Technologix
DECISION SCIENCES INC.

Optimizing Port and Maritime Resources

Case Studies

EXPO LOGISTICA PANAMA

Background

Thousands of years before the arrival of computers, algorithms or supply chain solutions, maritime transportation was already playing an important role in global trade.

During the last few decades, with globalization and the expansion of inter-continental trade, maritime transportation has grown significantly: From 25% of global trade in 1980 to the most recent figures in the high 80%'s.

From 1980 to 2012:

- Total global merchant fleet capacity grew from 672MM to 1,535MM DWT
- Total global container fleet capacity grew from 10MM to 198MM DWT

(source: UNCTAD Statistics)

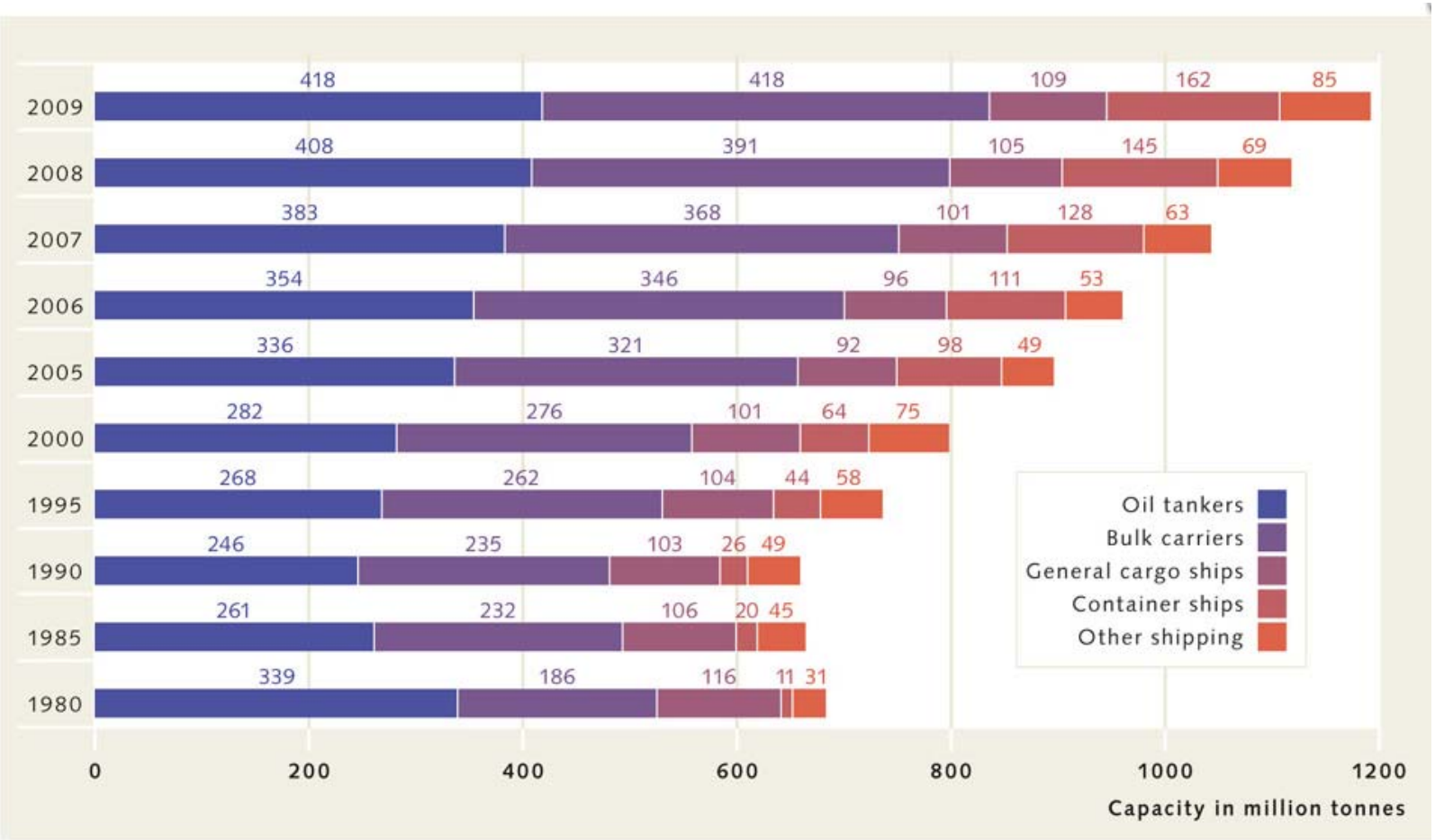
This is an industry where operating costs are very high and the availability of space and capacity very expensive. These are ideal 'conditions' for optimization and simulation models, essential tools in order to achieve higher levels of productivity and efficiency.

Most maritime logistics operations-related problems share two features that make them a poor candidate for packaged planning and optimization solutions: they are computationally complex and for the most part quite specific and unique to each situation.

These type of problems are best served by models and solutions scoped and tailored to their needs - perfect candidates for a Technologix implementation.

