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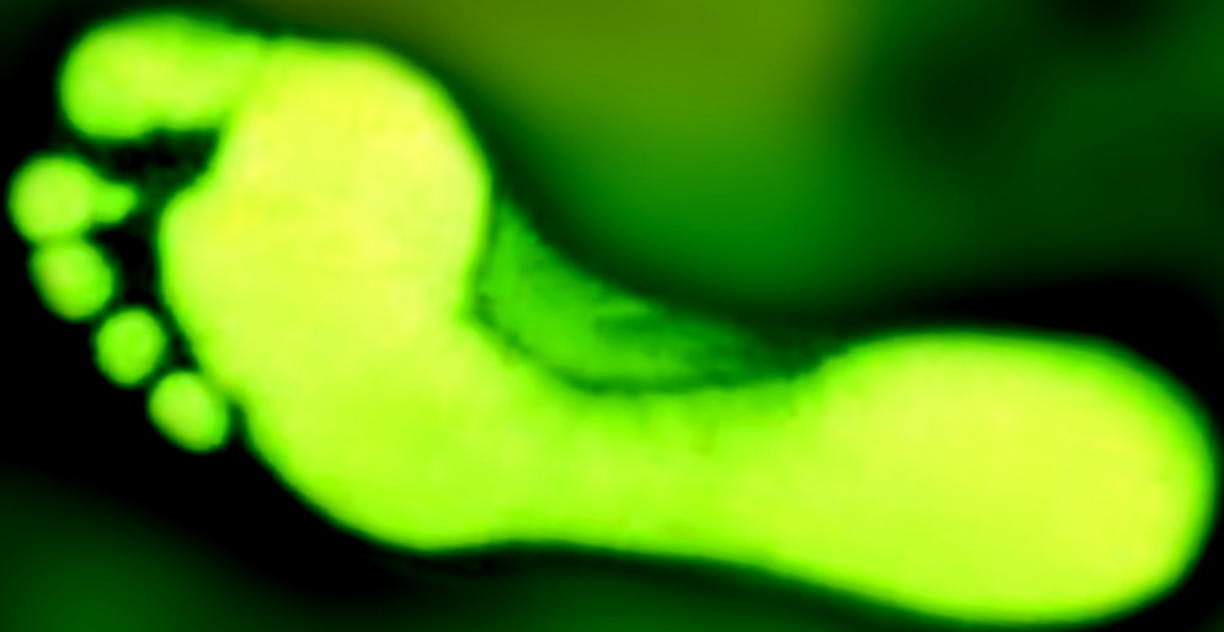
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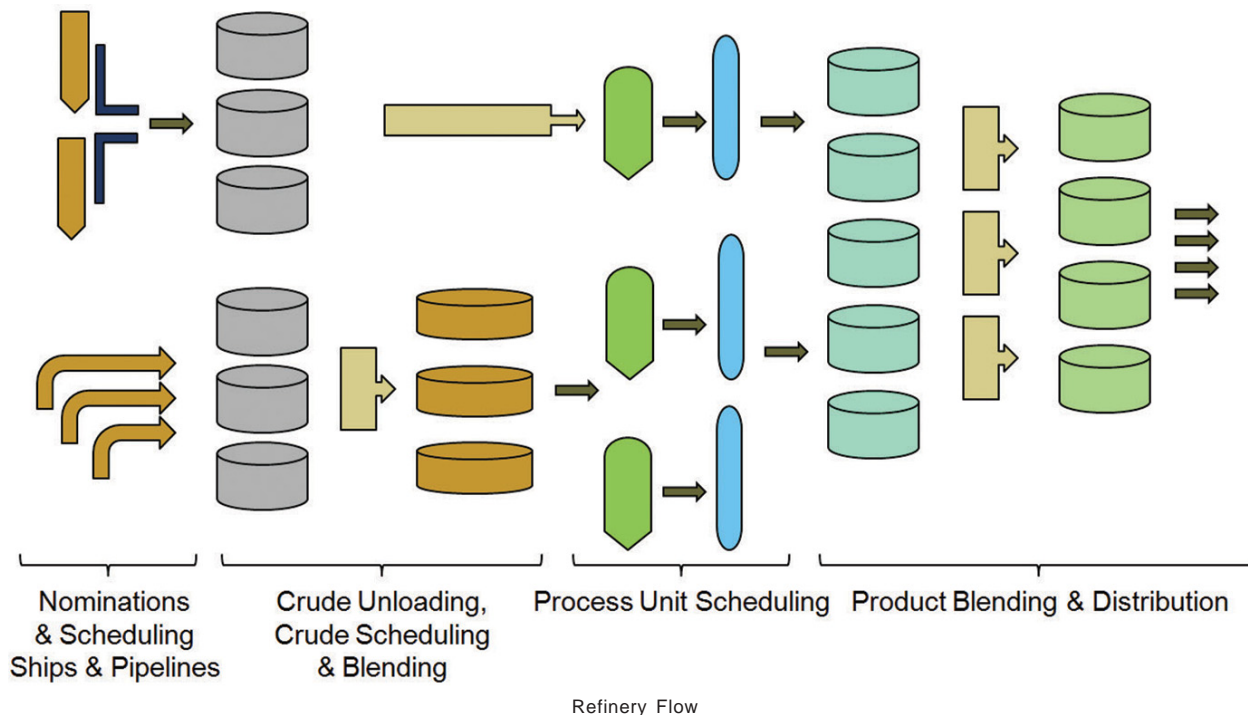
Special Supplement : Carbon Management

