COGNITIVE AI FOR REFINERY OPERATIONS

See the Big Picture and the Smallest Detail

Executive Summary

Situation

It has become progressively more difficult to align production plans and operational realities of refineries with financial goals defined in strategic plans. Legacy methods cannot keep up with changing conditions. Cognitive Artificial Intelligence can help improve operational efficiency.

Problem

+ Plan/Schedule/Operate (PSO) cycle times are too long.
+ Planners lack consistent access to comprehensive insights into the current and near-future states of the refinery, or its complex realities and limitations.
+ Refinery configurations and equipment are in constant flux.
+ Margins are tight and the difference between expected and actual yields affects profitability.
+ A complete feedback loop does not exist among various operation units or levels.

Solution

Beyond Limits Cognitive AI for Refinery Operations. A Cognitive AI software system designed to solve persistent problems in the operation of complex refineries.

Value

+ Simultaneously monitor entire production line and individual units.
+ Diagnose and rectify problems at the device or system level.
+ Reason and recommend more efficient settings to improve throughput.
+ Increase refinery efficiency by up to 10%.

# Beyond Limits Cognitive AI for Refinery Operations

Strategic Production Plans Often Conflict with Operational Reality
Every day, a petroleum refinery yields hundreds of thousands of gallons of product, utilizing acres of land, hundreds of people, and sophisticated equipment running 24 hours per day 365 days per year. To manage these highly complex production facilities, most refineries run continuous Plan / Schedule / Operate (PSO) cycles, some of which span months from beginning to end.

Plan
At the Strategic Level, planning typically applies sophisticated simulation and optimization models to define financial goals and operating objectives that culminate in a Strategic Plan for the refinery.
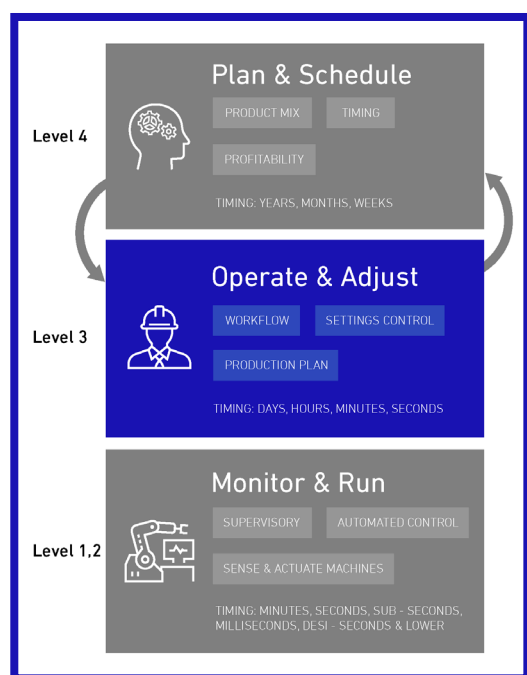
Schedule
Next, a schedule is created that focuses on supply chain objectives such as feedstock acquisition, delivery, storage and utilization, as well as distribution timelines to meet customer demand and expectations.

Once the plan and schedule are set at the Strategic Level, a production plan is created at the Tactical Level, typically by Optimization Engineers or other personnel intimately familiar with refinery processes, systems and optimization strategies. The production plan specifies process, unit and system level settings across the production process. The goal of the Tactical Plan is to put short-term configuration strategies in play to achieve the financial goals and objectives of the refinery. These production plans typically span days or weeks.

Operate
Bridging between the Tactical and Control Levels of the refinery, system operators work in real-time on small segments of the refinery to implement the production plan, monitor system/machine performance (including those with automated controllers), identify bottlenecks, and employ remediation or mitigation actions to bring systems and process yields as close to plan objectives as possible.

Although the manufacturing operations management approach described here has been the standard method for operating a refinery for many years, it has become progressively more difficult to align production plans and operational reality of the refinery with financial goals defined in the Strategic Plan.

Strategic Challenges
The challenges within refinery manufacturing processes are numerous and exist at each level of the organization. The stakes are high. Profitability is always on the line.

- **+** **The average Plan/Schedule/Operate (PSO) cycle time is too long.**
- **+** **Planners lack consistent access to comprehensive insights into the current and near-future states of the refinery, or its complex realities and limitations.**
- **+** **Feedback from the operations level, in the form of performance challenges, systems limitations and unrealistic planning objectives are limited, not codified or don't exist at all.**
- **+** **Margins are tight and closing the profitability gap – the difference between expected and actual yields - is a big challenge across the industry.**
- **+** **Refinery staff frequently change unit configurations, replacing worn gear with new equipment.**

Tactical Challenges

Optimization teams and optimization engineers do their best to create and implement production plans to achieve financial goals, but a complex array of internal and external constraints complicate production efficiency.