Background

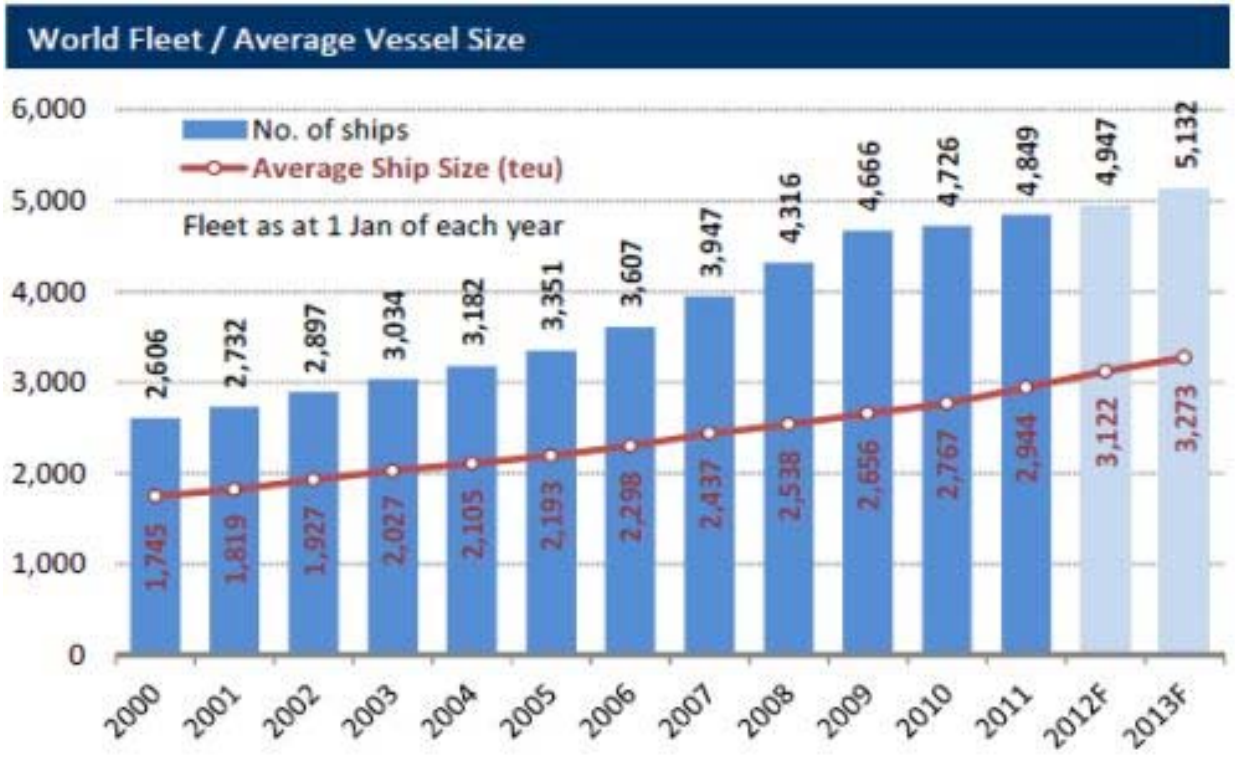
The Growth of the Global Merchant Fleet



8.2 > The growth of the global merchant fleet according to type of vessel (as at 1 January). © maribus (after UNCTAD, Lloyd's Register – Fairplay)

Background

Growth of the Global Merchant Container Fleet (Fully Cellular)



Source: DP World – Overview of Container Trades, Regional Demand & Port Development, 2012

Models and Tools: Areas of Opportunity

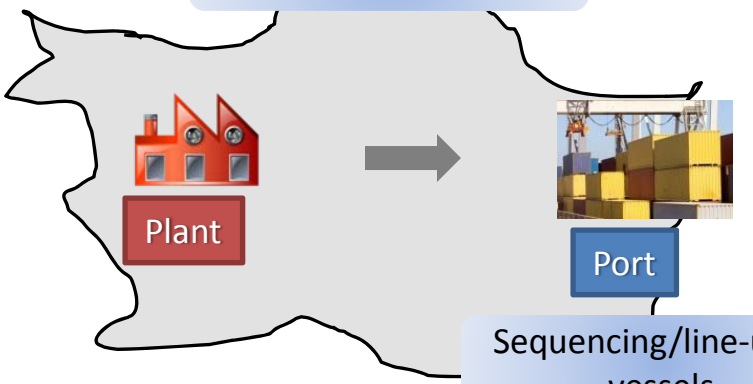
Design and Optimization of Global Supply Chains

