

Driving Change in Commodity Management in Engineering Led Firms Through Optimization Studies, Modeling, and Data Driven Decision Making

By

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B.S. Chemical Engineering, Rensselaer Polytechnic Institute (2001)

Submitted to the Sloan School of Management and the Department of Electrical Engineering in Partial Fulfillment of the Requirements for the Degrees of

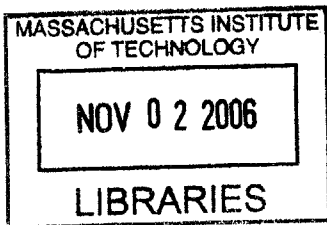
Master of Business Administration

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Master of Science in Electrical Engineering

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Abstract

Engineering focused companies often find difficulty in managing costs. As the innovations begin to slow and key products are commoditized these companies often find themselves far behind their competition from a cost perspective and quickly lose margin and market share. Shifting the supply organization towards one of cost awareness is a difficult and slow task. The challenge and goal in changing the mindset of the organization is to create a team which actively seeks and analyzes all opportunities to remove inefficiencies in the purchasing and management of supply. Large cost cutting initiatives start the process, but changing the mentality and culture of a supply organization involves more than shifting the factory footprint, reducing inventory, and taking away the free pots of coffee.

ABB is a large global engineering company with products ranging from automation to power technology. Historically relying on technological superiority and a strong customer focus, ABB has focused energy on growth of the top line revenues, and was inconsistent in managing the bottom line costs. In 2004 ABB margins were the thinnest among all of their competitors, and they were the furthest behind in EC sourcing.

This thesis emphasizes the need for engineering companies to manage commodity costs and describes different activities, performed within ABB to change the mentality and the culture of the supply organization from one of cost acceptance to one of cost awareness. The challenges in managing the indirect commodity spends at ABB will be outlined and the need for optimization studies, modeling, and data driven decision making to control costs and quality will be shown. Discussed will be the difficulties and discoveries from three projects: the modeling and optimization of European ground transportation, the management of a pan-European team to manage the electrical energy spends, and the development of cost models for training of the supply organization. These activities were performed to challenge the complacent mindset toward managing commodity costs and to effect organizational change.

Following the discussion of specific projects and results, higher level thoughts and more general considerations will be summarized.

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1 Introduction and Overview

ABB is a global company with over 150 manufacturing factories across countries in North America, Europe and Asia. ABB offers a wide range of products and services in power technologies, process automation and robotics, and systems. Within these product families, ABB is seeking, as a strategic objective, to increase manufacturing excellence and reduce commodity costs.

ABB had grown historically through the strategic acquisition of companies which augment the core competencies of ABB, mainly power and automation technologies. Individual factories have maintained their autonomy of decision making as well as the responsibility to perform on a profit and loss statement. Tying the company together was ABACUS, software that allowed for internal analysis of the financial performance of each individual company. As the company grew, the structure evolved into a matrix of a strategic hierarchy for product and design decisions, and country hierarchy for the control and reporting of the financial figures. This structure allowed the individual companies to respond quickly to domestic markets and encouraged each company to be self sustainable. In addition, this structure effectively isolated factories from one another, did not stimulate cooperation, and at times put ABB factories against one another in bidding wars.

Nearly three years ago ABB was struggling to maintain profitability. To recover, a newly nominated CEO began to sell off all non-profitable, non-core activities and reduced debt payments through financial re-engineering. Over the past two years, to remain competitive, ABB had struggled to decrease manufacturing cycle-times, increase quality, streamline product designs, eliminate overlap in production, and reduce commodity costs.

To accomplish a reduction in commodity costs, commodities were first divided into two categories, indirect and direct. Direct commodities included all supply which directly goes into the manufacturing of ABB products, such as core steel, copper wiring, steel cabinets and cases, etc. Indirect commodities include transportation of material, electrical energy purchase, travel expenses, cell phones, etc... that supported the manufacturing of the finished products. Cross company, virtual teams were formed to manage each of the commodity spends.

My project focused directly on two of these commodity teams: transportation and electrical energy. Over 100 million dollars was spent on the ground transportation of ABB material in 2004. In the past there was limited communication between factories to leverage the overall ABB volume and achieve economies of scale. Silos were developed based on product groups, and factories of different product groups were only occasionally coordinated at a country level. Attempts at global coordination and optimization were met with stiff resistance in the organization and could neither be agreed upon nor implemented. The majority of this document will discuss the approach, the challenges, the modeling and the conclusions gained from performing a detailed study of the transformer division (PP-TR) within ABB Europe.

In addition to the transportation project, the thesis author managed the electrical energy commodity team; a team formed of country representatives from the top nine spends of electrical energy across Europe. Each representative had different levels of experience in the position, knowledge of their markets, and had multiple local responsibilities that often conflicted with the development and implementation of strategies at the country sites. Proper management and progress reporting required careful definition of the current state within each country, as well as a detailed picture of the critical events and actions that

affected each region. Negotiating the responsibilities of local stakeholders to global commodity team was a challenge.

1.1 Project Motivation and Goal

Managing the flow of material across a network of factories, suppliers and customers could be a costly and complex challenge. Multinational corporations with global factories footprints were faced with additional country-specific regulations that impeded the free flow of materials and added to the cycle time and cost of these shipments. Adding to the complications were factors, which were shared across many large companies: a diverse group of products, a changing base of suppliers, and few repeat customers locations.