+ **Internal Constraints**
Refining is a continuous and complex production process where unexpected events, such as unplanned downtime, system performance issues and process bottlenecks put profitability at risk. Compound those complications with the undeniable fact that the skilled workforce experienced in managing those complex issues are nearing retirement.

According to *The 'Great Crew Change'*, a 2015 study by The Oil & Gas Journal, 25% of senior employees would be eligible to retire in the next 5-10 years. About 70 percent of all workers are over 50. This spells trouble for the industry because highly trained and experienced workers are critical to ensuring operational excellence, from routine operations to turnaround planning. These experienced workers are retiring; their knowledge and expertise may go with them.

+ **External Constraints**
Variation in crude feedstock quality is a constant concern because it can lead to upsets, production losses, system degradation and even plant shutdowns. It forces optimization teams and operators to continually adapt process systems to accommodate different crude qualities and the negative impact of variations on normal, expected systems performance. For example, systems may require constant fine-tuning, recipe adjustments, and intervention by human operators that result in higher operational costs and lower profit margins.

Over the past few years, the industry has also seen that all crude types – from light/sweet to heavy/sour - demonstrate significant deviations from their historical assay properties. Across the refining industry, crude feedstock quality, the increase in the volume and complexity of contaminants impact product quality as well as system, unit and process reliability. Refiners are finding it more difficult to achieve and sustain efficient operations through traditional methods of process optimization.

Operational / Production Level Challenges

Managing constrained systems to remove bottlenecks is a manual process. Typically conducted by operators in a control room, communication and collaboration between system operators, optimization teams, and strategic planning may be poorly integrated or not integrated at all.

Regardless of the complexity of the refinery, when systems are not operating according to plan and their pre-configured settings need to be adjusted, people are required to step in. However, bottleneck/constraint resolution approaches and results are typically not codified, universally shared or applied. And, the non-linearity of problem-states makes it difficult for engineers to find a local solution to a given problem because the solution may lie in a different unit or system. In these environments, operations teams struggle to execute mitigation actions within and across systems.

Cognitive AI System to Improve Operational Efficiencies and Profit Margins

To effectively respond to these challenges, refineries must vigorously strive for operational excellence and continuous process improvement to grow profits.

Beyond Limits Cognitive AI for Refinery Operations is a system for embedding and evolving operational best practices within production processes. This capability enables continuous process improvement, which will in turn, drive higher efficiency and improve margins.

The Beyond Limits software is designed to help operators, engineers and management staff monitor process, unit and system level performance, identify risks to production plan objectives and provide solutions to problems wherever possible.

Unlike typical IoT sensor-based systems that monitor a single device, the Beyond Limits Refinery Operations system comprehends and analyzes the entire refinery system. In many cases, it identifies a problem in one unit that is caused by an adjacent upstream or downstream unit.

The Refinery Operations system sees the entire refinery and individual components to identify problems and remedies.

Operators can update the graphical model by dragging in new units to replace or upgrade older systems and their sensors.

Refinery Operations AI System – Impact and Value

Area of Impact	Challenges	Benefits and Value
Strategic Planning & Scheduling	Long PSO Cycle Time	Designed to shorten PSO cycle times through persistent utilization of near real-time learnings/data from the Refinery Operations AI system.
	Planning Models Not Up-to-Date	Ensure lessons learned, information and data related to operating conditions, effectiveness or problems with objectives and areas where bottlenecks prevented resolution.
	Lack of Feedback from Operations to Planning	
	Gap Between Expected and Actual Yields	The Refinery Operations AI system is designed to guide operations with best practices, reduce time to mitigation, and increase the fraction time the facility operates in desirable states.
Tactical Planning	Degrading System Performance and Bottlenecks	The AI system provides engineers with the ability to plan more effectively due to presentation of near real-time feedback and retrospective lessons learned from operational data. Importantly, the system provides greater visibility and agility to respond with confidence to conditions that threaten plan objectives.
	Variability in Feedstocks	
	Aging Workforce / Lack of Skilled Labor	With the Refinery Operations AI system, both novice and experienced engineers can re-use historical, proven plans and strategies (operational best practices and knowledge). They can also build new strategies based on information provided by the system to devise and deploy more effective production plans.
Operations / Production	Constraint Management	The AI system identifies risks to production plan objectives (off-spec or other undesirable operations), interrogates all systems associated with the condition, and provides a globally consistent solution when possible.
	Transparent Reasoning Trail	The Refinery Operations AI system provides a fully auditable reasoning trail to operators to promote trust in the system and diagnose and repair plan errors. This visibility into the AI advisor's reasoning and evidence enables the operations team to adapt to changing conditions and quickly return the process to more profitable operating conditions.
	Variability in Feedstocks	The AI system identifies when the properties of a feedstock deviate from expected values and alerts operators and engineers about its findings.
	Aging Workforce / Lack of Skilled Labor	The Refinery Operations AI system encapsulates and embeds operational excellence and decision expertise directly into the process workflow to provide near real-time decision support. This serves as a training system and persistent method of ensuring standards of practice are universally captured and applied as upsets, process bottlenecks, or other deviations from the plan occur.