Route/Network design

Fleet assignment

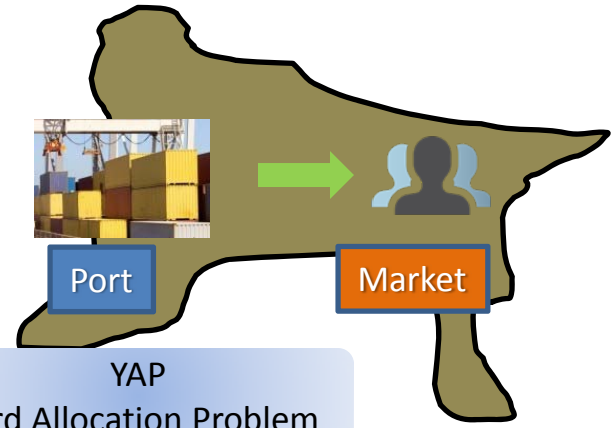
Empty container logistics optimization

Optimizing hinterland flow



Sequencing/line-up of vessels

Fleet

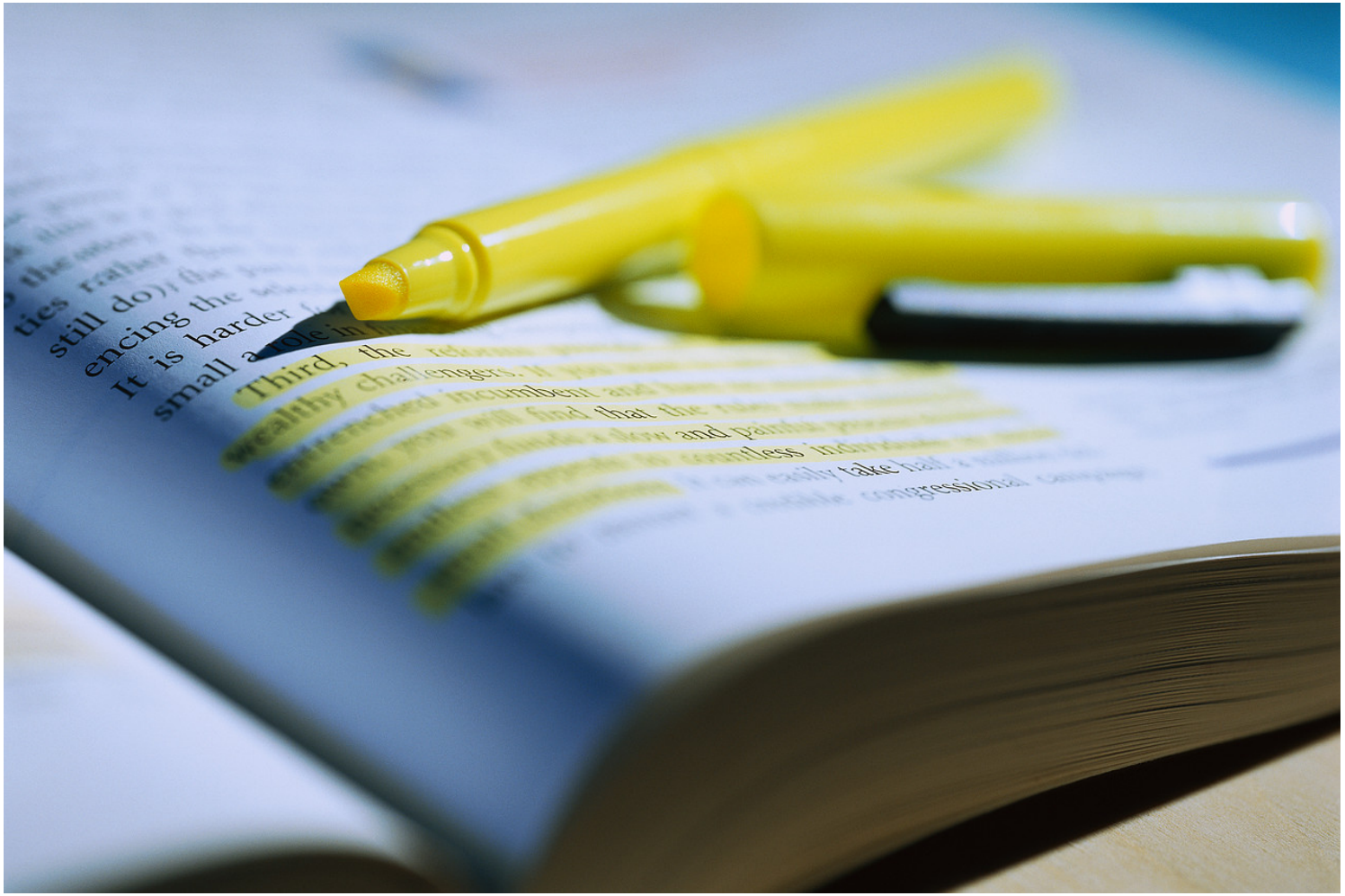


YAP
Yard Allocation Problem

BAP
Berth Allocation Problem

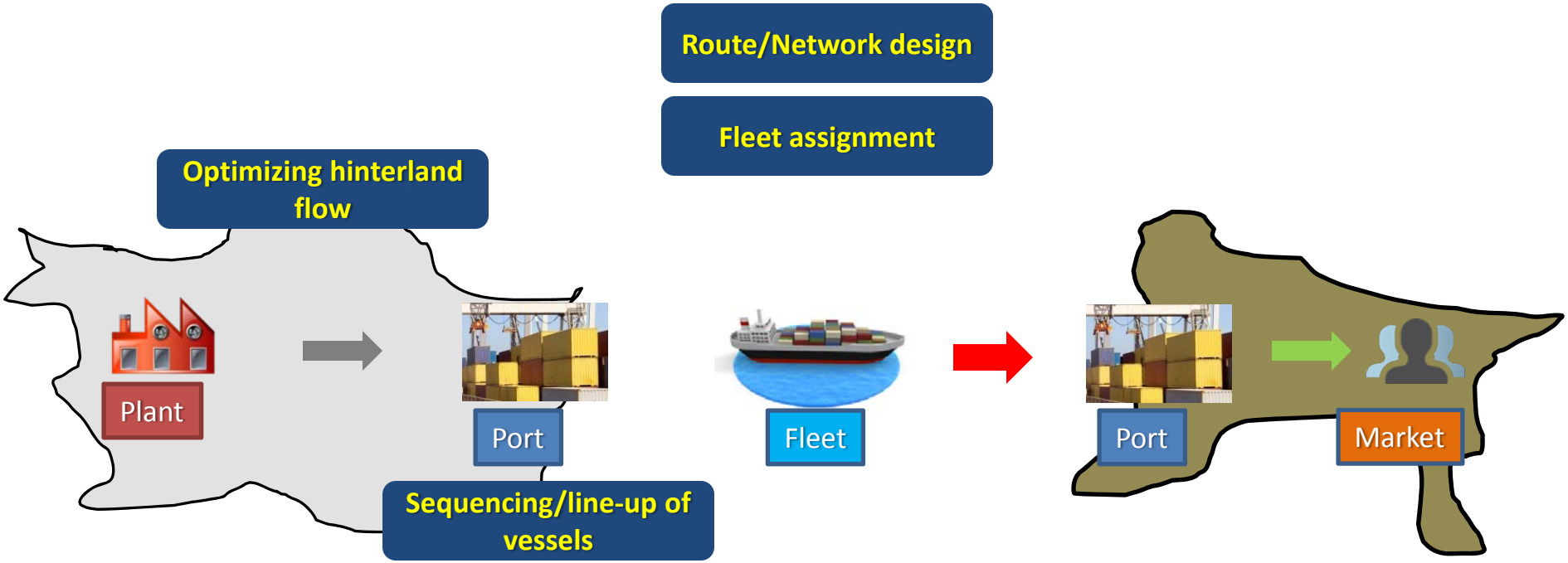
QCSP
Quay Crane Scheduling

Case Studies



Models and Tools: Areas of Opportunity

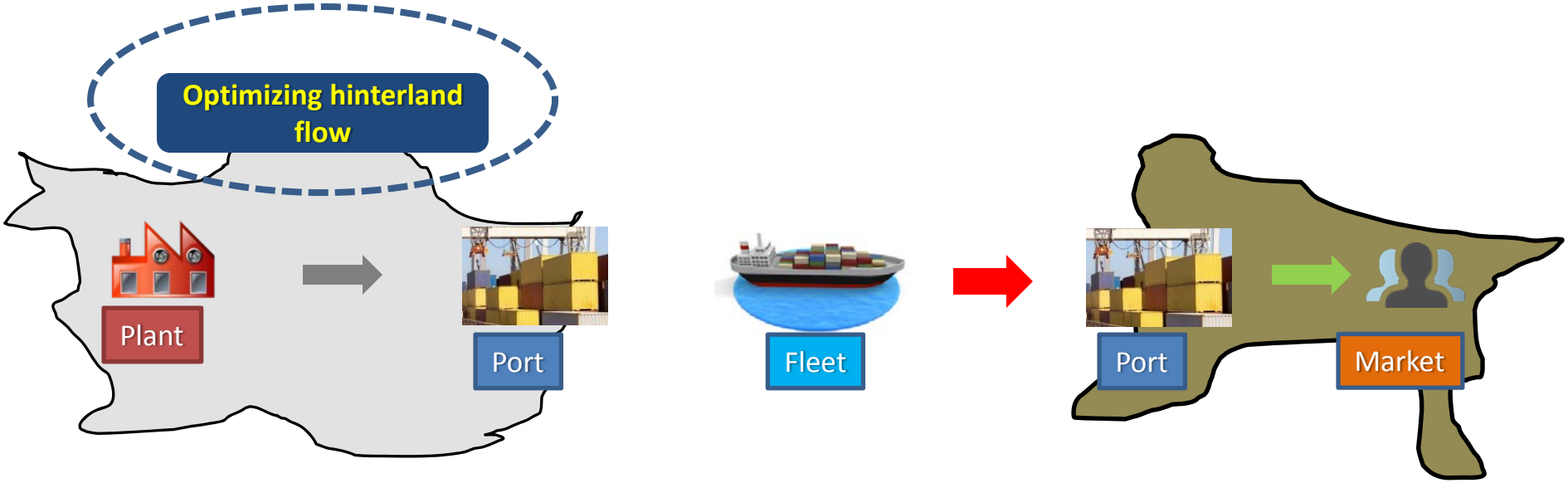
Design and Optimization of Global Supply Chains



Case Studies

1. Optimizing the Flow of Sugar From Mills to Port: Rumo Logística (Brasil)
2. An Optimization Model for the Sequencing/Line-up of Vessels: Port of Santos (Brasil)
3. A Route/Network Design and Fleet Allocation Model: The China Navigation Company (Singapore)
4. An Optimization Model of the Commercial Explosives Industry: Orica Mining Services (USA/Singapore)
5. Other Examples

Optimizing the Flow of Sugar From Mills to Port: Rumo Logística (Brasil)



Optimizing the Flow of Sugar From Mills to Port

The Client and Its Challenges

Rumo, a Cosan's company (now Raizen), is the world leader in logistics for sugar's exportation. It offers an integrated solution for transportation, storage and shipping from growing regions in the countryside of São Paulo to the Port of Santos.

The current Rumo logistics network connects 56 sugar mills , 6 multimodal terminals, 2 owned and 2 third-party port terminals. At the Port of Santos, Rumo has the world's largest operation of sugar exports, with lifting capacity of up to 6 tonnes per hour of bulk cargo or up to 5,500 sacks per hour of sacked goods for a total capacity of over 12 million tonnes per year. The Santos complex also provides 550,000 tonnes of warehousing capacity, in addition to the largest railroad and highway reception capacity at the port.