As a company grew, the solution of these complex logistics issues were often delegated to the control of the individual sites, allowing each factory to ensure that it had the material that it needed to meet production schedules and customer requirements. However, this method led to local optimizations with each of the sites developing its own information technology infrastructure and supplier base based on non-uniform requirements and cost structures. In a company of significant size, the economies of scale and scope should allow for better than market pricing for material transportation, based on increased volume with decreased variation. However, by disaggregating the total volume of supply, and decentralizing the decision-making, leveraging the total network volume and building consensus from all of the local decision-makers became complex and problematic.

The goal of this project was to perform an optimization study of ground transportation of materials across the ABB European network and present the results and recommendations. Discussion included a summary of the issues involved with defining and structuring the optimization problem, as well as case studies and models to determine where efforts with limited resources should be focused for maximum return. The true purpose of this project was to show that there was opportunity for cost savings by changing the way the supply organization approached commodity management issues – working smarter not harder.

A different approach of working with local sites for data collection and idea generation was developed to confront the challenging ground transportation situation. The strengths and limitations with this approach will be outlined. By applying the collected local data with developed cost models, a clear picture of savings was seen of opportunities within the organization. A roadmap was developed to determine the structure and scope of the response, allowing for determination of where the largest cost savings would be realized and have a high probability of success. Finally, the challenges involved in developing and implementing a global solution in a decentralized company structure and gaining uniform buy-in will be discussed.

1.2 Project Approach

The approach for this project followed three phases: Phase 1: Current state investigation and definition; Phase 2: Building consensus, gathering support, and collecting data; Phase 3: Model development and cost structure analysis; and Phase 4, Feasibility analysis and roadmap creation.

Phase 1: Current state definition and project scoping

The current state of inbound and outbound material transportation was defined for divisions within ABB Europe at a high level, using e-smart supply-side data, to show the volume and complexity. E-smart is a

software application that allowed for review and analysis of supply spend data parsed by business unit, region, supplier, etc. The approach and scope of the project to focus only on the transformer division will be discussed, and limitations with this approach will be highlighted. The three types of optimization schemes: matching flows, milk-run and shuttle solutions, and global hub and cross-docking solutions were selected and will be discussed in detail later in the thesis.

Deliverables from this phase included the following

- Initial maps of the supply material flow across the network
- Identification of factories on which to focus more investigation.
- Selection of optimization schemes to model

Phase 2: Building Support, Gathering Buy-in, and Collecting Data

The second phase of the project began with the development and distribution of a general survey to collect initial information about the focus factories. This information was used to develop accurate supplier and customer maps for each factory and for the network in general. However, this information was not easily obtained and very often required repeated documentation of the value of the project, site visits and at times, escalating issues through the chain of command. Site visits were invaluable.

Deliverables from this phase included the following:

- Understanding the differentiating product and process flows across ABB facilities
- Detailed supplier maps
- Process flow maps for the two types of logistical shipping models within the factories.
- Detailed flow information on the customers and suppliers of the selected factories.

Phase 3: Model Development

Models were developed for each of the possible optimization schemes by working with transportation providers to determine costs, existing contracts to determine pricing, and an existing limited trucking cost model. Other cost models were enhanced to include the two groups of underlying costs associated with hiring trucks, which were per kilometer costs, such as gas, maintenance, with a premium based on fill factor, and access costs, such as administration fees, permits, insurance, etc, with a premium based on fill factor due to handling fees.

Deliverables from this portion of the project included the following:

- Cost model development for matching inbound and outbound flow of goods
- Cost model development for performing a milk run or shuttle
- Cost model development for shipping through global hubs.

Phase 4: Feasibility analysis, Implementation Issues and Roadmap Creation

Finally, using the data acquired from the local sites, each optimization scheme will be tested for feasibility at the local, regional and pan-European levels. From this analysis, a best case cost savings was developed for each of the schemes, regardless of the cost of implementation and the associated issues. These issues can be divided into four categories: cultural issues, strategic issues, provider uniformity, and the changing supplier/factory landscape. The first were cultural issues, which included factory planning changes, alignment of factory goals, relationships with transportation providers, communicating with local factories etc. The second was strategic issues, such as decreasing cycle-times to customers, and not paying for supply deliver. The third was supplier uniformity issues. Transportation providers do not provide uniform service across Europe and thus global solutions will always favor certain factories and cost others in quality or reliability. The fourth were issues associated with a changing supplier and factory landscape, and thus any solution will have to be somewhat flexible. These issues will be discussed in detail and then a roadmap for implementation and next step analysis will be presented.

Deliverables from this portion of the project include the following:

- Numerical analysis of ABB data with approximations of cost savings for each optimization solution.
- Recommended roadmap of how to move forward with the optimization solutions.
- Clear identification of implementation issues with recommended solutions.
- Identification of other opportunities for future analysis

1.3 Thesis Overview

The thesis proceeds as follows:

Chapter 2, ABB and Group Supply Management Background provides a brief explanation of the management structure, culture and competitive environment of ABB as well as a more in-depth look at the structure of supply management within ABB.

Chapter 3, Business Context for European Ground Transportation discusses the transportation indirect commodity team and outlines the business environment for pan-European ground transportation.

Chapter 4, Cost Model Development describes the development of trucking cost models for analysis of the optimization routines discussed in chapter 6. Also modeled was the effect of EC vs. IC trucking. Product cost models were developed and will also be discussed to promote cost up negotiating techniques.

Chapter 5, Optimization Routine Model Analysis will discuss the limitations and results from each of the different optimization routines that were examined. Focus will be on the critical factors for success moving forward.

Chapter 6, Changing Minds and Mindsets will discuss research and activities undertaken to change the mindset and culture of the supply organization. An analysis will be discussed of past behaviors with suggestions of future activities such as workshops to create a flexible, fast moving, and cost aware organization.

