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The Aluminum Industry and Supply Chain Management

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THE ALUMINUM INDUSTRY AND SUPPLY CHAIN MANAGEMENT

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A West Coast Recycling Facility: A Network Optimization Approach

Background

An important issue raised during the exploratory research phase was the lack of a west coast used beverage can (UBC) processing facility. UBCs are consolidated at various points on the west coast of the United States and crushed for transport purposes. A significant portion is shipped to East Asia for eventual recycling. The low cost of transporting containers from the west coast to East Asia, primarily due to lane imbalances, is a major contributing factor. Indeed, the cost of shipping a container from the west coast to China is generally less than the cost of shipping a container from the west coast to various mid-west destinations. Various types of UBC value-added processing could be accomplished on the west coast, including smelting UBCs or melting UBCs into ingots or into other forms. Processed or partially processed UBCs have the potential to alter transport costs both to East Asia and to other regions of the United States. Yet little is known about the economics and total cost of the current arrangement or about the economics and total cost of operating various types of west coast UBC processing facilities.

Network Optimization Approach To Addressing the Problem

Network optimization refers to the simultaneous analytic assessment of the number, type, size, and location of facilities, the allocation of customers and suppliers to facilities, and the selection of transportation modes and carriers. Facilities refer to factories, flow-though sites (including cross-dock operations), and warehouses (Chopra and Meindl 2004). Generally, one starts by modeling the current situation (or the baseline) and then compares the baseline cost against the cost of various optimized alternatives. Sophisticated "off-the-shelf" network optimization software is available (Simchi-Levi, Kaminsky, and Simchi-Levi 2003). For example, LogicTools is a leading provider of supply chain software (LogicTools web site 2006). Their LogicNet network optimization software has been used by a number of Fortune 500 companies, including Steelcase, Home Depot, and True-Value to justify various elements of supply chain reconfiguration.

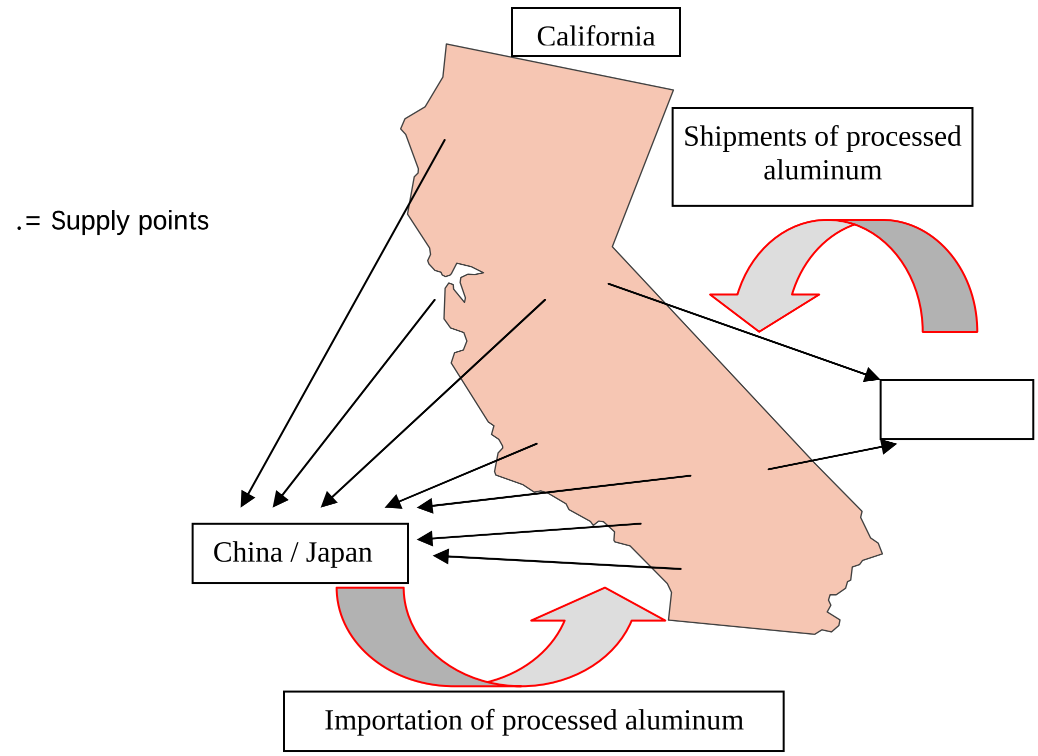
Geographic Scope of the Application

Network optimization projects are geographically scalable. Global, national, or regional supply chains can be analyzed. UBCs are widely available in California due to the state's density and required deposit on aluminum cans. This makes the state of California a good case to examine. The material that follows describes the problem for the state of California.

Project Description and Output

Figure 1 illustrates the current state of the UBC industry for the state of California. Quantities of UBCs are collected at various locations. These cans are either exported to East Asia (principally China or Japan) or shipped to the Mid West. A portion of the exported material is re-imported either as sheet aluminum or as components of finished products. A research study of potential value would focus on reconfiguring this network. The current network (Figure 1) would form the benchmark against which various optimized networks would be compared. Only California would be modeled along with shipments to East Asia and the Mid West.

