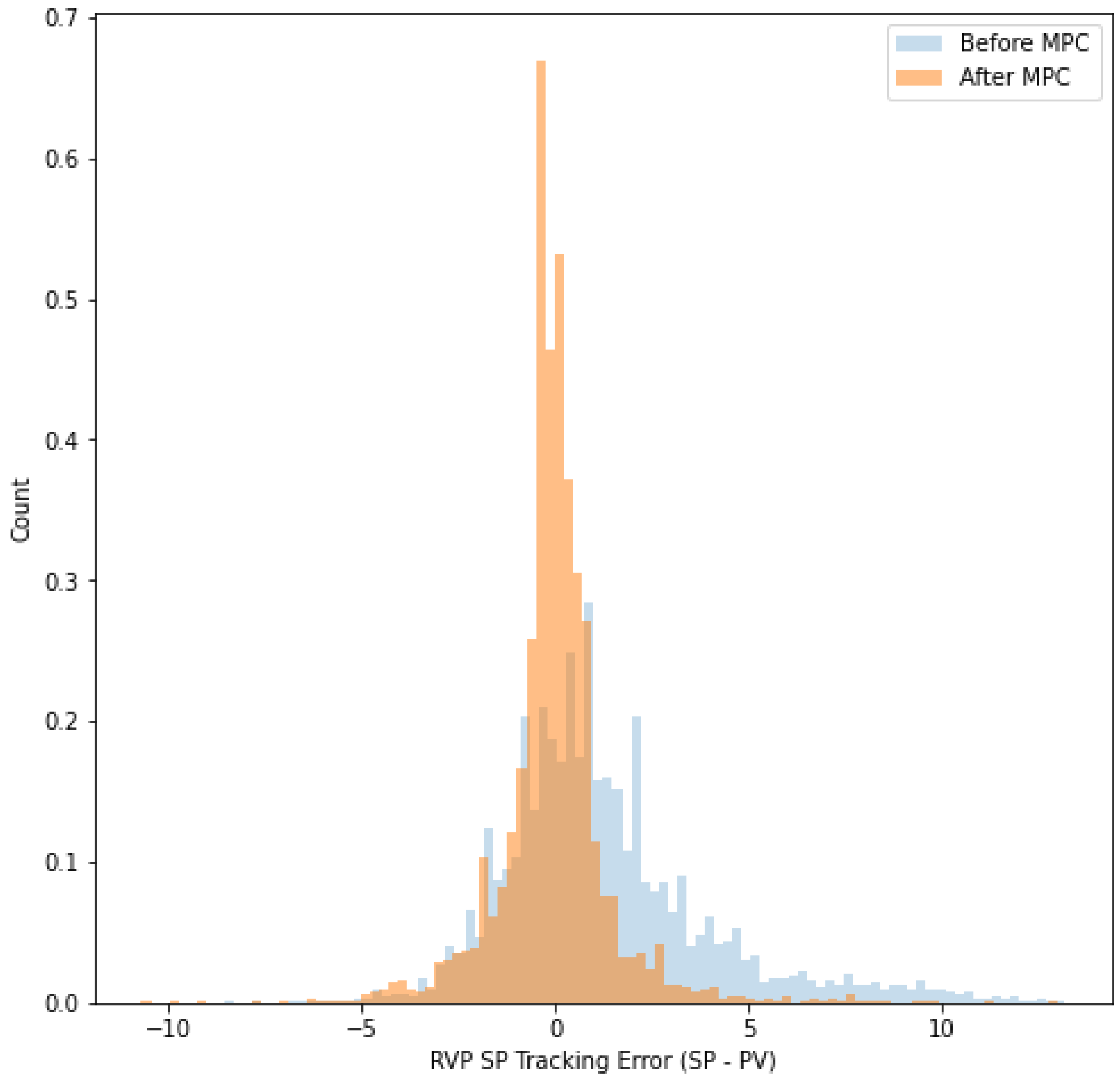
Reduced RVP Target mean error by 98%

$1.2M

Profit

Confidence to increase RVP target closer to specification limit resulted in > $1.2 M/yr in profits