Chapter 7, Organizational Change and Leadership Analysis examines this thesis work from the three perspectives of organizational processes – strategic design, political, and cultural. This chapter also includes a project leadership assessment, evaluation of the change process, and recommendations for continued success in global supply chain management. Power in the organization will be discussed and how the reporting structure should be reorganized to align strategic objectives with overall business goals.

Chapter 8, Conclusions ties the results and discussion of the preceding chapters together and offers some perspectives on how the framework developed in this thesis can be applied to other engineering-led firms navigating the perilous waters of cultural change and cost management.

2 ABB and Group Supply management Background

This chapter provides a brief explanation of the management structure, culture and competitive environment of ABB as well as a more in-depth look at the structure of ABB group level supply management. A short history of ABB's formation and development is also included. The objective of this chapter is to provide the reader with a sufficient knowledge of ABB's business structure, products, and culture to understand the remaining chapters of the thesis.

2.1 Corporate Structure

In 1987 ASEA AB of Västerås, Sweden and BBC Brown Boveri Ltd of Baden, Switzerland, announced a merger of their operations to form ABB Asea Brown Boveri Ltd, one of the largest electrical engineering companies in the world. The global headquarters was decided to be Zurich, Switzerland. Prior to the merger Asea was one of the top ten companies in the world in power technology and had 12 years of manufacturing experience in building industrial robots. BBC had nearly 100 years of experience in power transmission and a market almost exclusive of the Asea's market.

In its first year ABB acquired over 40 companies including the power transmission and distribution businesses of Westinghouse Corporation. Over the next 10 years, under the leadership of Percy Barnevik, ABB was focused on growth, both organic and through aggressive acquisitions. In 1998 ABB acquired Eltag Bailey Process Automation, the largest acquisition in its history to become the market leader in the global automation market.

In 1999, ABB began to divest non-core businesses and sold off the nuclear power, power generation, and rail businesses. Financial services were sold in 2002 and the Oil, Gas and Petrochemicals divisions as well as the Building Systems businesses were put up for sale. The company reorganized its core businesses into Power Technologies and Automation Technologies and continued to divest all non-core businesses. Under the divisions were the business areas that acted as "silos", or isolated vertical units within the company that did not communicate or coordinate with each other. Business areas were as follows: Transformers (PP-TR), Medium Voltage Products (PP-MV), High voltage products (PP-HV), Manufacturing Automation and robotics (RO), Process Automation (ATPA), Automation Products (ATAP), and Systems Engineering. In 2004 Fred Kindle became the youngest CEO of ABB and Michele Demare was hired as the CFO. (ABB Website)

ABB Organization 2006:

"We need to take what has been accomplished and established in the last two years and lead it forward to ensure further profitable growth." – Fred Kindle (Webpage)

In 2006 in order to strengthen execution, exploit economies of scale and scope, and to accelerate global optimization and globalization, ABB restructured. The core divisions of power technology and automation were eliminated and new business areas were created and elevated to division status. The new business areas became the following: power products, power systems, automation products, process automation, and robotics. In addition, geographic areas, which were countries, were aggregated into regions with more executive level control available for each. Two positions were created, one to focus on global markets and technology to manage the geographic profit and loss, and the other position to manage operations. The operations position tied together mergers and acquisitions, manufacturing and supply chain, and footprint to create a coherent strategy moving forward.

2.2 Global Businesses vs. Geographic Organizations

Local business units, named LBUs, reported not only to the global business divisions, but also to the geographic organizations. The role of the global business unit was the following:

- Run the businesses from R&D to sales
- Primary profit and loss responsibility
- Maximize global performance of specified products
- Execute strategies and deliver expected results

The global business units were the heart of ABB and had the mandate to develop, manufacture, market and sell innovative products to maximize global penetration and profitability. The global business units set the direction and decided the product mix for specific factories or business area units, BAUs, and were supported by the geographic organizations.

The roles of the geographic organizations were the following:

- Actively support business lines
- Monitor performance of business lines
- Carry legal and tax responsibilities for the factories within the region
- Provide efficient customer and factory support for cooperation and flexibility
- Provide a key decision maker and spokesperson for ABB on a country level

Historically, the geographic organization allowed for each autonomous business unit to be flexible and quick to react to changes in the market or country to which it provided products and services. In addition, because Europe did not have uniform tax laws, the global organization would handle all tax implications within their regions. Another role of the geographic organization was to coordinate operations and commodity purchases, such as electrical energy, between regional factories.

Both the global businesses and geographic organizations were directed by the corporate center, whose responsibility it was to shape policy and strategy, drive execution and performance to the strategy and provide shared services, such as IT.

2.3 ABB Competitive Environment

ABB's two major product divisions were power products, selling items such as transformers, relays and gas insulated switchgear, and automation products, selling items from small to large manufacturing robots. ABB's revenues from 2002-2004 had averaged around 20 billion dollars, and they were either the market leaders or second, from a volume perspective, in each of the market segments in which they compete.

In the power technology business, ABB's major competitors included giants such as GE, Siemens, and Honeywell, as well as Areva and Emerson Electric. These companies sold similar products to similar industries, but in general had smaller market shares than ABB. However, from a financial perspective, the earnings before interest and tax, EBIT, of ABB's competitors was nearly triple that of ABB. In addition the gross margin of ABB's competitors was nearly double and the cost of goods sold, COGS, nearly half.