Figure 1: Current Industry Structure



Data Requirements

The following data would have to be collected for the project:

1. UBC supply: The quantity available on an annual basis for by location.
2. Aluminum sheet and ingot demand: the quantity demanded by location.
3. Transportation cost by mode:
    a. For UBCs: From the supply points in California to East Asia and to the American Mid West and East Coast. Rates for different modes including rail, truck, and ocean are required.
    b. For aluminum sheet and ingot: From processing facilities in East Asia and the American Mid West and East Coast to demand locations in the U.S. West. Freight charges from potential facilities in the U.S. West to demand locations are also required.
4. Inventory carrying costs:
    a. Costs: Carrying cost ratio and replacement cost of inventory
    b. Costs are required by product type.
5. Shipment size and frequency. This data is necessary as it impacts transportation rates.
6. Estimated anticipated facility costs by location and by type:
    a. Annual fixed and variable cost for various types of UBC processing facilities will be required.

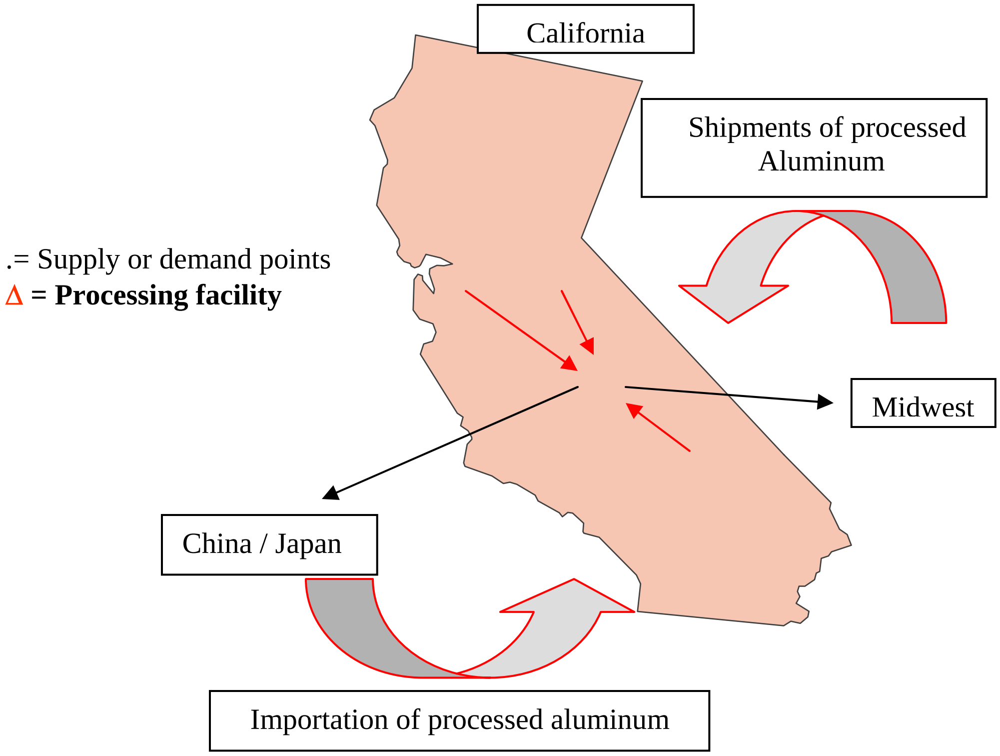
   b. The location of a facility may impact fixed and variable costs. For example, a facility in or near San Francisco may be more costly than one outside of Sacramento.
7. Estimated current facility costs by location and by type:
   a. Estimated costs must be collected for existing facilities in China and the United States and for anticipated facilities in California.
8. Order processing costs.
9. Warehousing costs for anticipated facilities:
   a. A new California facility will require a plant warehouse of some sort, both on the inbound and outbound side. Fixed and variable costs by location and facility type will be required.

Project Outputs

Part of the envisioned output is illustrated in Figure 2. It may be that an ingot facility of a particular size located in central California may reduce total network cost. The following would be included as part of the report:

1. Total cost analysis of the current network where total cost equals the sum of:
   a. Processing costs.
   b. Transportation costs.
   c. Inventory carrying costs.
   d. Order processing and warehousing cost (if applicable).
2. Total cost analysis and organization of the optimized network. This includes:
   a. The type of facilities to be operated (e.g., smelting, ingot), their location, and optimal size.
   b. The modes of transportation to be used and their cost by lanes.
   c. The allocation of UBC supply points to UBC processing facilities.
   d. The allocation of demand points to facilities.
3. A recommendation as to which type facility would be optimal – that is, a smelting facility, ingot facility, or sheet ingot facility, and a total cost analysis. The report would also provide second best recommendations. Figure 2, for example, illustrates the kind of solution that may be recommended. Various types of sensitivity analysis could also be examined. For example, the sensitivity of the solution to changes in fuel prices could be modeled.

Figure 2: Sample Proposed Solution



Summary

This project will estimate the baseline cost for the current system in California. The project will then provide optimized solutions for various types of processing facilities in California. The project will not provide revenue estimates. Whether the savings generated by the optimized solutions is worthy of the investment is left to others to determine.

TOTAL COST MANAGEMENT OF ALUMINUM PRODUCTS

Background

The general aim of this section is identify an approach to enhance aluminum purchasing decision-making processes and to recommend related strategies to optimize total system cost of purchased aluminum goods. From mining of bauxite to final conversion and recovery, each step in the value chain represents an opportunity to reduce costs. Alcoa Aluminum expects approximately $600 million in cost increases during 2005 resulting from energy, labor, raw materials, and currencies, according to Alain Belda, Chairman and Chief Executive Officer (Annual Report of ALCOA, 2004).