1 - Crude Blending Model Predictive Control



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2 - Automated Pipeline Startup/Shutdown

Challenges:

- Batched C2+/C3+ pipeline **occupies significant amount of operator time**
    - **Frequent start/stop** to track power savings based on power price predictions
    - Manually start/stop pumps which **requires many steps**
    - **Valves opening/closing can take several minutes**
    - Meter runs are **operated manually**

2 - Automated Pipeline Startup/Shutdown

Solution:

- Implement **Procedure Automation in DeltaV**
    - **C2+/C3+ Line Start Command**
    - **Product Swing Command**
    - **Stop all command**, to shut down the entire line in a controlled and consistent manner in accordance with procedures defined in the Pipeline Safety Documents, Best Operating Practices and operators' intimate knowledge
    - **Automated meter run logic** based on flow rates to reduce operator workload
    - **Automated pump selection logic** based on run-time hours to help distribute the operating wear-tear

Value:

1 h/d

Operator Workload

Reduced operator workload by 1 hour per day across two shifts

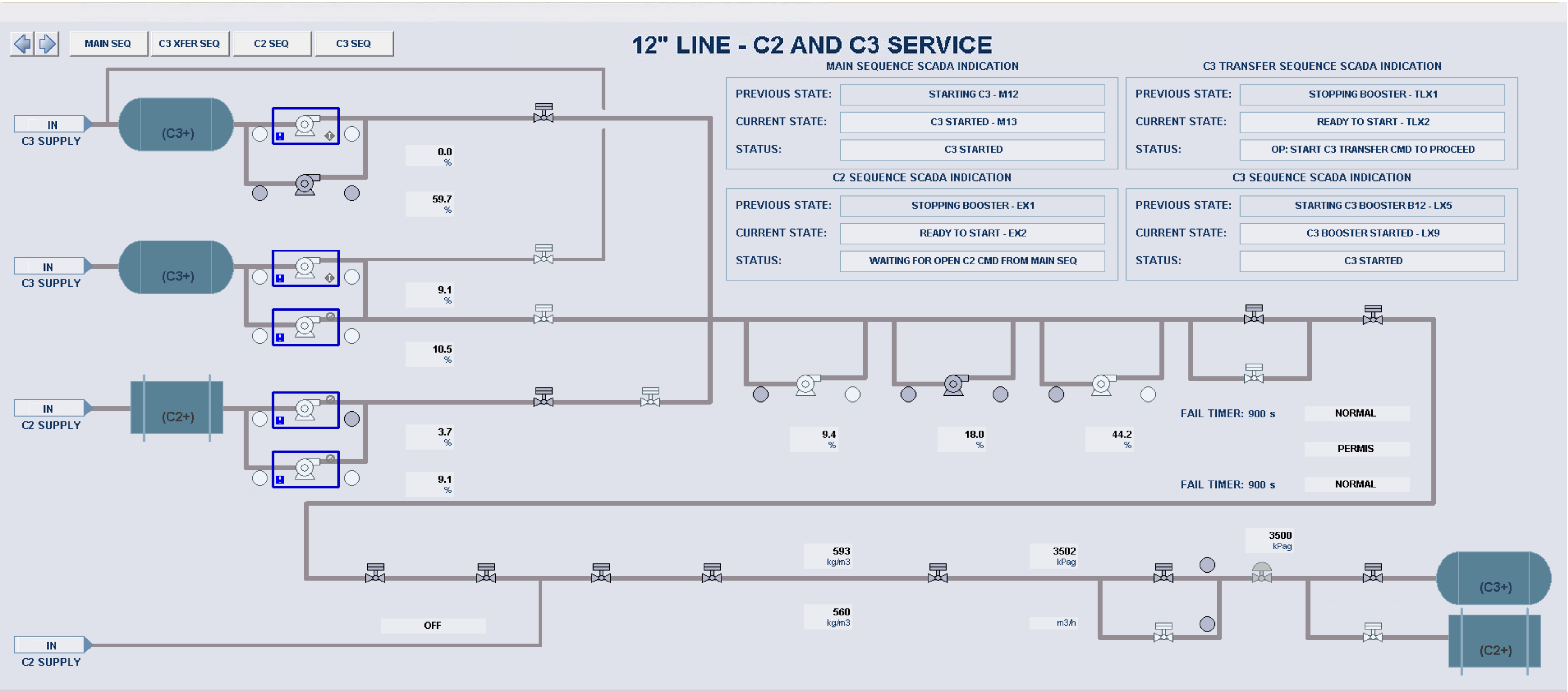
Start-up Time

Reduced line start-up time due to streamlined operation and minimize failed start-ups