Table 1. Process Key Financial Figures – ABB & selected competitors (3-year average 2002 – 2004)

	ABB	GE	TATA-Honeywell	Areva	Siemens	Cooper Industries	Emerson Electric
Pre-Tax Profit	2.3%	14.6%	6.8%	9.6%	4.7%	8.5%	11.1%
EBIT Margin	3.6%	22.4%	8.4%	7.2%	3.4%	10.2%	12.7%
EBITDA Margin	6.8%	26.9%	9.7%	11.6%	7.3%	13.2%	17.8%
Gross Margin	30.0%	65.2%	57.6%	56.0%	66.0%	32.2%	38.9%
Cost of Goods Sold as % of Revenue	70.0%	34.8%	39.2%	44.0%	34.0%	67.8%	61.1%

Source: Factiva, Thomson One Banker

It is clear from this data that ABB's competitors were managing costs better than ABB, and were seeing higher profits and EBIT because of it. The largest components of the cost of goods sold for ABB were raw material costs, transportation, direct labor, and fixed cost allocation of facilities, corporate entities, cell phones, travel, and energy costs. The largest costs commodity cost for ABB were raw materials, which had not been hedged and had severely increased with the cost of steel, aluminum, and copper prices in 2004, 2005.

Recently, ABB had taken actions to reduce these costs. They had consolidated product lines, reducing facility and labor costs, and had drastically reduced the corporate fixed expense by reducing labor and consultant costs accrued by the corporate entities. The global supply chain organization was also working on programs, such as materials hedging, and sourcing from low cost countries, to ultimately reduce raw materials costs. Cell phones, travel and hotels, energy and transportation costs were coordinated centrally through the group supply chain organization and strategies and policies to address these costs were in different stages of development.

2.4 Global Supply Chain Organizational Structure

ABB group supply chain management was managed by John Walker, my project sponsor, who had years of experience in supply management, but had only been with ABB for about a year. It was his role to align the organization to the vision of a dramatic commodity cost reduction and execute. Commodities at

ABB were segmented into two categories, direct and indirect. Direct commodities were items which directly went into ABB products, such as grain oriented and non-grain oriented core steel, steel cabinets, copper, aluminum, components, etc. Indirect commodities comprised such items as electricity, transportation, cell phones, travel, etc.

The method in which direct and indirect commodities were managed within ABB was fundamentally different. Direct materials contracts were negotiated by group supply chain and, thus, the global group could leverage ABB's economies of scale to gain favorable pricing. Although, it was worth noting that local sites were not forced to use the globally negotiated prices. Indirect materials were mostly managed by the local regions / countries because of regulation or localization. For example electricity was regulated and the country markets which were all highly structured, different, and not open to free trade. Electrical energy was negotiated by country managers, who had expertise in the local market, for all ABB sites within a country. Similarly, hotels, transportation, and cell phones varied from country to country and, thus, local expertise was required for optimal service and price. These commodities were controlled by country or local logistics managers, although global contracts were possible with global suppliers.

However, group supply management was responsible for global cost reduction in both direct and indirect commodities. To achieve this goal, commodity teams were formed with local, country, and global representation. Commodity team leadership was distributed between the global and local representation on the teams. The team leader was responsible for leading commodity team meetings and gaining buy-in from the local representatives on team and individual goals. The leader would then report progress to the head of group supply chain management, John Walker, who would report this information directly to the CFO and CEO. Historically there was no official accountability for missing cost reduction targets.

To summarize, group supply chain management was in a support role to the local units to ensure that logistics and purchasing costs were controlled across the global network of ABB facilities. In addition they were to assist the local sites by leveraging ABB's economies of scale and scope with suppliers for direct and indirect commodities. Although group supply chain management had the ability to sign global contracts and negotiate global deals, local BUs had the final decision to either use the global contracts or go out and find local contracts, which better met the needs of local sites. In addition, commodity teams had been set up to manage individual commodities, but accountability to global goals had historically limited success.

In addition to the commodity teams, the global supply chain group was developing IT systems that would allow for spend visibility by division. Historically, there has been very poor spend visibility because of the sheer number of ERP systems used across the company. Currently, there still exists nearly 200 different systems which could not easily be connected to collect summarized data. Recent advancements in the supply chain IT at ABB allow for full transparency and visibility into the income statements by local business unit. This visibility has two effects: first, it allows for an analytic, apples to apples comparison at a local factory level, and second it is a signal to the factory purchasing people that group level supply chain management not only cares, but monitors closely their local spends.