In an industry marked by fierce competition, high fixed costs, competing substitute products, and thin margins, the ability to manage costs for direct and indirect materials, supplies and services remains critical to long-term viability. Furthermore, the aluminum industry has witnessed significant changes over the past decade: Alcoa acquired Alumax, Inespal, Almix and Reynolds; and Alusuisse and Penchiney were acquired by Alcan. High operating costs within the domestic aluminum industry threaten long-term viability. Alcoa, the industry's lowest cost producer, cost-of-goods sold is approximately 80 percent of sales, while 60 percent of this represents costs other than energy (Song, 2005). Depending on the participants' position in the value chain, the costs for direct materials ranges from 50 to 80 percent of sales.

The oil embargo of 1974 punctuated the U.S. dependency on foreign oil. Since that time, many industries that rely heavily on energy as a key input to production has fallen. Scarcity of resources, increased global competition, substitute products, scrap recovery, rising cost of health care, and government regulations plague the sustainability of the U.S. aluminum industry. Individually, each represents a systemic problem of a much greater magnitude. Viewed within the context of the value chain, the solution lies within industry participants and stakeholders who face these challenges individually and collectively.

The Problem

Purchasing executives often make decisions on product/source selection with incomplete information. Supplier selection and evaluation and total cost analysis are critical to a firm's success (Bhutta 2002). The problem lies in evaluating hidden costs and in estimating total life cycle cost within formal and support activities of the enterprise (Ferrin and Plank, 2002). Relevant costs that are often excluded include expediting, inbound transportation, inspection, testing, administration, error correction and follow-up, warranty service, line downtime, customer returns, and lost sales (Ellram 1992, 1996).

The aluminum industry faces challenges on many fronts. Competing products such as steel, plastics, titanium, composite materials, and wood and vinyl provide viable substitute materials for buyers. The cost versus value relationship of material substitutions compared to aluminum products on a total life cycle cost basis is threatened by volatile costs of energy, alumina, and other raw material inputs. Realistic cost modeling is increasingly important in evaluating total cost in global supply chains (Cirimele 2003).

According to research conducted by the University of San Diego, the total cost of ownership associated with acquiring materials, services, or leases can be reduced by as much as 25 percent through a world-class approach to supply management (Burt, 2003).

In addition, Michael Porter's (1985) Five Forces Model (see Figure 3) demonstrates the challenges faced by the aluminum industry, especially on three major fronts:

1. Strength of industrial buyers with significant purchasing clout driving down margins.
2. Products that are easily substituted for aluminum (i.e. plastics, wood, steel, titanium, etc.
3. Bargaining position of suppliers is strong since no substitutes for bauxite and aluminum scrap exists for basic materials input.

Aluminum industry participants rely upon bauxite as the basic input for production. Bauxite, primarily found in tropical and subtropical regions, is the basis for aluminum production, provides the thermal insulator for the top of electrolytic cells, coatings for prebaked anodes, and the absorbent filter for cell emissions. The industry has no latitude in alternate input materials for its process. Since aluminum is produced solely from bauxite, the industry as a whole is at a competitive disadvantage with competing products (i.e. steel, plastics, wood, etc.).

Strategic Sourcing

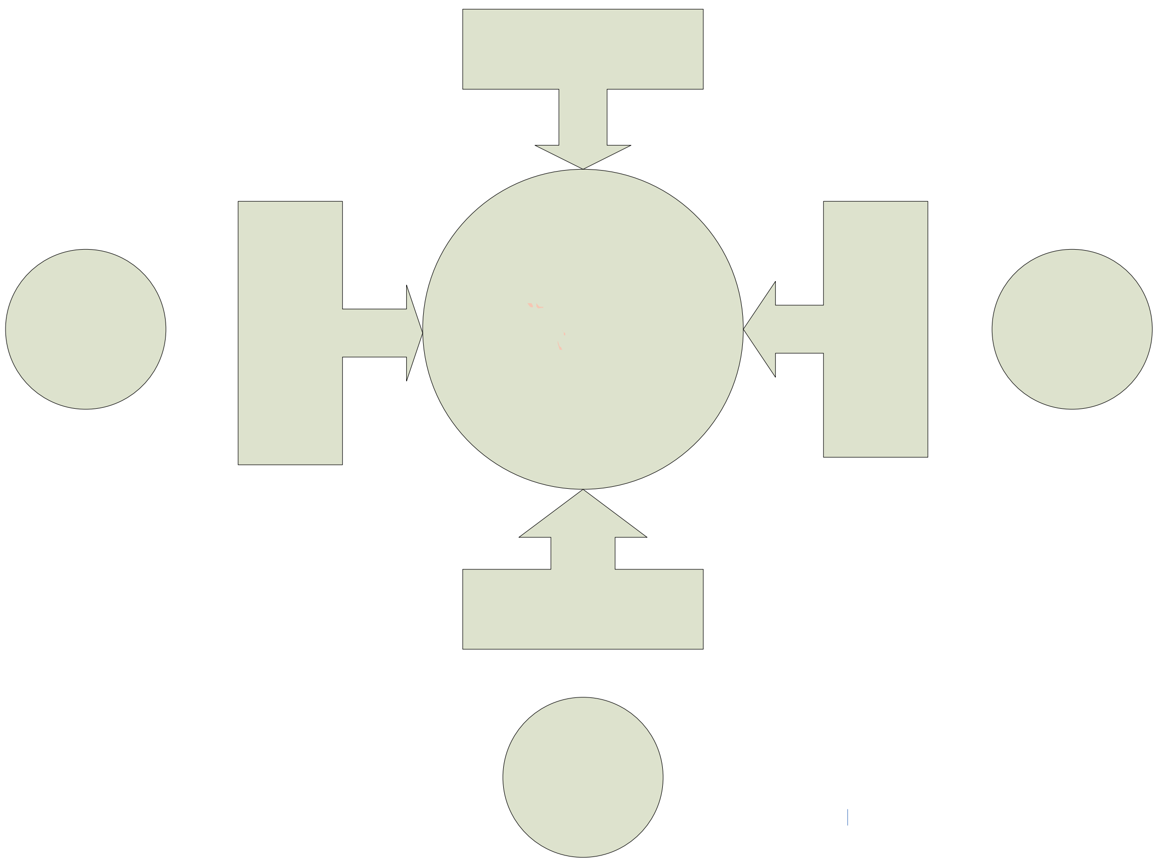
Industry executives consistently echoed concerns over the unpredictable costs of inputs, primarily raw materials and energy. As a whole, the industry faces challenges to grow shareholder wealth in times when the cost for materials and energy radically fluctuate.