Reliability

Improved equipment reliability and safety

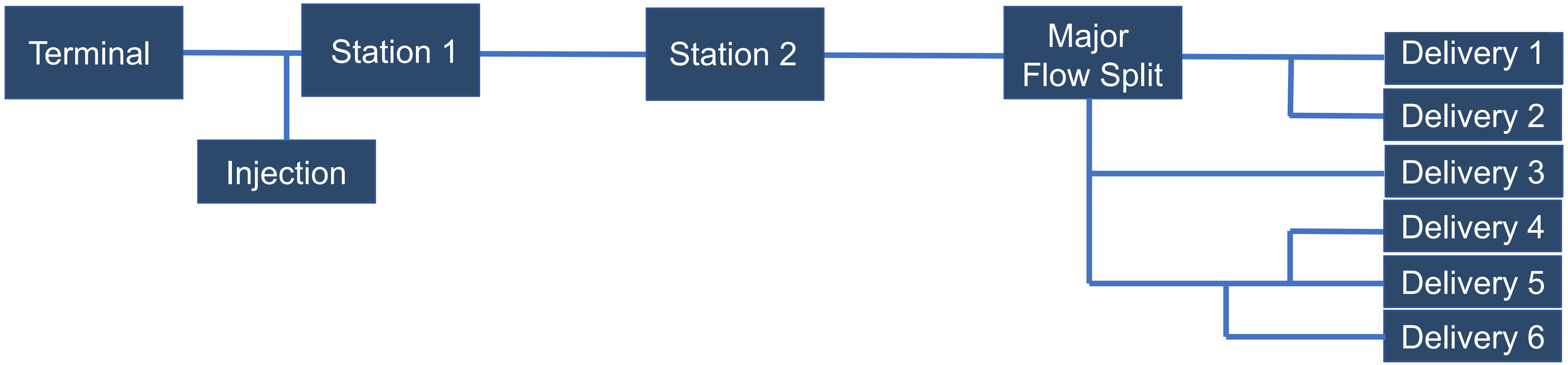
2 - Automated Pipeline Startup/Shutdown



3 - Automated Pipeline Flow Mode Procedure Automation

Challenges:

- Complex pipeline with many deliveries, operating states, and flow paths
  - **Significant operator workload**
    - Manually start/stop pumps which **requires many steps**
    - Meter runs are **operated manually**
    - Manually change operating flow rate
  - **Frequent start/stop and mode changes** to track power savings based on power price predictions



3 - Automated Pipeline Flow Mode Procedure Automation

Solution:

- Implement **Procedure Automation in DeltaV**
    - Automated Logic to **transition between different operating states (flow modes)**
    - **Delivery start/stop Commands** (for 6 deliveries)
    - **Start/Stop pipeline commands**, to start/shut down the entire line in a controlled and consistent manner in accordance with procedures defined in the Pipeline System Narratives, Best Operating Practices and operators' intimate knowledge
    - Automated meter run logic (open/close)
    - Pump trip detection with **pump restart logic**
    - Line Scraper tracking logic to provide **advanced alerts for operator required actions**

Value:

Operator Workload

Reduced operator workload

Start-up Time

Reduced line start-up time due to streamlined operation and minimize failed start-ups