Given the size and complexity of this massive commodity network, the ability to generate quality supply plans and schedules can result in millions of dollars in monthly savings.

Project Scope

To Improve service metrics and overall profitability by optimizing the flow of sugar from the sugar mills to the port of Santos and their loading on the cargo fleet. This optimal flow must satisfy all vessel loading commitments at the port of Santos as well as ensuring the right volumes of sugar are removed from the sugar mills to avoid storage bottlenecks forcing production stoppages.

Optimizing the Flow of Sugar From Mills to Port

The Solution

Two optimization models were developed and implemented based on Oracle's Strategic Network Optimization (SNO) modeling platform: A 12-month model (complete harvesting cycle) and a second, shorter-term weekly model covering the immediate next month.

Input

- Sugar mill shipment commitments to ensure continuous production activity ("Push" effect)
- Unloading, handling and storage capacity at the multimodal terminals
- Unloading, Handling, storage and vessel loading capacity at the 4 port terminals.
- Transportation costs (sugar mills to port)
- Vessel loading commitments ("Pull" effect)

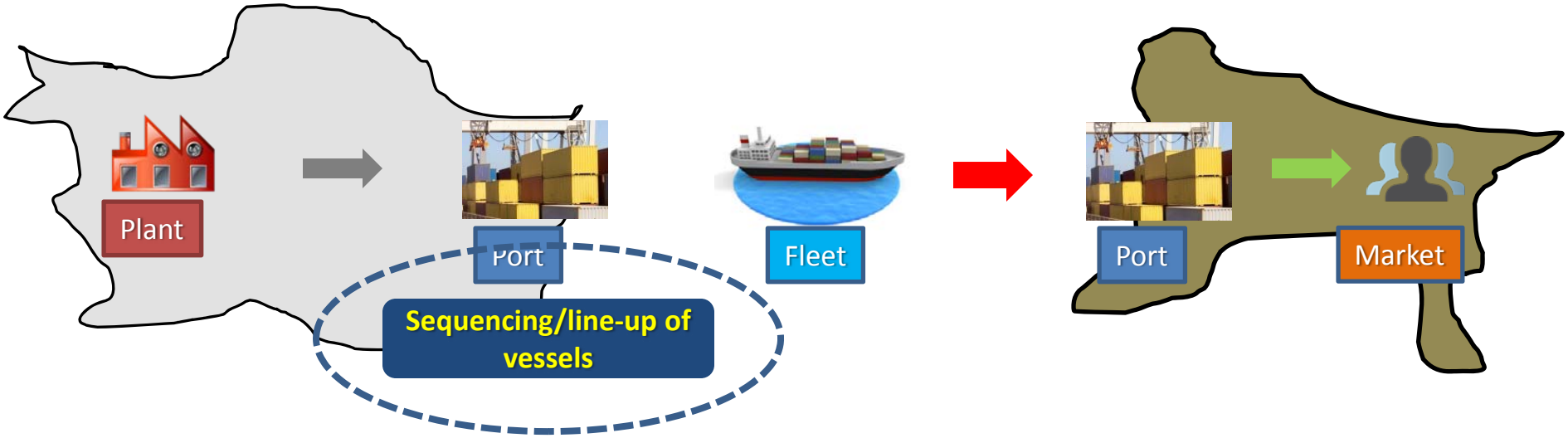
Output

Optimal shipping plans, by sugar mill and sugar type, with the resulting flow and storage profiles.