Strategic sourcing develops short and long term strategies to achieve business objectives. Businesses benefit through the alignment of business and procurement strategies and improvement in purchasing processes (Kauffman and Crimi 2005). While a number of definitions can be found for strategic sourcing, one common theme exits among them all: integration of business processes (Smeltzer, Manship, and Rossetti, 2003).

Enterprises use strategic sourcing as a tool to align the purchasing function with long-term goals of the enterprise (Bernstein 2005). The intent is to remove the tactical, transactional processes with acquiring goods and focus on supplier relationships and other elements necessary to achieve strategic objectives. Strategic sourcing has proven to be a successful tool in many large organizations, and while the model has yet to be applied for an entire industry, specific components of the model would improve supply chain and total cost performance by enhancing communications among supply chain participants and integration of business processes.

Purchasing and supply management professionals have gained a great deal of attention in recent years by leveraging cost savings and providing a competitive advantage to the firm (Ellram 2002). To improve income statement performance, industry participants have few options. Increasing prices to industry customers is often met with fierce opposition from large industrial consumers who have a variety of options to substitute materials at a lower cost. Steel, plastics, titanium, and wood, while often offered at a lower "price" may not offer the lowest "life cycle" or "total cost" to the ultimate customer.

Figure 3: Competitive Forces Model



The Solution

The total cost management approach would seek to identify all-in costs beyond the initial cost of acquiring goods or services (Humphries and McClaeb 2004). By evaluating and understanding all components of the total "all-in" costs, a model could be developed to: (1) identify non-value activities within the industry and strategies to minimize or eliminate those costs; and (2) develop a long-term strategy in evaluating the actual cost of goods or services in total throughout the product's useful life. Non-value added activities and cost drivers that are often overlooked include both formal and support activities (Ferrin and Plank, 2002).

In addition, the distribution channel for scrap can be best described as a conventional channel with channel participants being opportunistic and price driven. The speculative nature of channel participants at one end of the supply chain manifests itself into holding inventory during periods of escalating prices creating irregularities within the supply chain. The added cost of pipeline inventory throughout the supply chain creates several problems. First, the cost of pipeline inventory is often not considered in supply

Bauxite

chain total cost analysis. This leads to decision errors adding unnecessary cost to the entire chain in the form of inventory and resource allocation cost adders that cumulate from one end of the supply chain to the next. Secondly, financial performance throughout the supply chain carries the additional burden of these errors in the form of "hidden" costs that typically get charged to product prices or overhead. And finally, supply managers fail to see the entire supply chain as a cohesive whole, which creates further decision errors and inability to achieve optimum supply chain performance.

The Benefits

Table 1 presents a profitability analysis of Alcoa (Annual Report of ALCOA, 2004). Using their sales to cost of goods sold ratio of 79 percent as a benchmark, a reduction in the cost of goods sold of one percent represents a before tax increase in profits of 17 percent. The strategies to be studied will focus on improving this ratio and overall profitability at various stages in the supply chain. Strategies to be studied include: (1) strategic sourcing; (2) supply base optimization; (3) total cost management (inter and intra-firm costs); and (4) life cycle costing. In so doing, marketing and sales professionals may enjoy better price elasticity to compete in the global marketplace.

Table 1: Profitability Analysis of Alcoa

	Beginning Statement (in billions)	Percent	Savings from a 2% Reduction in CoGS (in billions)
Sales	$23,478	100%	$ 23,478
Cost of goods sold (CoGS)	18,623	79%	18,250
SGA and other expenses	1,284	5%	1,284
R&D expenses	182	1%	182
Depreciation, depletion, and amortization	1,204	5%	1,204
Restructuring and other charges	(289)		(289)
Interest expense	270 $21,274	1% 90.6%	270 20,902
Income before taxes on income	$2,204	9.39%	$2,576

Source**:** Annual Report of ALCOA, 2004.

Value Chain

The sales to cost-of-goods sold ratio varies depending on where the channel participant is within the value chain, the level of value add services preformed at that stage, and costs associated with the basic input materials. Figures 4 and 5 present two different perspectives on the industry's value chain. The importance of the Figures lies in the concept that value added services performed by channel intermediaries, margins, and business processes varies depending on the level in the channel. The ratio of sales to cost-of-goods sold within primary and secondary smelting operations ranges from 40 to 80 percent. Value added services by channel intermediaries within the smelting segment range from smelting to ingots/t-bars, rolling sheet, to fabrication of finished and semi-finished components for downstream customers.