Cognitive AI for Refinery Operations – Capabilities

The Refinery Operations AI system provides valuable monitoring, oversight, and diagnosis to assist key members of refinery operations staff, including planners, operators, managers, and engineers with decision-making.

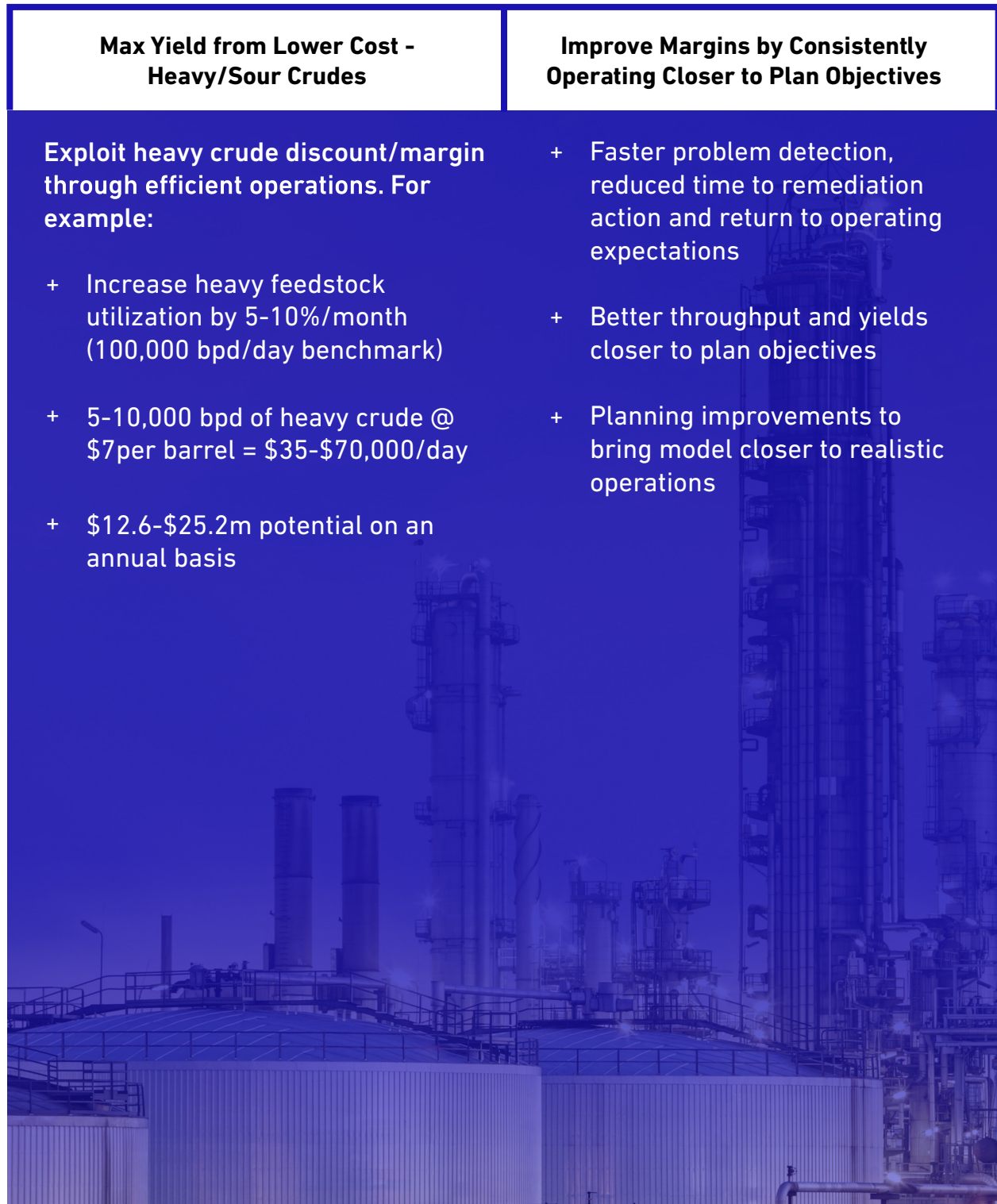| For Production Planners	For Operators	For Managers
Plan Digitization + Create, manage, and evolve operational plans to achieve targeted objectives + Fully leverage historical operational plans and strategies to learn from experience and codify best practices **Retrospective Analysis, Dashboards and Reports replay process level data to:** + Understand overall operational performance for critical refinery objectives + Know where and when operational challenges and bottlenecks occur + Identify where best practices and actual operations are in conflict with one another + Isolate and share data when plan assumptions are not consistent with the current state of the refinery **Feedstock Quality Report** + Understand operational impact of feedstock changes + Ability to provide adaptive guidance to operators based on current feedstock	+ Monitor, identify risks, and recommend remediation to support production goals in near real-time + Provide rapid assessment of feedstock properties with specific operational guidance + Provide a means to capture and share emerging mitigations strategies that work	**Dashboards and Reports** + Unit, system and process level results and challenges + Operator performance + Production plan vs actual performance + Effectiveness of daily, weekly or monthly strategies + List of known problems/risks and unused mitigation actions + List of known problems/ risks where plan cannot supply a mitigation action + Feedstock impact on production goals and objectives