Carbon Footprint



The carbon footprint is a measure of the exclusive global amount of carbon dioxide (CO₂) and other greenhouse gases emitted by a human activity or accumulated over the full life cycle of a product or service. The life cycle concept of the carbon footprint means that it is all-encompassing and includes all possible causes that give rise to carbon emissions.

Act on CO₂



End-to-End Refinery Scheduling

By : Robert Hutchings, Dr. Dong Dong, Nam Nguyen, M3 Technology Inc., SIMTO™ Refining, US

Scheduling systems play a vital role in process industry's supply chain. The scheduling decisions involve many competing factors such as: achieving economic targets and handling environmental regulations, meeting quality requirements and reducing quality giveaway, supplying adequate feedstock and reducing feedstock inventories, responding to operation disturbances and maintaining operation safety. Scheduling a site is a complex and multi-dimensional task, requiring the coordination of many schedulers and operators.

Planners and schedulers need to visualize the plant level operation and drill down as required to see the cascading effect of crude changes and quickly run what-if scenarios to evaluate alternative schedules. The advanced technology provides simultaneous execution of crude scheduling, process unit scheduling, crude and product blend optimization, product progression and product lifting.

SIMTO systems represent the new technology trend for process

industry's scheduling systems – visualization and optimization. Visualization technology provides the right tool for schedulers to identify the scheduling problems and interactively solve the problems. Optimization technology helps the scheduler achieve maximum profitability and find feasible solutions on short-term and long-term schedules.

SIMTO Refinery Solution Overview

This paper describes how M3TECH's Refinery Scheduling solution can be applied to a world class refinery.

The SIMTO Refinery Solution is an integrated solution for planning and scheduling management in refineries. The solution covers refinery activities from feedstock to products, from receiving to shipping, from corporate to plant planning, and from internal to external scheduling:

- Summarizing multi-site schedule data across the supply chain to communicate among enterprise

applications and to share with traders, managers, and enterprise personnel.

- Planning activities across the enterprise on a single user-interface to integrate data from multiple sources, improve data comprehension, and increase outcome visibility.
- Scheduling feedstock receipts, processing unit operations, and product shipments to improve asset utilization.
- Optimizing blends of feedstock and products for multiple periods to comply with equipment limitations, improve yields, meet quality specifications, and deliver products on schedule.
- Scheduling receiving and shipping docks or terminals with considerations for constraints in weather, traffic, vessels, berths, and inventories.
- Integrating planning and scheduling activities in an enterprise solution to facilitate communication and enhance coordination and cooperation.

The SIMTO Refinery Solution is comprehensive but user-friendly. All

the pieces of the solution work seamlessly together to streamline business processes and minimize human error.