Figure 4: Flow Chart

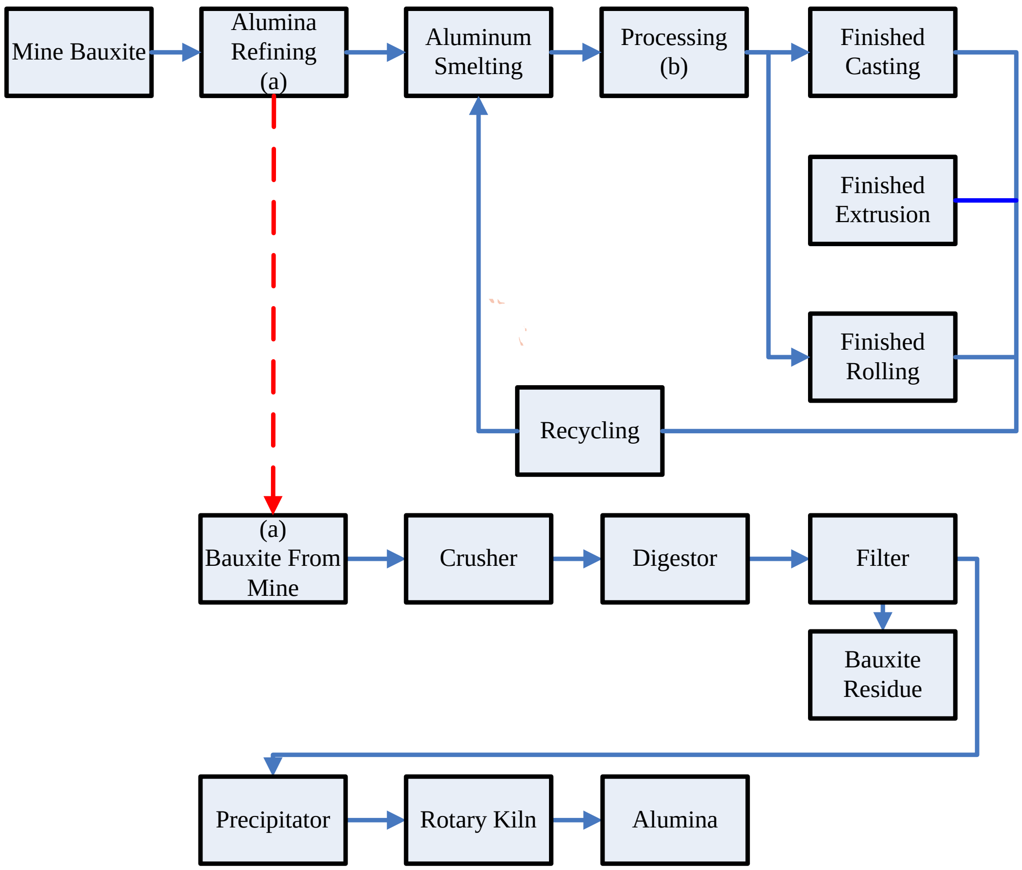
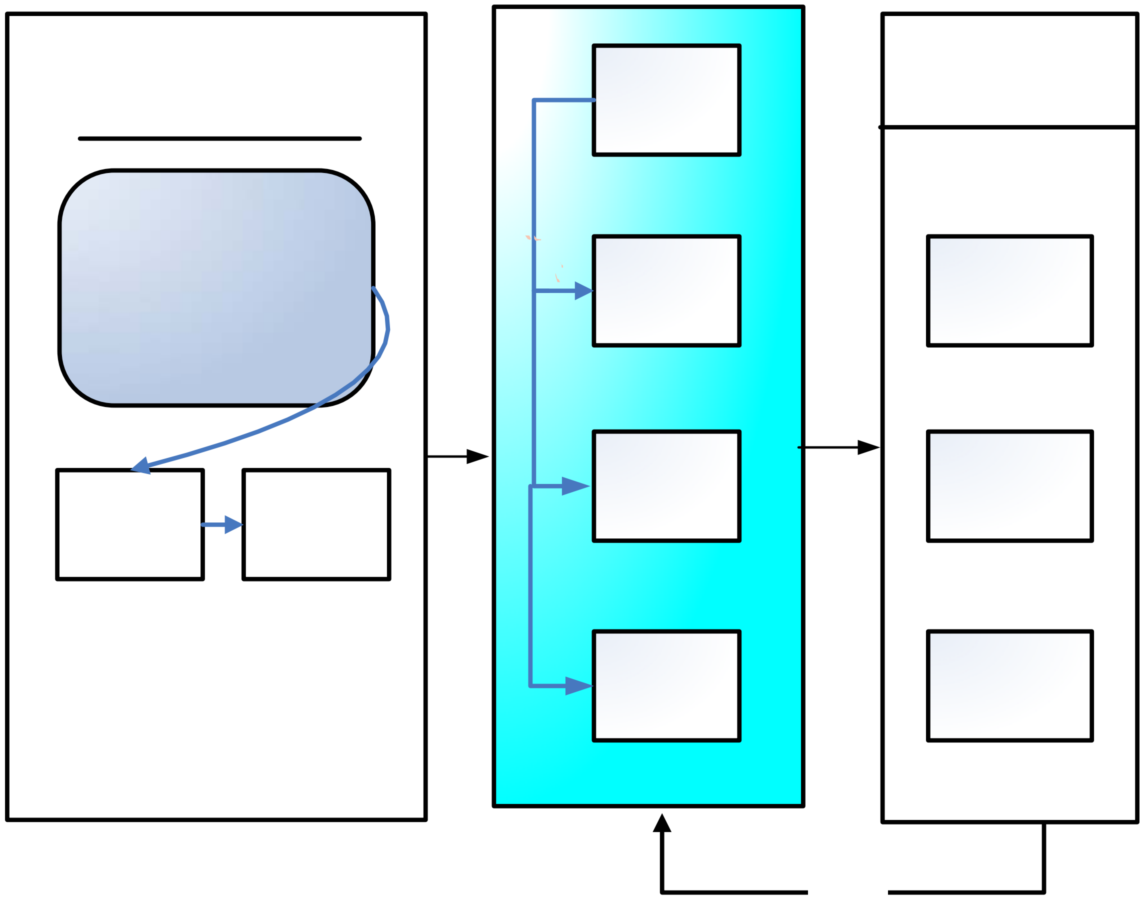