Results

A 10% reduction in total operating costs, estimated at US $ 250MM per year.

An Optimization Model for the Sequencing/Line-up of Vessels: Port of Santos



The Client and Its Challenges

Vessel line-up is the physical sequencing of a set of cargo vessels that are waiting to unload and/or load their goods at a port terminal.

Line-up decisions have major cost implications for the producers of goods, ports and cargo shipping lines. For example, during the sugar harvest season in Brasil, the cost penalties due to the failure to comply with contractual loading schedules can reach millions of dollars per month. This same issue affects other commodities such as grains and minerals, as well as the container trade.

An efficient line-up schedule is driven by a set of conditions that must be met simultaneously:

- By default, FIFO rules.
- There usually is a window of opportunity for the actual load, with significant financial consequences.
- The vessel must meet a number of technical and sanitary conditions at the time of loading.
- The product to be loaded has to be available, both physically and fiscally (ownership issues)
- Complete loading documentation must be available for loading to start.
- Other factors related to weather conditions, custom brokers, etc.

Unfortunately there are often situations where some of the elements above force an adjustment to the planned line-up schedule. This is where a planning tool becomes very effective.

In Rumo's case, a busy month will see a total of approximately 1MM tons being loaded in 50 vessels that must be sequenced at port.

An Optimization Model for the Sequencing/Line-up of Vessels

Project Scope

Develop an optimization model and tool that will recommend the most cost-effective sequence of vessel loading , balancing the impact of dispatch (premium for early loadings) and demurrage (penalties for delays).

The Solution

A customized solution was designed and implemented based on mathematical programming (MIP) concepts adapted to the very specific aspects of this problem.

This solution ensures that the necessary physical conditions are being met:

- The vessel is available or will be available within the planning horizon based on its ETA
- The product to be loaded is either at the terminal or will be available when required, both physically and legally.

It also factors the following restrictions:

- Loading capacities at terminals
- Loading docks timetables/availability

Input

Vessels' arrival schedule (ETA), cargo loading rates, capacity and availability (downtimes) of port terminals, availability of product

Output

The recommended loading schedule, and the comparison of costs to both the actual schedule and the FIFO alternative.

An Optimization Model for the Sequencing/Line-up of Vessels

Results

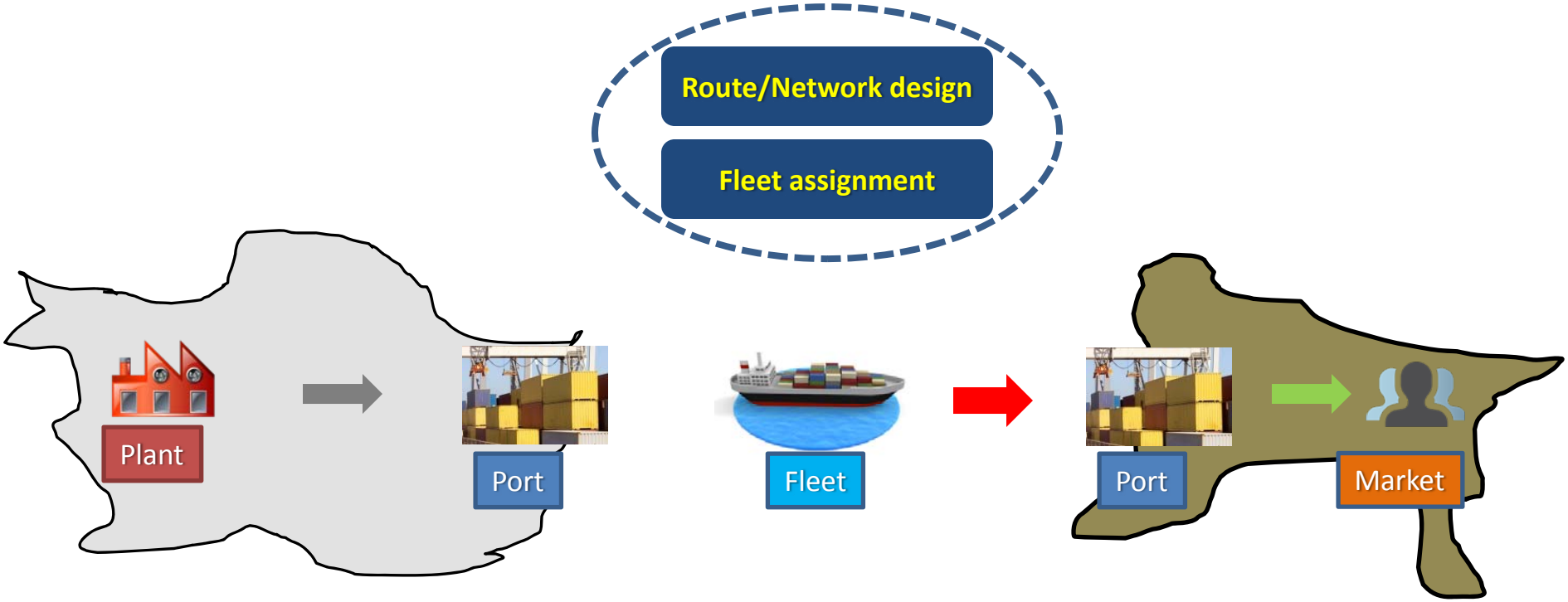
The system is in use since 2011 and is being run daily, generating revised schedules as a function of the latest information on vessel activity.