M3 Technology's refinery solution incorporates innovative applications in business intelligence, planning, scheduling, and optimization. Production plans provide refineries with guidelines comprised of monthly averages, but refineries need efficient schedules to make those plans a reality. M3's refinery solution has applications that schedule plant activities, optimize blending, and manage dock or terminal operation.

SIMTO™ Scheduling

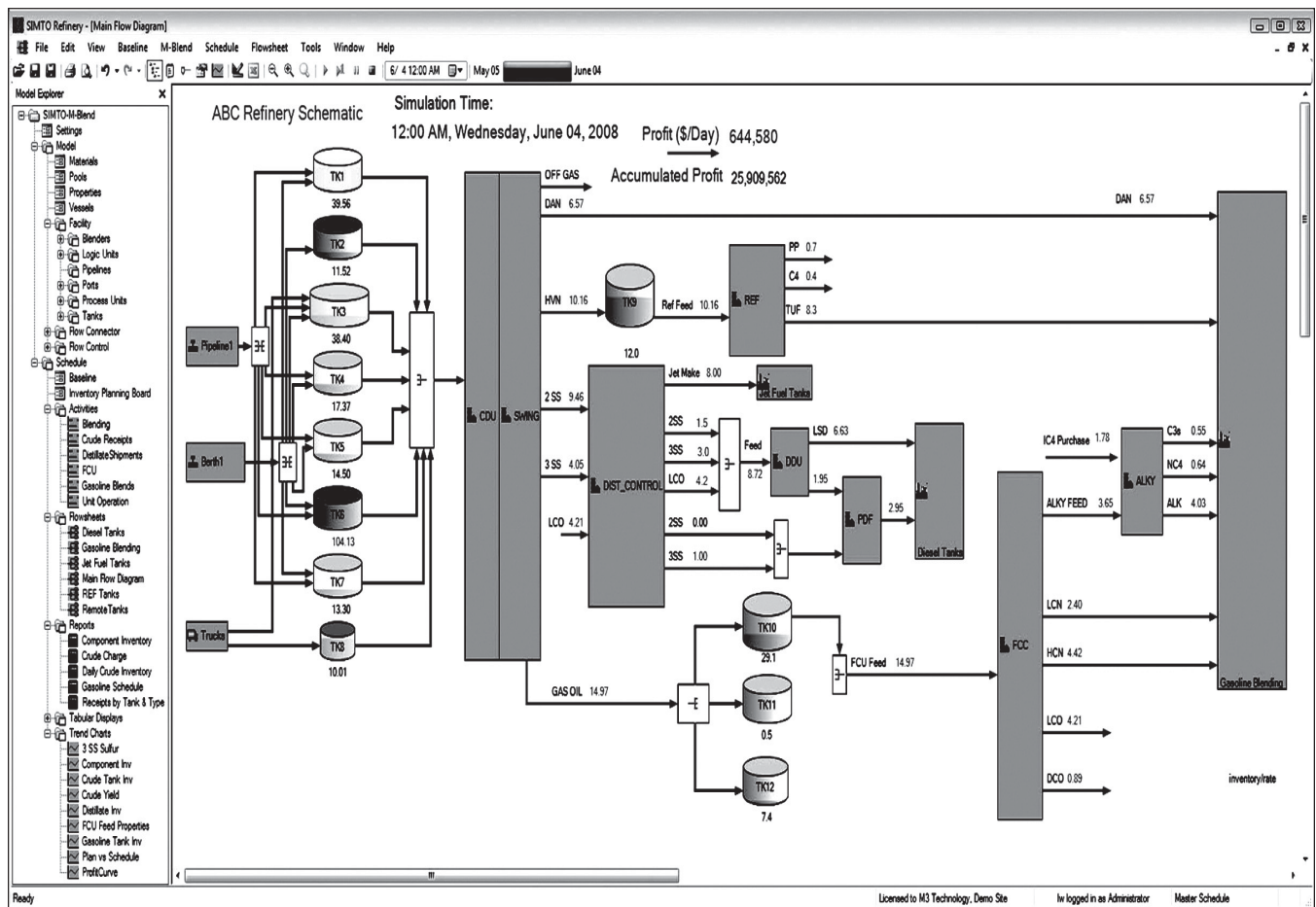
SIMTO Scheduling provides a flexible scheduling platform combined with a comprehensive modeling tool that is functionally powerful, simple to use, easy to maintain, and easy to integrate with other systems.