Figure 5: Value Chain



Project Outputs

The major project output will consist of a process map of the supply chain from extraction of bauxite to final consumer. The map will encompass a total cost of ownership model associated with aluminum products at each stage in the value chain. Included in the project output will be:

1. A business process map to identify opportunities to eliminate non-value added activities.
2. A total cost of ownership model for products at various stages of manufacture identified in Figure 4.
3. A strategic sourcing model at each level of the value chain as shown in Figure 5.
4. Metrics and performance standards to measure total cost of ownership performance within the supply chain.
5. An action plan to improve collaboration with up/downstream suppliers and enhance channel management.

TRANSPORTATION INEFFICIENCIES OF ALUMINUM PRODUCTS

Background

Movement of goods within the aluminum supply chain, both up and downstream, presents major challenges. Raw material inputs (bauxite) from South America must be transported via ocean cargo vessels and barges into U.S. ports and then through the inland river system to smelters located along the river systems. Scrap secondary aluminum traverses throughout the labyrinth of highways and rail systems. The bulky nature of raw materials leaves few alternatives to aluminum smelters to manage inbound shipments on a just-in-time basis. Few alternatives exist on the downstream side of the supply chain. Finished goods in the form of coiled sheet, billets, extrusions, etc., commute to the ultimate customer via truck or rail. Just-in-time inventory management up and downstream within the supply chain is limited at best.

These challenges are exacerbated by rising fuel costs and increasing congestion at various ports along the coastal waterways (Guido 2004). This also makes it difficult from a cost perspective to return secondary scrap back to smelters. Increasingly, the shortage of freight carriers, inefficient back-haul routes, and loading delays escalates costs and reduces cycle time while increasing pipeline inventory. The strategic placement and identification of break-bulk points, route efficiency, and balancing of carrier supply and demand will offer long-term competitive edge to the aluminum industry over competing products.

The rising cost of fuel has prompted the transportation industry to institute surcharges for fuel to the base rate for freight. Freight companies find it easier to pass along increases in the form of fuel surcharges rather than increase the basic transportation rate. With heightened homeland security threats, the potential for additional surcharges to cover insurance, port congestion, and terrorist threats are likely to be passed along in the future (Levans 2002). As a consequences, transportation and logistics managers will face greater challenges to controlling costs while maintaining adequate customer service levels.

Pipeline inventory for aluminum smelters and downstream customers represents a significant investment. It is a cost that gets passed along throughout the supply chain and distribution channels. According to the Annual Survey of Manufacturers NAICS code 331312, the beginning inventory value of primary aluminum products exceeded $539 MM in 2003 (U.S. Department of Commerce 2003). Small reductions in pipeline inventory offer significant improvements to balance sheet and income statement performance.

The movement of goods throughout the supply chain is not a problem unique to the aluminum industry. Logistics certainly plays a major role in every industry, especially those industries that transport large, expensive, and bulky items across long distances. To create value and maintain the competitive advantage, firms that effectively manage the logistics and supply chain functions are nimble in serving customer needs; delivering goods in the right quantity, at the right time, and at the right location; and respond rapidly to slight changes in supply and demand. To do this effectively requires compressing timing throughout the supply chain. The strategies and means to execute inter-modal transportation schemes to minimize costs and time are at the heart of this research project.

Flowcharts and Process Mapping

A flowchart may be defined as a "graphical representation of a process" that depicts "inputs, outputs and units of activity" and, depending on the detail level, allows for the analysis and optimization of workflows (Six Sigma web page, 2006). Six sigma tools, in particular process mapping, have long been utilized for process improvements in manufacturing and business process reengineering (Aldowaisan 1999). From a supply chain standpoint, business process mapping has not been exploited to improve the entire transportation component of the aluminum industry supply.

Furthermore, the aluminum industry has made great strides in integrating upstream and downstream suppliers through Enterprise Resource Planning (ERP) tools and to integrate ERP into business processes. This has improved manufacturing cycle times, reduced finished goods inventory, and enhanced communication between supply chain partners. However, up to this point, transportation and inbound/outbound logistics has primarily considered carrier selection, rate negotiation, and expediting deliveries. Lack of integration into supply chain management has detached transportation services from the serious business of improving efficiencies of carriers and inventory reduction (Wisner, Leong, Tan 2005).