Reliability

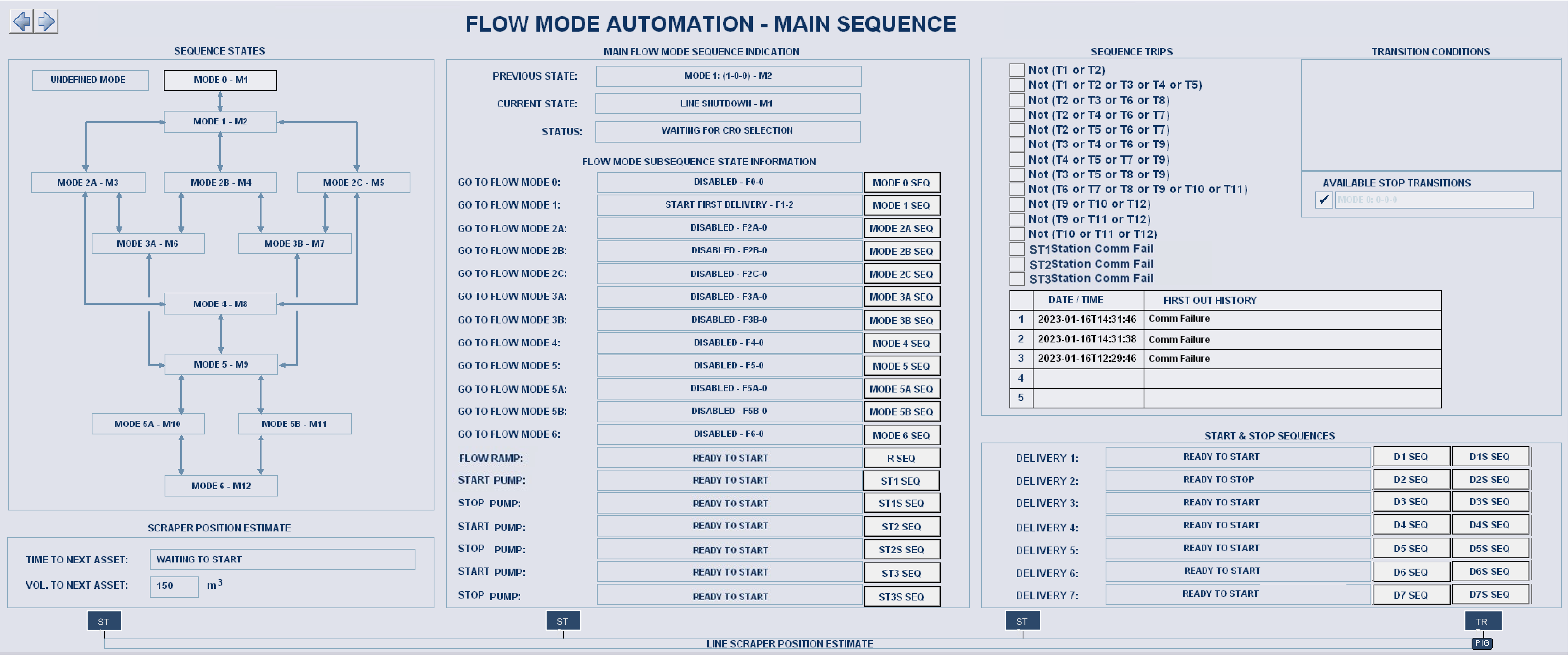
Improved equipment reliability and safety

Profit

$$$

Increased profit due to operating cost savings as the operators can be greedier in following the power savings predictions