Schedulers need to know the usable capacity of a plant to schedule feasible production. This capacity is hidden in the constraints and interdependencies of the plant's facilities. SIMTO Scheduling simplifies these complexities with graphical representations or flowsheets of production processes. Modeling involves drawing icons and setting their parameters on window-based forms. Relationships among facilities like tanks and processing units are determined by logic units and operation modes. The current plant capacity is represented by a baseline, a set of values including tank inventories, qualities, unit yields, blend compositions, and line fills. From a baseline, schedulers arrange sequences of operational activities to meet near-term deliveries.

With the model handling the complexities of the production process, schedulers are free to focus

on scheduling. SIMTO Scheduling gives schedulers the flexibility to manage operational activities and still observe the plant's usable capacity by enforcing dependencies and constraints. Schedulers assign activities such as feedstock receipts, tank or pipeline transfers, unit operations and status changes, blending, and product shipments by creating bars on a Gantt chart and editing their parameters on a window-based form. These activities can be serial or parallel and linked or unlinked. SIMTO Scheduling's user-friendly interfaces and customizable Gantt charts make schedulers more efficient and support better decision making.

Schedulers receive instant feedback about inventories, product qualities, and constraint violations after scheduling changes so that schedulers can monitor the performance of schedules. At any given



time, SIMTO Scheduling's simulation engine predicts raw materials inventories and qualities, production rates, unit yields, and product quantities and qualities, while enforcing interdependencies and constraints defined by the model. Configurable tabular displays and trend charts help schedulers monitor changes in inventories and qualities. Violation icons warn schedulers about tank overflow or underflow. Schedulers can identify time gaps on Gantt charts for possible demurrages and shipment delays. Schedulers can do what-if analyses to compare the performances of different scheduling scenarios so that schedulers can manage inventory effectively and develop feasible and profitable production schedules.

SIMTO™ M-Blend

Part of scheduling is to ensure that the right crude mix is processed and the right product is shipped. M-Blend (Multi Period Blend Optimization) is a comprehensive, flexible, and versatile solution for blending, which is a common activity in refineries and has strong economic and operational impacts.

M-Blend solves the blend optimization problems involving multiple products and multiple periods in refineries. This optimizer finds the optimal recipes that meet the specifications of individual blends across the schedule horizon, while minimizing the cost and quality giveaway and honoring the constraints of material balances, logistics, and shipments. Materials are distributed within the minimum and maximum limits of material pool and component compositions. Logistic considerations ensure that tanks service the right materials, follow the proper switching sequences, do not overflow or underflow and are transferred within pumping capabilities. Products will be shipped at the right volumes and on schedule.

M-Blend accommodates flexible objectives and breaks infeasibili-

ty. While searching for the optimal recipes, the optimizer may enforce or relax the requirements to meet specifications, depending on the user-assigned penalty factors for those specifications. The optimizer may try to meet the exact specifications for the user-specified, immediate future of the schedule and loosen the specification limits for the distant future. When flexibility fails to produce optimal results, the optimizer specifies the volumes of materials required to break the infeasible problem.

M-Blend tracks the qualities of blend products and tank inventories during the optimization search. The optimizer blends properties, using available blending methods such as indexes, biases, property bonuses, interactions, formulas, and nonlinear correlations. These blending methods are versatile and adaptable to a wide range of blending applications including reformulated gasoline (RFG), diesel, naphtha, fuel oil, crude oil, and asphalt.

SIMTO™ M-Blend for Crude Oil Blending

Refineries must minimize crude cost while meeting production requirements. Quickly and accurately determining crude recipes for the coming week, month or any period with SIMTO refinery solution allows the crude scheduler to see the cascading effects of crude blending and schedule changes.