2.4.1 Direct Commodity Team Structure

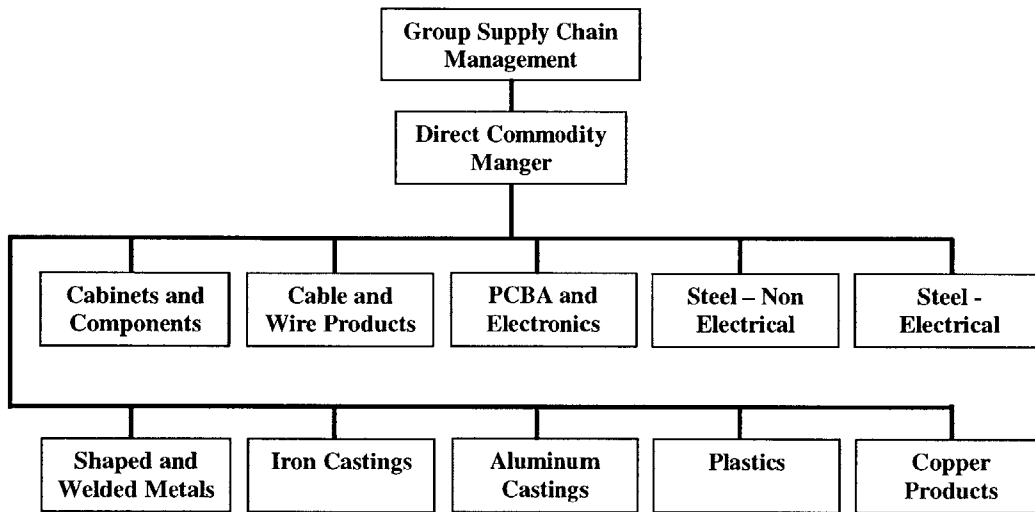


Figure 1. Direct Commodity Team Structure

2.4.2 Indirect Commodity Team Structure

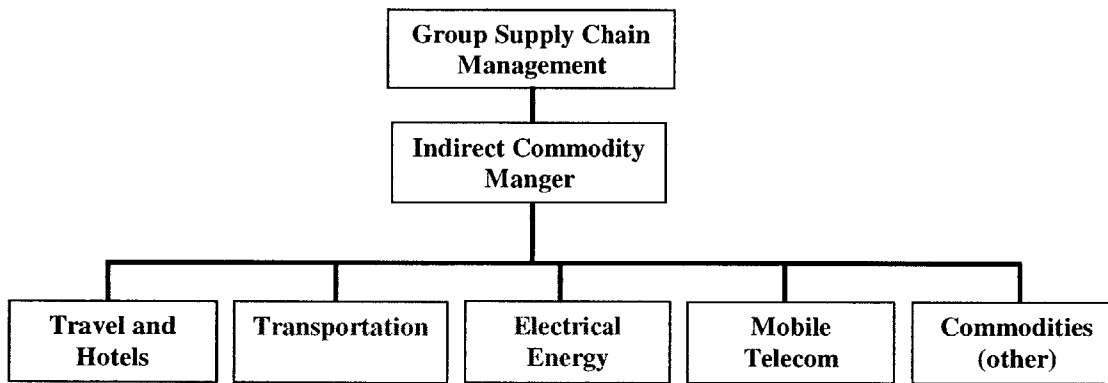


Figure 2. Indirect Commodity Team Structure

3 European Business Environment for Ground Transportation

This chapter is designed to give the reader an overview of the ABB transformer division as well as the structure of ABB's layout across the European landscape. The European ground transportation market and major players will be summarized and ABB's developing strategy toward managing ground transportation will be discussed. The objective of this chapter is to provide the reader with an understanding of the current logistical needs and the business environment in which ABB managed ground transportation.

3.1 ABB Factory, Supplier and Customer Profile

ABB was the quintessential multi-national company with large manufacturing facilities and suppliers in most every European country. Initially the thesis author reviewed about 50 different European factories for applicability to the transportation optimization study, but limited the scope of this project to the transformer, PP-TR, division. Initially, this section will review the various types of supplies and products which were shipped within this division. Then the profile and logistics involved in dealing with ABB suppliers will be discussed as well as the inter-factory shipping. The customer profile and the logistical difficulties of managing a highly variable customer base will be discussed. Finally, the major transportation carriers will be reviewed as well as the two different logistics models within the factories, and their implications on the optimization study.

3.1.1 ABB Transformers

Generally, a transformer was an electrical device that transfers energy from one circuit to another purely by magnetic coupling. No relative motion of the parts of the transformer was required for the transfer of energy. Transformers were most often used to convert between high and low voltages to change the impedance and to provide electrical isolation between circuits. (www.wikipedia.com)

ABB builds three types of transformers, as shown below, that can be separated into two categories, Power Transformers, and Distribution Transformers. Power transformers, shown below as the oil-immersed large transformer, tended to be extremely bulky, weighing in excess of 60 tons. Each power transformer was specialized both in its internal specifications and external shape and size. Distribution transformers, both dry and oil-immersed, tended to be small to medium sized transformers. There was a high degree of specialization in design for both categories of transformers, and a low level of automation associated with the manufacturing and productions of each.

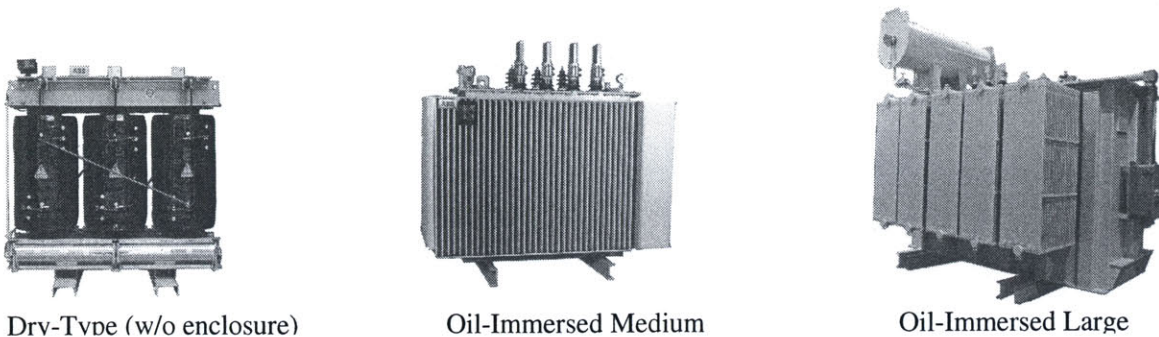


Figure 3. Transformer types: Dry-Type and Oil Immersed Distribution Transformers, and Oil Immersed Power Transformers

Each product was constructed at multiple manufacturing facilities across Europe and shipped across Europe and the globe. Because of the high degree of customization, the European factories were mainly build-to-order and because of the sheer size of the products, many factories had to use creative solutions, such as railroads into the factory and direct to ports to transport the material.