Causes of Inefficiencies

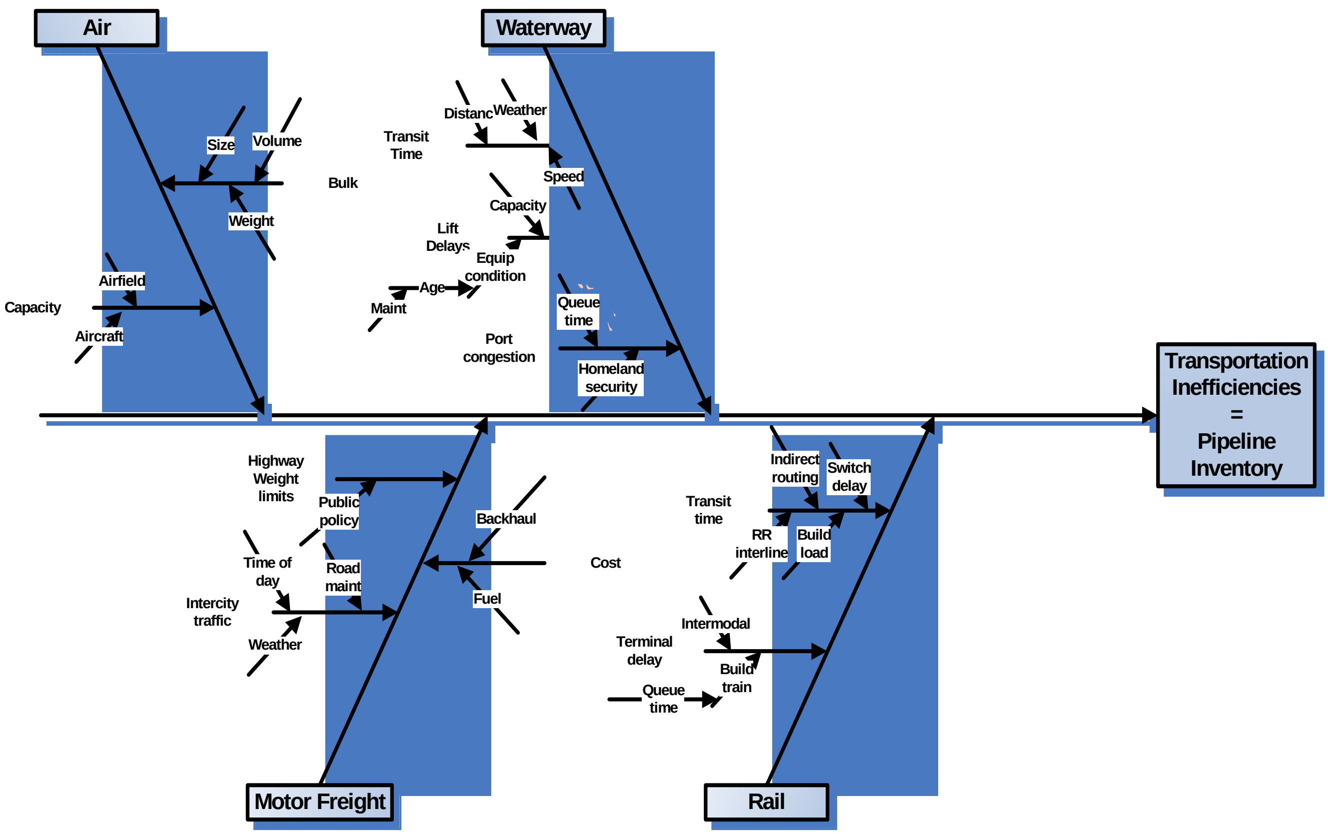
The first step in applying process mapping concepts to the transportation of aluminum products is the creation of a general cause and effect diagram. First we present an overall cause and effect diagram (Figure 6), followed by some comments on specific modes. Figure 6 illustrates the four major modes of transportation. Air transport methods are not practical for basic input materials due to the size, weight, and volume of raw bauxite, alumina, and smelted primary metal required to produce one pound of finished product. It would be impractical to analyze transportation inefficiencies for air freight and, therefore, this component will not be examined.

Typically, transportation costs are based on the distance between the point of origin and the final destination. For the most part, the freight costs between competing carriers would be based on similar mileage times at a fixed unit per mile. This leaves the problem of carrier selection to two major elements: delivery lead-time and total freight cost. In general, we shall assume that deregulation has leveled the playing field between competing carriers and that equipment availability is the same between all competitors.

With a level playing field and all carrier selection criteria being equal, then the one can assume that the time from pickup at origin to delivery at destination would be identical between carriers. The value of goods in transit (pipeline inventory) represents an opportunity that is frequently ignored or overlooked. These hidden costs of pipeline inventory ultimately finds its way into the cost of the final product.

The ultimate goal within the value chain is to create margin through value added activities defined by Michael Porter as the sum of support and direct activities that contribute to the total offering (Porter 1985). Each activity within the value chain is a collection of activities that ultimately produces a product through a value offering where the consumer's perceived value is greater to or less than the cost of the item itself. With inbound and outbound logistics representing a major cost generally outside the firm's control, how these costs are managed has a major impact on the overall balance sheet.

Figure 6: Causes for Pipeline Inventory (By Transportation Method)

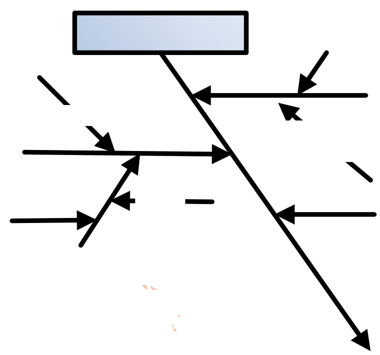


<u>Cargo and Barge Inefficiencies:</u> (Raw bauxite/aluminum T-bars/scrap)
This mode is generally used to move bauxite from South America into the North American river system. Cargo/barge transport times are currently one to three weeks. Once in the port, additional delays occur due to port congestion, queue times, equipment availability, and port capacity. River systems only provide access to Southern and Central United States where primary smelting operations are typically located.

Barging bauxite, alumina, and primary ingot is the most cost efficient method. However, this is the slowest means of moving basic input materials. Depending on inland waterway conditions, barges may move at a speed of three to six miles per hour. Transit time from ports in New Orleans could take seven to ten days to arrive its final destination. Actual delivery to the end customer could be longer depending on queue time to build tows, and delays for shifting and fleeting at inland harbors. Figure 7 depicts inefficiencies of moving goods via barge. Barging is the only practical method of moving bauxite, alumina, and primary ingot due to the vast volumes, weight, and location of aluminum facilities in the mid-west. Barging is the only alternative to move bauxite from South America into the inland coastal waterways for offloading into rail and truck.