M-Blend is a comprehensive blending tool that helps the crude scheduler deal with the complex constraints in specifications, inventory, logistics, and production schedules. Key capabilities of the application are:

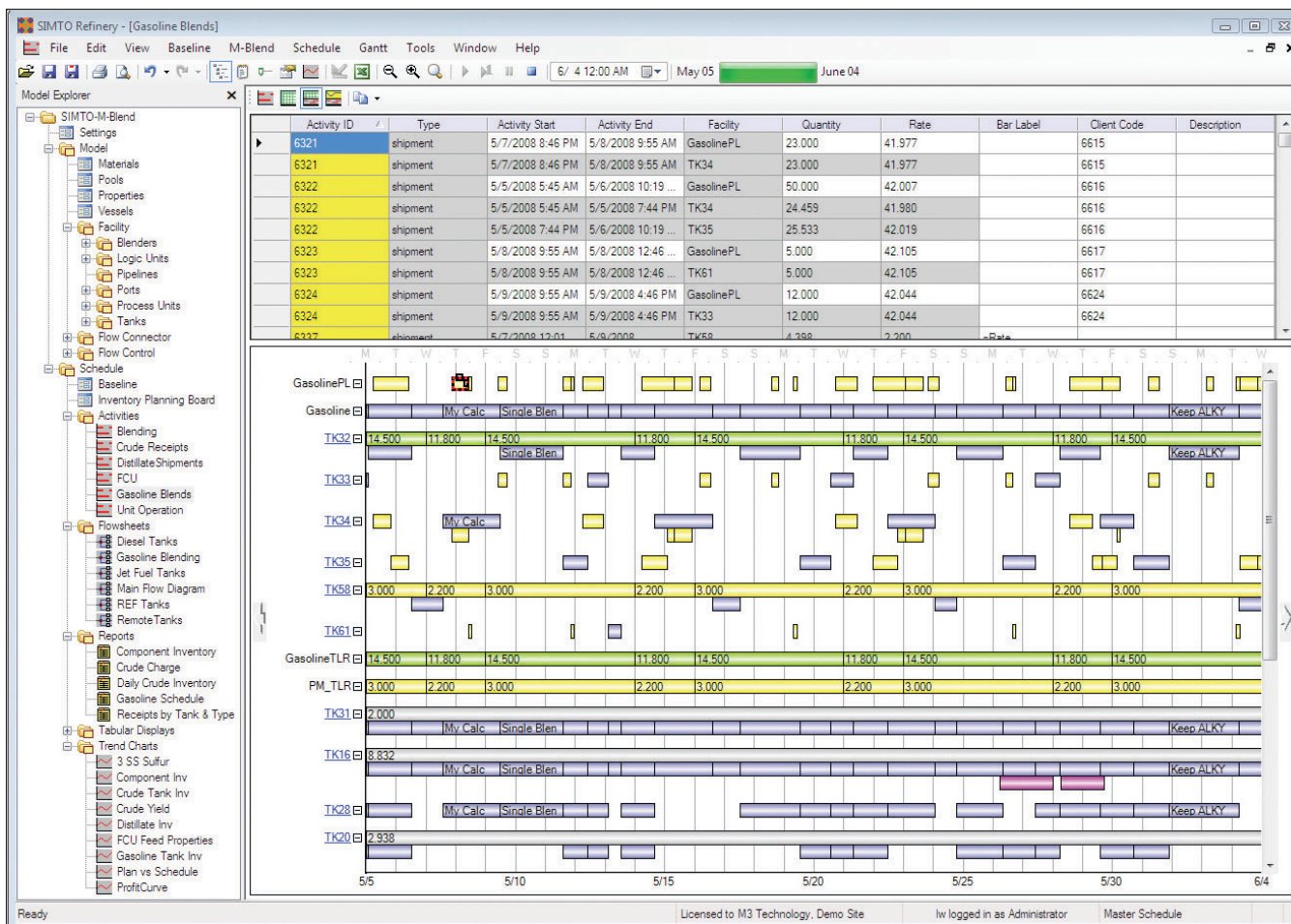
- Stabilizing crude feed qualities and using more economical crudes by optimizing crude blending to meet quality specifications
- Minimizing the total cost of multiple blends of crude oil over multiple periods in the schedule horizon, while honoring constraints in

specifications, inventory, logistics, and production schedules.