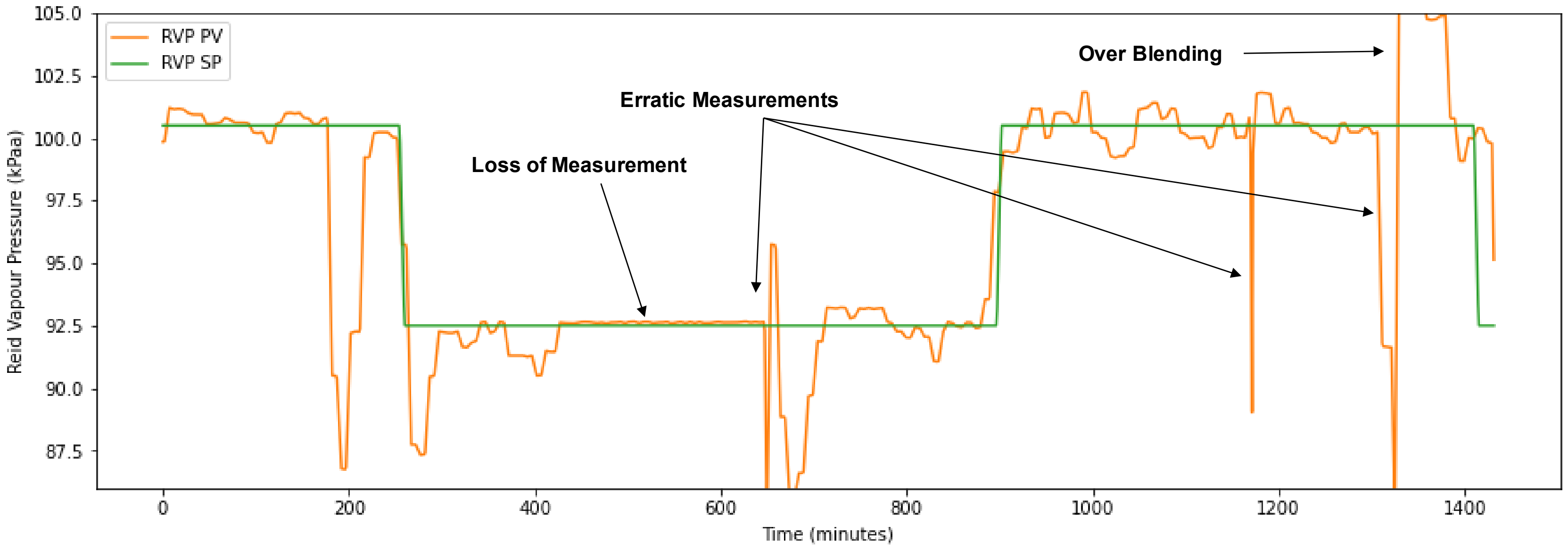
3 - Automated Pipeline Flow Mode Procedure Automation



4 - Kalman Filter - Reid Vapour Pressure

Challenges:

- Poor measurement performance resulted in **reduced blending capabilities**
    - Stale or bad RVP measurements can cause **significant short-term over-blending** which violate customer RVP limits
    - Infrequent 10-Minute RVP sampling time can cause **poor closed loop control** until next good measurement is sampled
    - Analyzer needs frequent maintenance where **significantly reduced crude blending** is done while the measurement is unavailable



4 - Kalman Filter - Reid Vapour Pressure

Solution:

- Implement an **RVP Kalman Filter**
  - Blends real and model-based measurements for **improved accuracy**
  - Provides RVP estimate when no measurement is available to **enable higher blended** volumes
  - **Rejects short-term** and **attenuates medium-term** measurement anomalies

Value:

59%

Over Blending

Reduced over blending by 59%

Operating Confidence

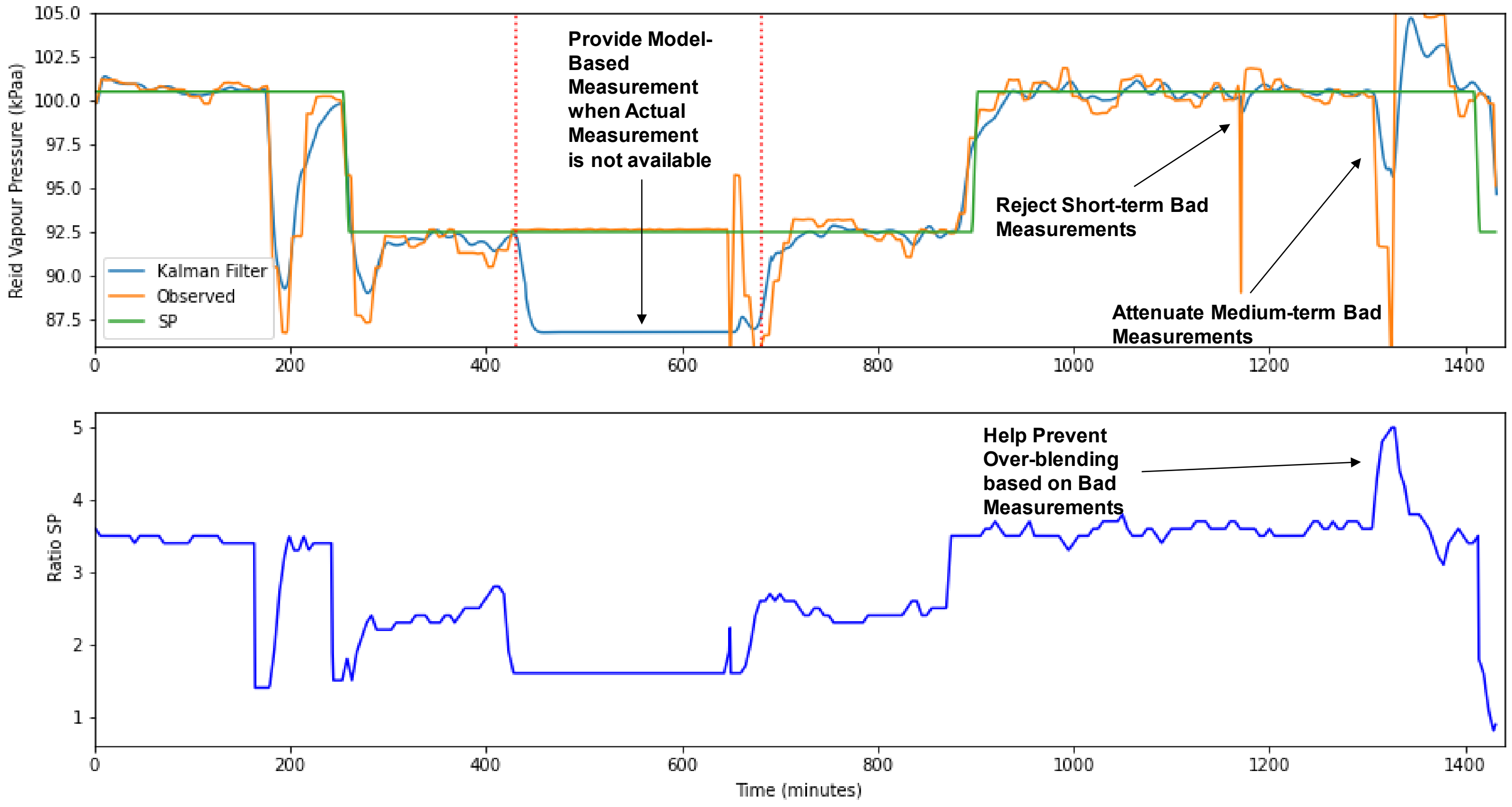
Increased confidence to blend butane more aggressively closer to specification limits

$840k

Profit

Generate $840,000 per year in profit for each 0.5 kPa increase in RVP SP target

4 - Kalman Filter - Reid Vapour Pressure



Value:

Over Blending

59%

Reduced over blending by 59%

Operating Confidence

Increased confidence to blend butane more aggressively closer to specification limits

Profit

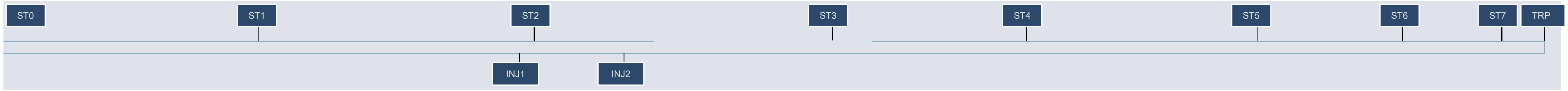
$840k

Generate $840,000 per year in profit for each 0.5 kPa increase in RVP SP target

5 - Line Scraper Tracking and Automated Asset Shutdown

Challenges:

- Valuable **blending time is regularly lost**
    - Operators **manually shut down** assets and **blending** before line scrapers arrive
    - Blending is often **shutdown/restarted based on convenience** of the operator's schedule, resulting in significant lost revenue



5 - Line Scraper Tracking and Automated Asset Shutdown

Solution:

- Implement **Soft Sensor** and **Procedure Automation in DeltaV**
  - A **line scraper position soft sensor** was implemented to track the line scraper as it progress down the pipeline
  - An **on-line learning algorithm** allows the soft sensor to improve its position accuracy
  - Procedure automation **automatically isolates assets** and allows the line scraper to pass through
  - Automation **stops the blending and restarts** it after the line scraper passes the blending station

Value:

Operator Workload

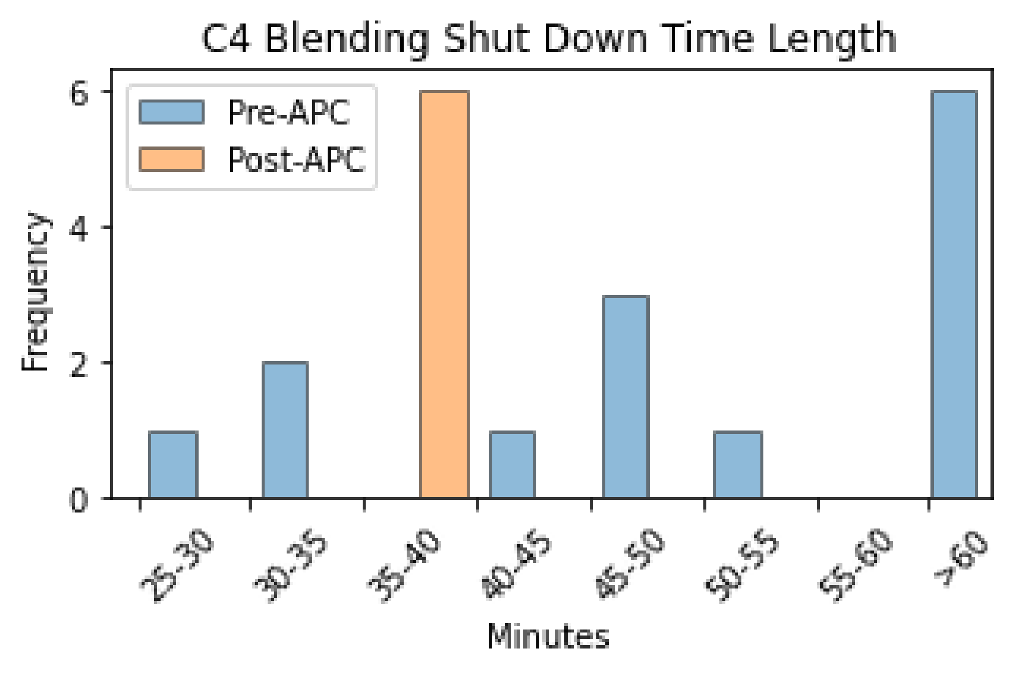
Reduced operator workload due to more streamline operation

Line Shutdown Time

Reduced line shutdown time by an average of 30 mins per scraper run

Profit

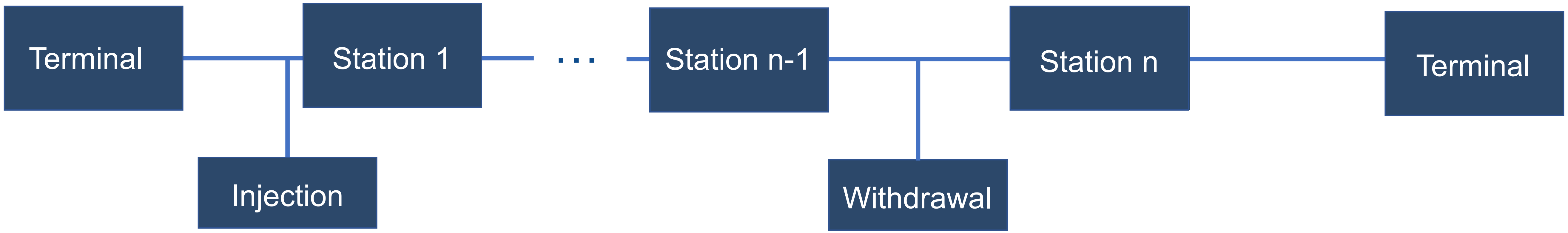
Increased revenue from crude blending due to reduced shutdown time