What was important about transformers was that technology was no longer driving the business, and had not been for nearly 20 years. The products could be thought of as a specialized commodity product. Consequently, ABB competed on product flexibility and customizability, and overall service. This strategy added to the cost of manufacturing, and complicated logistics, but allowed ABB to maintain its market share.

3.2 Factory Profile and Logistics

ABB factories from the six different business areas are scattered across Europe. Critical to the success of the project was choosing a representative set of factories that could implement a solution on a small scale and serve as a role model for other factories and other divisions. Initially, it was necessary to investigate 20 factories from 4 different divisions to determine the possibility of performing a study across divisional silos with the results applicable for a broader range of factories. However, due to limiting scope creep, it was decided that a single division with a small range of products would be an acceptable study.

The transformer division was chosen after speaking with the business area supply chain managers from each division. The transformer division would be a challenge because of the product dimensions, and customer profiles, but if a solution was found in this division, it would have a large business impact. In addition the transformer division had two interesting characteristics: a distributed pan-European layout where each factory responsible for manufacturing one type of transformer or component, and large amounts of inter-factory shipments.

Below was the original selection of factories that was considered. This figure was included to give the reader further insight into the distribution of ABB factories across Europe. The four divisions shown are PP-TR, transformers, PP-MV, or medium voltage products, PP-HV, high voltage products, and RO, manufacturing automation and robotics.

Division	Country	City
PTPR	Germany	Roigheim
PTPR	Germany	Bad Honnef
PTPR	Germany	Brilon
PTPR	Germany	Halle
PTPR	Poland	Lodz
PTPR	Sweden	Pitea
PTPR	Sweden	Ludvika
PTPR	Sweden	Figeholm
PTPM	Czech Republic	Brno
PTPM	Germany	Ratingen
PTPM	Switzerland	Geneva
PTPM	Denmark	Fredericia
PTPM	Finland	Vaasa
PTPM	Poland	Lodz
PTPM	Poland	Przasnysz
PTPM	Norway	Skien
PTPM	Sweden	Ludvika
PTPH	Switzerland	Wettingen
PTPH	Switzerland	Zurich
PTPH	Germany	Hanau
PTPH	Poland	Przasnysz
PTPH	Sweden	Ludvika
PTPH	Sweden	Karlskrona
PTPH	Sweden	Landskrona
ATMA	Czech Republic	
ATMA	Germany	Mannheim
ATMA	Germany	Logistics Center E
ATMA	Norway	Bryne
ATMA	Poland	Warsaw
ATMA	Sweden	Vasteras

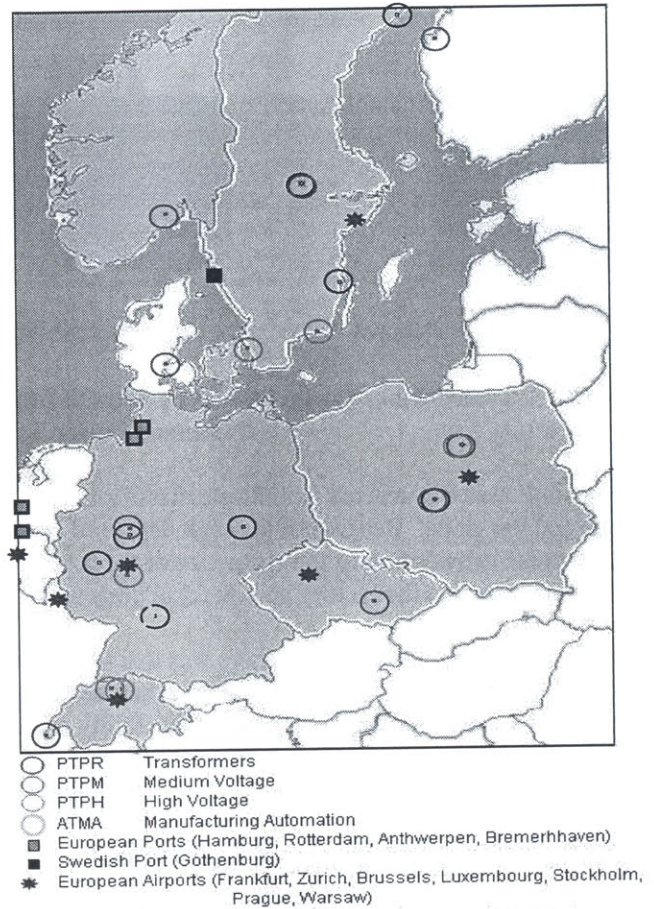


Figure 4. Investigated ABB European factories with PP-TR, PP-MV, PP-HV and RO for optimization study

3.2.1 European Transformer Manufacturing Facilities

Within the transformer division, 12 plants were chosen for study. These locations had a variety of products, 5 distribution transformer plants, 4 insulation and components plants, and 3 power transformer plants, as well as a variety of production schemes. The yearly production of the facilities ranged from 69 power transformers per annum in a western European facility to 15,000 small oil filled distribution transformers per annum at a eastern European site.