The key performance metric used is the cost (penalties) differential when comparing the suggested sequencing by the model against the standard FIFO policy and the solution generated by the existing tools utilized at Rumo.

Monthly Total Costs by Terminal (Busy Period)		
Methodology	Costs (in M US)	% Reduction
Optimization Model	1,282	71.98
Existing Rumo Models	2,979	34.90
FIFO Sequencing	4,576	-

On average, during busy months the model generates savings of approx. US 1.7MM when compared to the current methodology used at Rumo - a 57% improvement.

Network Design & Fleet Allocation @ The China Navigation Co. (Singapore)



The Client and Its Challenges

A vast body of scientific and practical literature has been devoted to routing problems in general. However, the liner shipping industry has not yet embraced the use of advanced mathematical algorithms that have otherwise proven very successful in other capital intensive transportation sectors such as airlines.

This lack of effective and practical tools, models and solutions can be mainly attributed to the inherent complexity of the problem. These are difficult problems to model and solve and, as far as we know, there have been few success stories reported in the industry.

This was the challenge presented to us by The China Navigation Company (CNCO) in 2011.

The China Navigation Company (CNCo) was established in Shanghai, China, back in 1872, and is now part of The Swire Group. CNCO has a fleet of 20 multi-purpose (MPP) cargo vessels that transports containers, bulk and bulk-break products and special cargo.

Although the company ships globally, its main area of business activity focuses on the Asia-Pacific region, where 14 vessels service about 60 ports over 6 different routes, moving approximately 2.75MM tons of cargo per year.

Currently all route and vessel planning activities are done with the help of spreadsheet models that have been developed internally.

Network Design & Fleet Allocation @ The China Navigation Co.

SWIRE SHIPPING

Project Scope

Develop a planning tool to generate cost-effective service routes and, at the same time, assign the various vessel types to them. The proposed solution had to satisfy a number of operational and business restrictions imposed on the operation

The Solution

A multi-tier, customized optimization model was developed under the leadership of J. Fernando Alvarez Ph.D., a member of our team and one of the best known academics in this field. The model was based on similar work completed by Fernando for other shipping companies and adapted to reflect CNCO needs and rules.

The logic is based on mixed integer mathematical programming (MIP) concepts, combined with heuristic components developed specifically for this project. As is the case in all projects of this level of complexity, we relied on Xpress-MP, FICO's optimization engine for the fast processing and optimization of scenarios.

Network Design & Fleet Allocation @ The China Navigation Co.

SWIRE SHIPPING

Input

- Annual volumes by product category and port pairs
- Port operational and capacity data
- Sea distances for all port pairs
- Fleet specifications:
  - Vessel types
  - Vessel capacities
  - Speed ranges by vessel type
  - Fuel/bunker consumption grid, by vessel type and speed

- Service level requirements by port pairs, as a function of their importance (ABC grouping):
  - Homogeneous interarrival times
  - Minimum number of trips per planning horizon

- Business rules and restrictions related to product categories and ports
- Cost data:
  - Bunker,/fuel costs
  - Port calling fees
  - Daily running costs (DRC) by vessel type
  - Transshipment costs
  - Feeder System Charges
  - Canal fees

- Real volume and financial data for comparative purposes (base case scenario)

The Solution

Output

- Optimal network design – route composition
- Assignment of vessel types to individual routes
- Average suggested speed by route and vessel type
- Service level metrics
- Scenario cost details and profitability estimates
- Fleet utilization metrics
- Port activity

Pilot Project Results

The results generated by the model have been very promising, generating very attractive savings and efficiencies when compared to real performance under very similar conditions: Service level is maintained or even improved with a reduced fleet and lower total operating costs.

Under varying scenarios and conditions the model consistently outperforms real operations:

- Total costs are reduced by 3 to 5%
- Overall profitability increases by 5 to 10%
- Empty ton-miles are reduced by 30%

Like similar models and tools applied to other problems and industries, these models are able to analyze and quantify different scenarios with a degree of accuracy and speed that would be impossible to achieve otherwise.

Academic papers published on this topic

Álvarez, J.F., 2009
Joint routing and deployment of a fleet of container vessels.
Maritime Economics & Logistics 11 (2), 186–208.

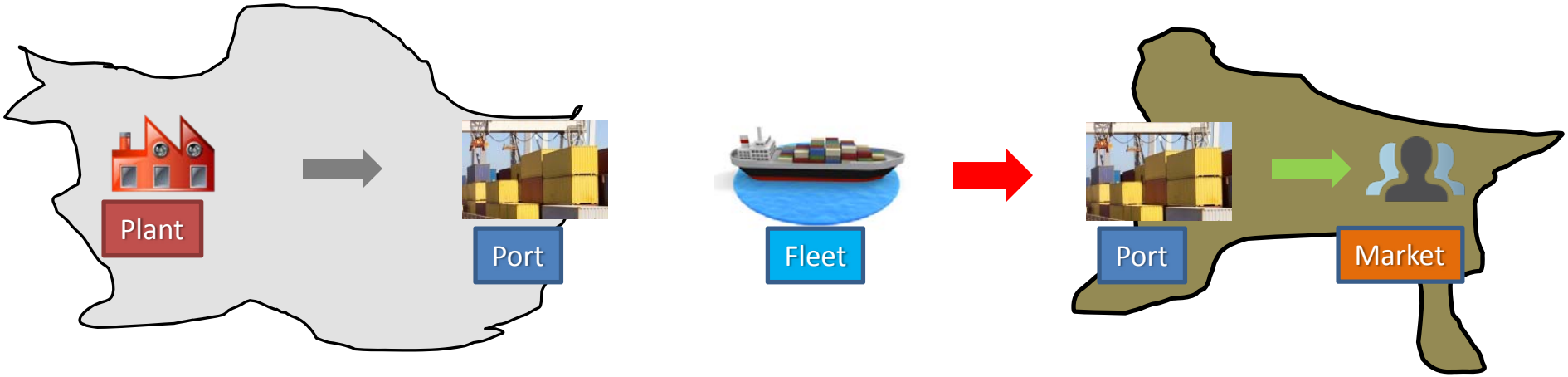
Álvarez, J.F., 2012.
Mathematical expressions for the transit time of merchandise through a liner shipping network.
Journal of the Operational Research Society, 63, 709–714.