Balance of trade deficits with imports from Asia and around the globe have congested entry ports (Wonacott 2003 and Guido 2004). As more manufacturing leaves the U.S., increased pressures will be placed on our already strained resources to offload, load, and move finished goods and raw materials to the point of consumption (*Transportation Topics* 2005). With increased risk of terrorist activities and increased homeland security, further delays and congestion are not likely to improve (Levans 2005).

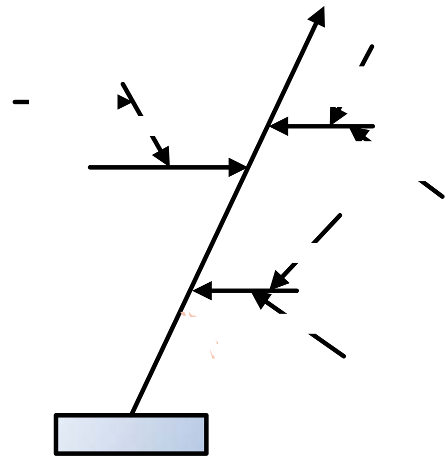
Figure 7: Barge/Cargo Inefficiencies



<u>Rail Inefficiencies</u> (Raw bauxite/aluminum T-bars/scrap/finished; semi-finished product)
The U.S. rail system has over 200,000 miles of track (excludes yard tracks and sidings and does not reflect the fact that a mile of track may include two, three, or more parallel tracks) from coast to coast. Issues include access to transloading facilities and trackage rights, indirect routes, switch and transfer delays (Mongelluzzo 2005). Figure 8 lists several potential causes for pipeline inventory associated with rail transportation. Rail provides and efficient means to move input materials from the port of entry to smelters in the mid-west.

<u>Truck Inefficiencies:</u> (Scrap/finished-semi finished goods/bauxite)
Trucking is the most expedient method to move finished goods and intermodal containers. Common inefficiencies are shown in Figure 9. Delivery at the final destination is affected by several factors. Inter and intrastate roads are often congested, especially during peak commute rush hour. Road and general weather condition, especially during winter months, create delays that prevent truck arrivals in narrow windows of time required for just-in-time manufacturing. DOT regulations restrict the number of hours per day that a driver may operate before resting and shortage of drivers challenges motor carriers ability to “team drive” across long distances. And the aging conditions of roadways in the U.S., maximum load limits, and competition for a available trucks further complicates supply managers from maintaining inventories at just-in-time levels. Consequently, many organizational managers responsible for production planning and scheduling and inventory managers have created pipeline inventory as a means to keep inventory off their books as means to meet periodic performance measures. Failure to recognize pipeline inventory as a hidden cost ultimately places the industry at a disadvantage, especially during times of slim margins and heightened competition with competing products.

Figure 8: Rail Inefficiencies

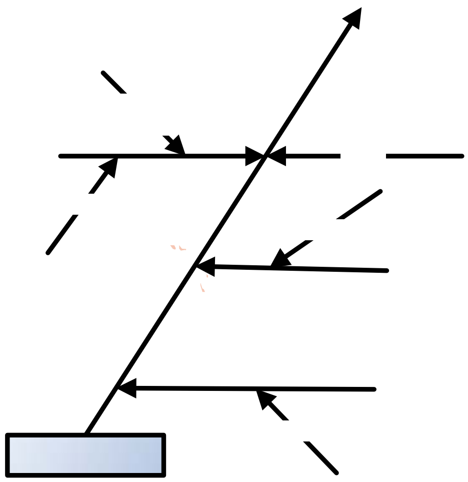


<u>Project Outputs</u>

Business process mapping would achieve the following objectives:

1. Construct a business process map to identify inefficiencies within each transportation segment.
2. Perform gap analysis on inefficiencies and identify non-value added activities within each supply chain transportation link.
3. Assess opportunities to reengineer change (public, private, or collaborative) to eliminate non-value added activity and associated financial impact on industry and up/downstream suppliers, partners, and channel participants.
4. Suggest strategies to eliminate or minimize transportation inefficiencies, minimize routing errors, and improve performance measures.
5. Suggest methods that leverage technology and integrate transportation tracking and cost components into planning and replenishment systems.

Figure 9: Motor Freight/Truck Inefficiencies



<u>Summary</u>

Companies that are nimble respond quickly to sudden changes in derived demand. These companies are quick to adjust production schedule and inventory levels to accommodate the swings in demand. Companies that are slower to adjust demand variations have higher cost of goods due to excess inventory and resource allocation. The addition of the bullwhip effect within the supply chain due to variations in demand and lack of responsiveness ripples throughout the supply chain causing increased costs both down and upstream.

Agile companies are good at scheduling delivery windows to minutes rather than hours or days. They minimize pipeline inventory and safety stock. Both pipeline inventory and safety stock are due to two major factors: (1) an inability to accurately predict demand and schedules; and (2) a lack of delivery schedule reliability. Delivery schedule reliability is due in part to transportation inefficiencies.

In summary, the purpose of this project is to assist the aluminum industry in becoming more agile through an examination of pipeline inventory by mode of transportation. The process mapping will provide insight as to where the inefficiencies within the logistics supply chain exist. The goal is to understand and suggest strategies for optimizing transportation mode and minimize cost for moving aluminum scrap, finished products, and raw materials in the U.S.

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