The location and product type, product description as well as outputs for selected locations are listed in the table below:

Product Type	Country	Comments
Distribution Transformers	Germany(1)	PowerT RESIBLOC® Dry Type Distribution Transformers
	Italy	Large Distribution Liquid-Filled Transformers
	Norway	10 to 3150 kVA mineral oil and silicon filled transformers. Produce about 1300 units per year
	Poland	Oil distribution transformers, Up to 2000kVA and 36kV; 15000 units per year
	Spain(1)	Dry Type Distribution Transformers
	Sweden(1)	On-load tap-changers, 1800 units/year ; Bushings, 9000 units/year
Insulation	Germany(2)	Division Transformer Insulation , PUCARO supplies pressboard in sheets and press paper in rolls as well as components of pressboard for production of power transformers, and distribution transformers.
	Sweden(2)	Insulating materials and components made of fiber composite materials.
	Sweden(3)	A paper machine for making pressboard, approx. 10 000 tons/year.
Power Transformers	Germany(3)	Large size power transformers, industrial transformers, phase-shifting transformers. 69 units/year.
	Spain(2)	Power Transformers (Shell-form and Core-form types)
	Spain(3)	Small and Medium Power Transformers (10-200 MVA), 125 units/year

Figure 5. Transformer factory types and outputs

The Germany (1) facility, the Italy facility, the Spain (1) facility and the Poland facility were high volume distribution transformer facilities. The product size ranged from large distribution transformer, with unique design characteristics, in Italy, to small distribution transformers that were more standardized products, as in Poland. The larger distribution transformers were manufactured with little automation, and often had groups devoted to preparing and managing the special shipping requirements. To the contrary, the small distribution transformers were produced in a more automated facility, although they too required a considerable amount of manual labor.

Distribution transformer facilities required supplies of raw materials at an irregular basis, depending on particular orders at the facilities. Because of varying product specifications, it was difficult to produce to stock, and thus make-to-order manufacturing schemes had been created. The types of raw materials supplied to these factories were: copper wire, grain oriented and non-grain oriented steel, components such as bushings, steel cabinets, transformer oil and insulation. Outputs of these factories were distribution transformers, which on the whole, could be shipped using standard or minimally modified trailers.

The Germany (3) facility, and the Sweden (1) and Sweden (2) facilities were three **insulation** producers that supplied raw material for power and distribution facilities. Supply for these factories comprised of raw pulp, plastics, and other chemicals, and outputs were wet and dry paper insulation, as well as fiber composite insulation material. These raw materials were often shipped to a “kitting” facility, in Poland, where they were arranged into kits for all European transformer plants, based upon orders and designs

already received at these facilities. Kitting required high amounts of labor and was performed in Poland, where the labor rates were considerably less than ABB's other European locations.

The Germany (2) facility, and the Spain (2) and Spain (3) facilities produced large, highly unique **power transformers**. Shipping for these products could exceed 20% of the entire invoiced cost, and, consequently there were teams of logistics specialists that managed the transportation and installation of every power transformer produced. Supplies for power transformers facilities were similar to distribution transformers, just more massive. Outputs, which ranged between 69 and 120 power transformers per year, required special methods of transportation, and the outbound logistics was often outsourced.

3.2.2 Inter Factory Shipping

Because of the high level of integration between the factories in PP-TR, there was a surprising level of factory to factory shipping. This data was readily available through e-smart, the newly implemented system that tracked the value of supply-side material deliveries and supplier locations. It was worth noting that PP-TR factories were often co-located with facilities from other business divisions. A good example of this was a co-location with medium voltage, PP-MV, and manufacturing automation, RO, in Ludvika, Sweden. Co-location of inter-divisional facilities increased the potential gains from an optimized solution, but were not considered when building the models and analyzing the output due to project scope

Below is a schematic of the entire PP-TR European network of facilities. The arrows represented the direction of traffic, whereas the magnitude of the line and arrow represented the amount of traffic, in dollar value, flowing from one ABB facility to another.

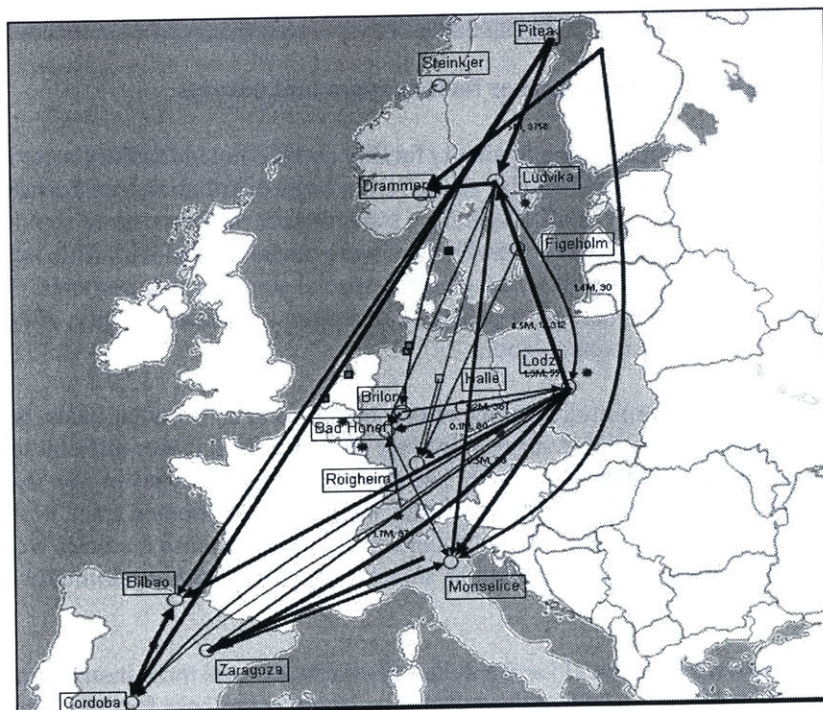


Figure 6. PP-TR inter-factory shipments with the arrows representing direction of traffic and the magnitude of the line and arrow representing the dollar value of traffic