Álvarez, J.F., Longva, T., Engebrethsen, E.S., 2010.
A methodology to assess vessel berthing and speed optimization policies.
Maritime Economics & Logistics 12, (4), 327–346.

Álvarez, J.F., Tsilingiris, P., Engebrethsen, E., Kakalis, N.M.P., 2011.
Robust fleet sizing and deployment for industrial and independent bulk ocean shipping companies.
INFOR 49 (2), 93–107.

Models and Tools: Areas of Opportunity

Design and Optimization of Global Supply Chains



The Client and Its Challenges

Our client is one of the major global players in the commercial explosives industry.

Its extremely progressive strategic planning team wanted to develop a global planning tool to analyze the entire industry, not just their own network. The objective was to use this tool to drive major strategic decisions such as plant expansions or closures and potential acquisitions.

Developing a strategic network design model for a commodity such as explosives was not new to us. What attracted us to this project was the concept of modeling the entire industry and the massive financial implications resulting from its recommendations.

Given that the data available on the competition (plant costs, raw material supply sources, etc.) was for obvious reasons incomplete, heuristic models were developed to generate missing information (for example: estimating the annual fixed costs of a plant based on grouping of plants by age and technology).

One of the major challenges in this project was to design and implement the computational logic to derive plant to market mixed freight rates (land to port, sea rates between ports, land to market) for millions of feasible combinations, based on forecasted costs of fuel and other freight-related parameters.

The scope of the proposed software solution incorporated a major BI/Analytics component, including very specific graphical displays and the difficult task of physically displaying real and complete sea routes instead of the quasi-straight line connections that are customary in supply chain optimization software solutions.

Design and Optimization of Global Supply Chains

Project Scope

Develop and implement a customized global supply chain strategic planning system, integrated to corporate sources of data and incorporating a BI/Analytics component fully adapted to the very specific needs and requirements of the client organization.

The Solution

A fully customized version of **Opti-Net ™** was designed and implemented to meet these requirements, powered by Xpress-MP, FICO's mathematical programming optimization engine.

The system first generates all the required scenario data based on a number of heuristic rules developed for that purpose, and then identifies optimal supply patterns based on plant and freight costs and restricted by a variety of pre-determined operational and business rules.

Input

- Demand data: 200 market destinations, 4 major product categories, 10 year-planning horizons
- Plant data: 100+ plants, capacities by line, costs, bill of material considerations, multiple processes
- Port data: Capacities, restrictions and service charges
- Operational restrictions related to product types and ports
- Fleet data: operational characteristics and costs
- Multiple currencies and exchange rates
- Global parameters such as bunker costs, natural gas indices, future cost trends, etc.