Explainability: Beyond Limits Cognitive Reasoning Trace

Efficiency, Effectiveness and Profitability – The Value Story

The Refinery Operations AI system is designed to enable improvements across the refinery production process resulting in improved efficiency, effectiveness and profitability.

Max Yield from Lower Cost – Heavy/Sour Crudes	Improve Margins by Consistently Operating Closer to Plan Objectives
Exploit heavy crude discount/margin through efficient operations. For example: + Increase heavy feedstock utilization by 5-10%/month (100,000 bpd/day benchmark) + 5-10,000 bpd of heavy crude @ $7per barrel = $35-$70,000/day + $12.6-$25.2m potential on an annual basis	+ Faster problem detection, reduced time to remediation action and return to operating expectations + Better throughput and yields closer to plan objectives + Planning improvements to bring model closer to realistic operations

Leverage Best Practices – Democratize Veteran Expertise

At the ground level, refinery teams, including planners, engineers, and operators will have the ability to leverage and extend best practices to consistently improve upon production processes. Teams will be empowered to:

+ **Capture and leverage operational best practices to directly improve production processes**

+ **Enable a more integrated, intelligent and collaborative plan/schedule/operation cycle**

+ **Institutionalize the benefits of knowledge acquisition and transfer of lessons learned to drive continuous process improvement**

+ **Improved situational awareness and cross functional communication**
    + Everyone's efforts, from top to bottom, are aligned to global objectives
    + Planners and engineers can easily see where plans are not performing as expected
    + Planners and engineers will run their own plans, not presets from the system, and can modify them as they learn from experience

+ **The entire system is extensible and configurable to accommodate changing conditions**
    + Operators can confidently make mitigation decisions to return systems closer to plan objectives
        + Production teams effectively manage the processing challenges caused by the variability of crude feedstocks
        + Even when the problem-state makes it difficult to find a local solution to a given problem, the system can search for - and provide - solutions in a different unit or system

Summary and Benefits

Beyond Limits Cognitive AI for Refinery Operations is a powerful AI software system designed to solve persistent problems in the operation of large-scale refineries. By monitoring the entire production line and individual components, diagnosing and rectifying problems in near real-time, the system is designed to improve throughput and increase revenue.

The Cognitive AI for Refinery Operations system:

+ Helps operators, engineers, and planners align production plans and operational realities of refineries with financial goals defined in strategic plans.

+ Modernizes legacy methods that cannot keep up with changing conditions.

+ Shortens Plan/Schedule/Operate (PSO) cycle times.

+ Supplies planners with accurate understanding of current and near-future state reality and limitations of the refinery.

+ Increases visibility into the entire refinery to achieve tight margin targets and track the difference between expected and actual yields that weigh on profitability.

+ Dramatically increases volume and quality of crucial feed-back from the operations level.

+ Increases refinery efficiency by up to 10%.

About Beyond Limits

Beyond Limits is a pioneering Artificial Intelligence engineering company creating advanced software solutions that go beyond conventional AI. Founded in 2014, Beyond Limits is transforming proven technologies from Caltech and NASA's Jet Propulsion Laboratory into advanced AI solutions, hardened to industrial strength, and put to work for forward-looking companies on earth.

Beyond Limits leverages this unparalleled innovation portfolio, along with proprietary cognitive technologies, to help companies solve tough, complex, mission-critical problems and transform their business. We apply a unique hybrid approach to AI, combining numeric AI techniques like machine learning with higher order symbolic AI and expert human knowledge to deliver intuitive cognitive reasoning and information. The result is faster, better decisions that reduce risk and increase revenue.

Footnote: (https://www.ogj.com/home/article/17294840/the-great-crew-change)