- Avoiding the problem of optimizing a single blend at the risk of inventory shortage and unit shutdown or slowdown for subsequent blends of the crude mix.
- Managing inventory economically by accurately predicting demands of crude oil components. Inventory control is important with the tight supply of crude oil.
- Controlling critical properties that limit the amount of crude mix can be processed. For example, sulfur and vacuum resid contents have maximum targets because of the battery limits of the sulfur recovery and coking units. A crude mix with a high total acid number may be incompatible with the metallurgy of the processing units. Hydrogen availability and hydrocracking capability determine how heavy a crude mix can be processed.
- Predicting blend properties accurately with versatile blending methods including linear blending, bonuses, formulas, interactions, and dynamic libraries. The library blending method can handle complex correlations of oil compatibility models to predict asphaltene insolubility to prevent oil separation and heater fouling.
- Blending the crude mix consistently for stable operation and consistent product quality.
- Increasing refinery flexibility with the ability to blend crude oils outside experience and to adapt quickly to changes in crude supply and quality.
- Managing product specifications and blending methods through a blend knowledge base.

SIMTO™ M-Blend for Gasoline Blending

Gasoline blending contributes an important portion to the profit margins of fuel refineries. Fluctuations in costs and qualities of blend stocks and stringent quality specifications and regulatory requirements



of gasoline products increase pressure on refineries to minimize cost and quality giveaway. SIMTO M-Blend for Gasoline Blending can help refineries optimize gasoline blending and manage the complexities of this process. Key capabilities of this application are:

- Minimizing cost and quality giveaway of multiple blends over multiple periods in the schedule horizon, while honoring constraints in specifications, materials, logistics, and shipments.
- Providing standard and customizable blending library such as RFG, CARB, and Distillate and solving nonlinear blending optimization problem.
- Avoiding the problem of optimizing a single blend at the risk of inventory shortage, shipment delay, and even loss of sale for subsequent blend products.
- Managing inventory economically by accurately predicting demands of blend stocks. Inventory control is important when the availability of qualified blend stocks decreases

with stringent regulated properties such as sulfur, NOx, and VOC.

- Predicting blend properties accurately with versatile blending methods including linear blending, bonuses, formulas, interactions, and dynamic libraries. The interaction and library blending methods can handle complex correlations in calculating gasoline properties such as RON, MON, NOx, and VOC.
- Increasing market flexibility with the ability to blend stocks outside experience and to adapt quickly to changes in inventory and product requirements.
- Transitioning efficiently from grade to grade, season to season, and even area to area. For example, the multi-blend, multi-period optimization balances between blend down and draw down for the transition from winter fuel to summer fuel.
- Managing product specifications and blending methods through a blend knowledge base.
- Tracking material usage and regulated properties to comply with

regulations such as anti-dumping and environmental protection laws.

SIMTO™ Dock Manager

Refineries receive feedstock for processing and ship products to customers. Scheduling receipts and shipments of large feedstock or product cargoes at refineries is challenging with constraints involving weather, channel traffic, vessels, dock facilities, terminal inventory and sendout rates, and contractual obligations. Dock Manager considers all these constraints and automatically generates an optimal schedule and a report listing the scheduled time of each step for every cargo and provides an overview of demurrage and delays.

SIMTO Dock Manager is an integral feature of the SIMTO Scheduling system. Dock Manager automatically schedules the ships at a dock. The system considers many factors which may impact the terminal operation including berth/jetty constraints, traffic congestion, weather conditions, terminal inventory, ter-

minal send out rates, contractual limit, cargo arrival schedule and facility maintenance. SIMTO Dock Manager provides the ability to visualize the future and to generate a schedule for the cargos arriving at the jetty or berths.

The automatic scheduling technology addresses major activities at the dock such as:

- Automatically choose docks/berths.
- Automatically assign receiving tanks
- Automatically check for constraint violations before inbound and outbound transits
- Automatically calculate delays

SIMTO Dock Manager facilitates inventory management and reduces costs by minimizing demurrage across feasible schedules while considering active constraints including the berth or jetty and channel traffic.

Scenario Evaluation

M3's refinery solution's power is

evident in its ability to rapidly explore and analyze what-if scenarios to provide refinery personnel such as plant managers, crude traders and plant operators, with information to make fast and accurate decisions. For example:

- A refinery manager may ask what plan the refinery should follow to meet its goal when demands for certain products have changed.
- A crude trader may ask what crude oil should be purchased, how the new crude fits in with the existing crude mix, and whether it is compatible with processing units.
- A refinery scheduler may ask what inven-

tory levels in crude tanks should be maintained to reduce demurrage costs due to unloading delays and to prevent unit shutdown or slowdown due to low feed supply or when certain products should be blended to prevent late shipments.