Design and Optimization of Global Supply Chains

The Solution

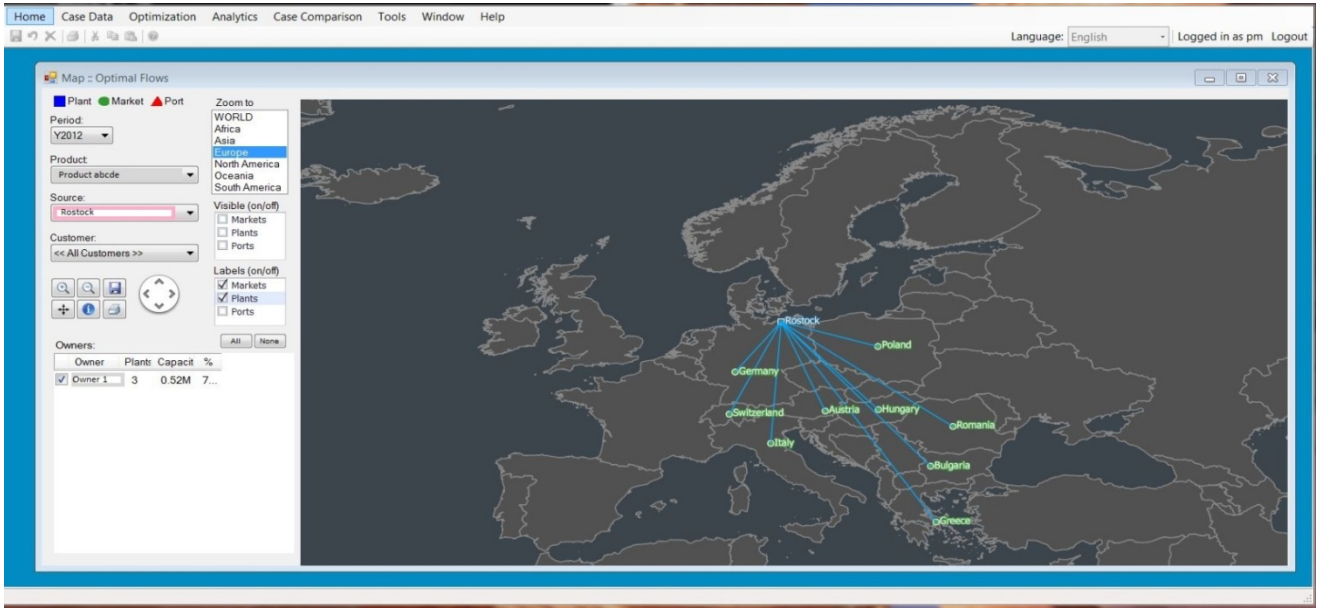
Output

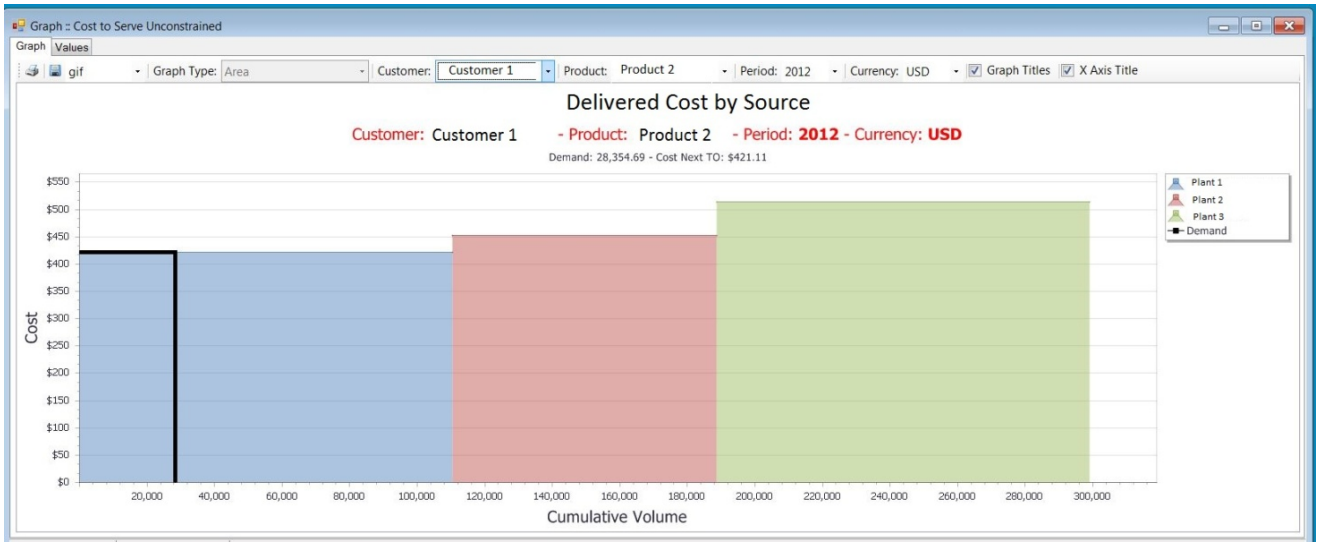
- Optimal flows from plants to markets
- A comprehensive BI/Analytics component, including:
  - Graphs
  - Queries
  - Cubes/pivots
  - Map display
- Competitive analysis: by owners, specific plants, markets and products
- Case management and comparison functionality

Results

The full system, from scope to documentation, was completed in 6 months. As of early 2013 the client organization has relied on this tool to analyze a number of different strategic issues, both globally and regionally.

Design and Optimization of Global Supply Chains



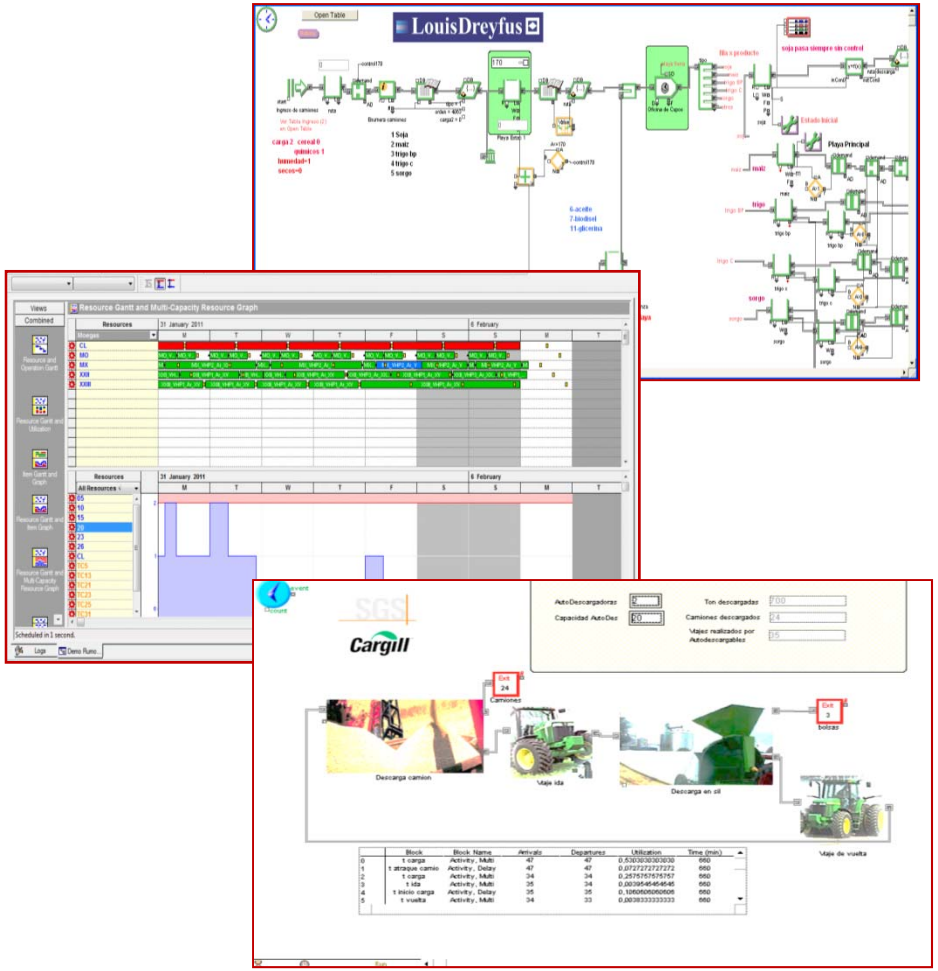


Other Examples

Beyond the case studies presented in this paper, our consulting staff has undertaken other projects where different aspects of the inbound-outbound port terminal product flow have been modeled and optimized.

Examples:

- A simulation model to re-design receiving operations at a port grain terminal
- A simulation model to support the re-engineering of sugar handling and storage at a port terminal
- Weekly scheduling of hoppers at a sugar port terminal
- Daily and weekly scheduling of truck and railcar receiving operations at a grain port terminal



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