Future - Real-time Optimization of Pipeline Pressure Profile

Challenges:

- Complex Pipeline with many ways to operate
    - Pipelines spanning long distances can be subject to significantly different electricity/operational costs
    - Operational efficiency often relies on the skill of the Operator on shift, and is **inconsistent shift-to-shift**
    - **Significant operator workload**
        - Operational guidance often vague and decisions left to operator
        - Significant time spent micromanaging parameters (valves, pumps, pressures, flows, injections, withdrawals)
        - Disturbances and unplanned events require **frequent re-adjustment of parameters**

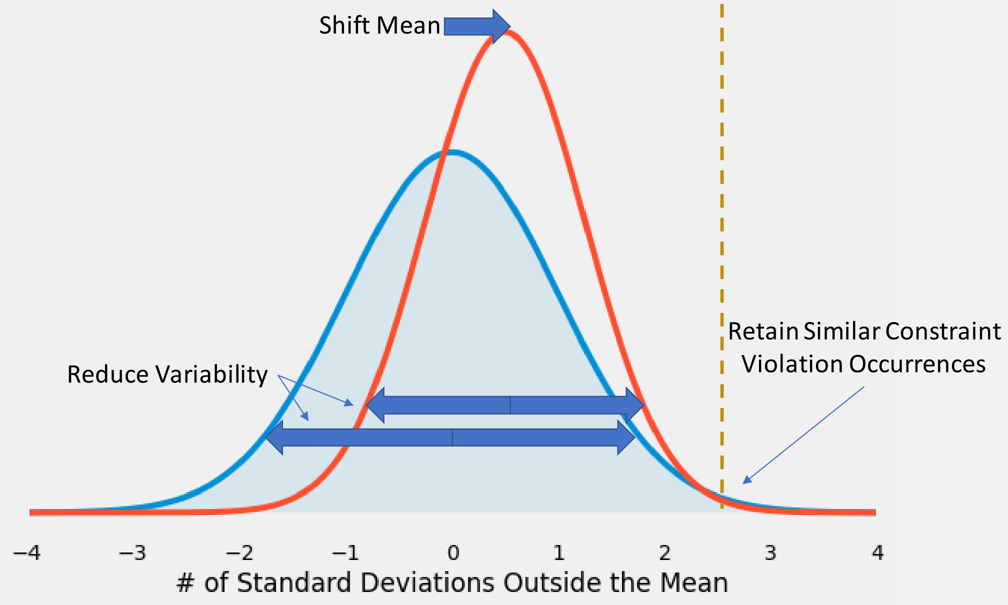


Future - Real-time Optimization of Pipeline Pressure Profile

Solution:

- Implement Advanced Process Control to determine optimized operating point
    - A steady-state optimization algorithm (nonlinear program) to **Minimize Operational Costs** subject to:
        - Pipeline Parameters: diameter, length, elevation, resistance coefficient
        - Fluid Properties: density, viscosity, DRA injections
        - Pump Parameters: Pump Curves, Minimum/Maximum Suction and Discharge Pressures
        - Maximum Operating Pressure, Injection/Withdrawal flow rates
        - Cost of Electricity at each Pump Station
    - Use a **Multivariable Model-based Control** algorithm to regulate the pipeline to the steady-state solution

Value: TBD



Conclusion

- Pipeline operations are managed locally using PLCs.
- PLCs integrated with Centralized SCADA system allows basic control but results in inefficiencies due to siloed architecture.
- Pembina Pipeline collaborated with Spartan Controls to have a unique installation of DeltaV to allow for advanced automation over an entire pipeline asset.
- Various MPC, Soft Sensors, Procedure Automation applications deployed.
- Significant operational, financial, and safety & reliability benefits achieved.

Operator Workload

Reduced operator workload due to more streamline operation

Start-up Time

Reduced line start-up time due to streamlined operation and minimize failed start-ups

Process Variability

Reduced process variability

Reliability

Improved equipment reliability and safety

Profit

$$$

Increased profit by > $10 M/yr from Advanced Automation

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