- A unit engineer may ask what the impacts on downstream units are when a unit is taken off-line.
- A plant operator may ask how close to the operational limits a processing unit should run with a new feedstock.
- A shipper may ask which vessel should be docked first and if it fits in the first available berth.

M3's refinery solution can simulate these scenarios and provide refinery personnel with qualitative and quantitative information to make time-constraint decisions.

Enterprise Solution

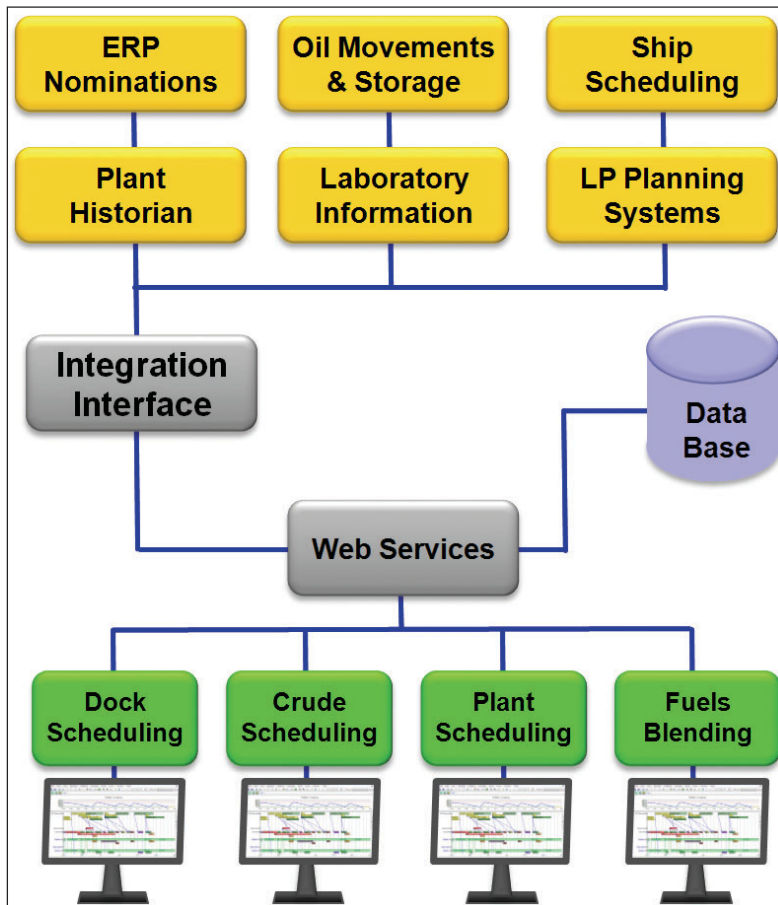
M3's refinery solution provides a uniform view to the enterprise

through user-friendly interfaces, visualization of results, multi-user and multi-site operation, and data integration.

Multi-user and Multi-site Operation – SIMTO applications make communication easy by allowing multi-user and multi-site operation. Users can be assigned to one of the following roles: administrator, nominator, scheduler, and viewer. Depending on their roles, some users can make and save changes to all or certain parts of the scheduling system, but all users can view the schedule and do what-if analysis. The enterprise architecture of SIMTO applications improves communication and promotes coordination and cooperation among groups within an organization.

SIMTO™ Integration Depot and Web Services – Data integration is another factor in improving communication. Integration Depot provides importing and exporting abilities to

transfer data among SIMTO Product Family. Integration Depot, along with Web Services also facilitates interfacing between the Product Family and external systems such as planning systems, ERP, accounting systems, lab information systems, process control systems, and real-time movement tracking systems. The applications in Refinery Solution are smoothly integrated with corporation network security systems because they were developed with Microsoft .NET technology to produce pure managed code applications for secure internet/intranet deployment.



Operational Benefits

The scheduling applications of M3's refinery solution can help a refinery not only improve its promises to customers and shareholders but also achieve safe and sound operation by predicting the outcomes against all the constraints in the model. The impacts of any change in weather, feedstock, or product quantities and specifications can be simulated by SIMTO Scheduling, SIMTO M-Blend, and SIMTO Dock Manager.

SIMTO Scheduling can save the refinery money by tracking feedstock inventories. It tells schedulers the exact time window in the near future to bring in a certain feedstock. Tank underflow and demurrage can be significantly reduced.

SIMTO Scheduling's inventory planning board can improve inventory management and prevent incidents such as unit shutdown, tank overflow, tank underflow, and late shipment.

SIMTO Scheduling can also help the refinery plan for the long-term. Refinery traders can decide when to buy and sell certain materials and in what approximate amounts. SIMTO Scheduling gives a refinery the ability to evaluate a new or price-advantaged feedstock available in the market and to determine its compatibility with existing feedstock and processing units. Along with M-Blend, a refinery can save money through feedstock blending to provide the optimal feed qualities for the processing units.

SIMTO Scheduling gives users the flexibility to simulate the whole plant or just one processing unit. Users can easily change operating parameters through an interface window to evaluate the impact of different operating conditions before applying the selected condition to the real world production.

SIMTO Scheduling provides users the ability to prepare for and adapt to daily supply changes.

Dock Manager automatically adjusts docking schedule according to weather conditions to avoid traffic con-

gestion and to direct inbound and outbound vessels to the right berths for safe docking, loading, and unloading.

Summary

M3's refinery solution provides a world class refinery with an integrated system to help plan and schedule productions that meet customers' demands and increase shareholders' return on investments. The solution is comprehensive and extensible. SIMTO Scheduling simplifies scheduling with flow-sheets to model manufacturing processes, Gantt charts to arrange operational activities, and case comparisons to evaluate various operational scenarios. SIMTO Scheduling

solution will help a world class refinery make difficult and time-constrained decisions regarding unprecedented changes in feedstock and additive costs. SIMTO Scheduling simulates the impact of feedstock quality and composition changes on product yields. M-Blend optimizes multiple blends over multiple periods to minimize costs and quality giveaway. Dock Manager automatically schedules cargo receipts and shipments within constraints from weather to terminal inventory. These applications work together seamlessly and communicate with other systems through SIMTO Integration Depot and Web Services. dewjournal.com

ABOUT THE AUTHOR

Robert Hutchings has 30 years experience in the oil & gas and petrochemical sectors with 10 years working in Texas Gulf Coast oil refinery. Bob has extensive experience in upper level sales, marketing and consulting roles for major computer integrated manufacturing and supply chain management software companies. Bob has worked as lead engineer and project manager on U.S. domestic and global projects including Russia, Korea, Japan, Czech Republic, Saudi Arabia, China and many more. Bob has a BS Degree, University of Tennessee in Chemical Engineering and a Master's in Business Administration, University of Phoenix.



Dr. Dong Dong has 18 years of experience of research, development and service in process automation, product optimization and information integration applications for process industries. Dong founded M3 Technology in 2002 and he has instituted a clear vision that has guided M3 to become a leading provider of planning, scheduling, multi-period blend optimization and distribution systems and solutions for both the plant and enterprise level. Dong has extensive industry experience, including acting as a Senior Consultant and Team Lead and project manager at Aspen Technology. Dong has a B.S. degree in Electrical Engineering from Tsinghua University, a Masters in Process Control from Tsinghua University, and PhD in Chemical Engineering from the University of Maryland.



Nam Nguyen has 18 years experience in oil refining industry. He is the lead engineer in rolling out the SIMTO refinery solution to Tesoro Corporation, a leading independent refiner with 7 refineries. Nam has worked as senior engineer in technical teams to support joint ventures and supply chain of several refineries in the Texas Gulf Coast. Nam has extensive experience working for Pennzoil – Quaker State where his duties included conducting pilot plant tests and providing technical expertise to support refineries and process development. Nam has experience in catalyst, feedstock, and crude oil evaluations and is skilled at interpreting process data and developing models and correlations. Nam has a B.S. in Chemical Engineering from the University of Houston.