3.2.3 Supplier Profile and Logistical Challenges

Suppliers varied in characteristics by the nature of the product produced at the ABB facility. The suppliers of the direct commodities such as grain oriented and non-grain oriented steel were often shared between transformer factories because of globally negotiated reduced rates. However, common to most facilities was the idea of localized supply, or having the majority of suppliers within 200 kilometers from the factory, and this will become evident when reviewing the supplier map for the European factories attached below:

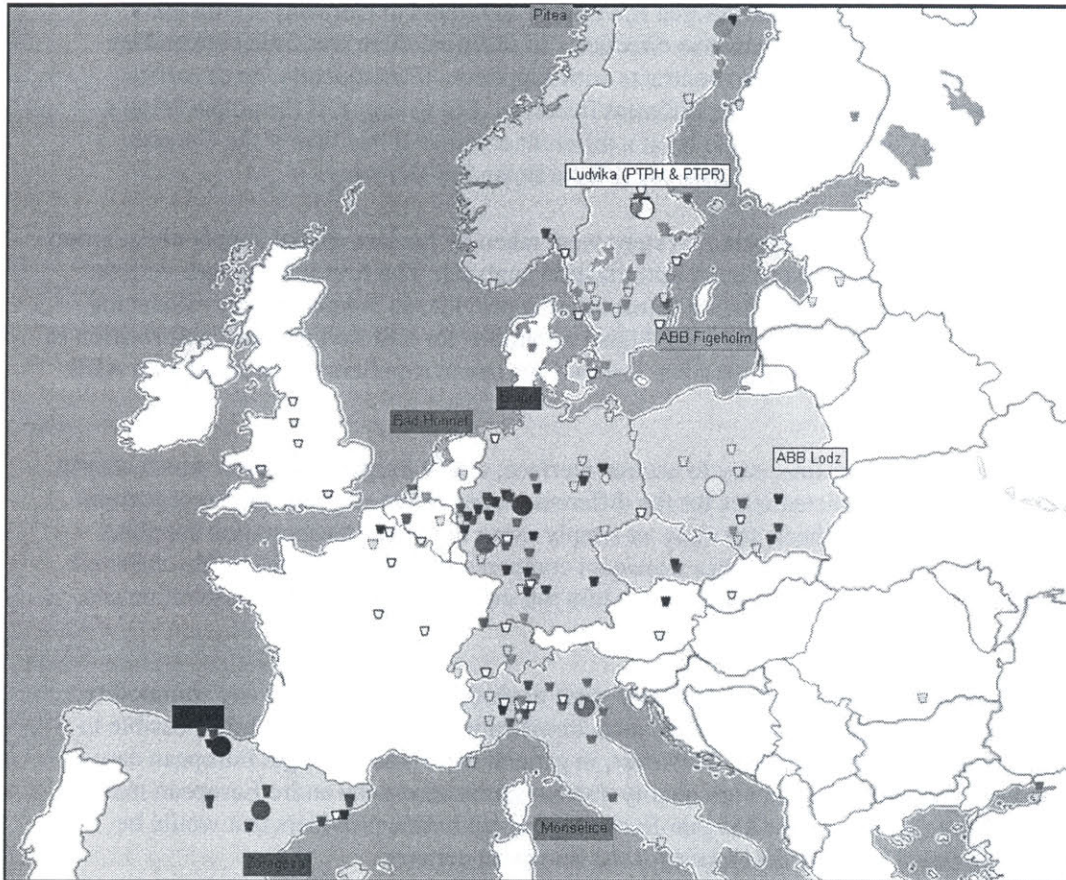


Figure 7. Map of supplier locations for ABB European transformer facilities.

This map was color coded by facility. The supplier data for this graph was gathered with much effort by visiting each ABB facility and speaking directly with the site logistics managers. Although supplier locations and dollar values were listed in e-smart, the delivery logistics information was known only by the local sites and the data was not tracked electronically. So, although it may not be very clear in black and white prints, this figure showed that the majority of major suppliers for the facilities were located close to the factories, with the exception of Pitea which was in the very far north of Sweden. This was an important observation for suggesting and validating optimization schemes later in the project.

3.3 Transportation Carriers and logistical models

Although ABB was looking to determine a method to optimize its ground transportation across Europe, they were not looking to enter the trucking business. Thus, the transportation carriers were an integral

factor in this study, and will be key suppliers and stakeholders in the implementation of an optimized transportation scheme.

3.3.1 Major European Transportation Carriers

As ABB grew in the 1990's each autonomous transformer factory was charged with the task of managing its own transportation to the success metrics that it saw desirable. Thus, across ABB European facilities there were over 100 different carriers used by the factories, making costs difficult to control and overall quality nearly impossible to tabulate. Materials that traveled from Poland to Germany would use a different carrier than product traveling the reverse direction. In addition, there was little cooperation between factories, and little transparency into contracts with suppliers. Consequently, large carriers would have different contracts with each of the different factories. For example, if the polish factory hired a truck from Poland to Germany, it would be at a different contracted rate than if the German factory hired the same truck going along the same route from Poland to Germany.

Management at a global level was needed and two steps were taken by the new global supply chain group that were important factors for the transportation optimization analysis. The first was to work with the local sites across Europe to reduce the number of transportation provider to 3-4 per factory. Reducing suppliers allowed each of the local sites to leverage higher quantities for cost savings and conformation to quality metrics. At a global level, allowed for a few key pan-European suppliers that worked with ABB across regions.

The second step was to create an on-line, easy to access interface, called freight calculator, which clearly and quickly showed all of the contracted rates for the different carriers from all of the different regions. Instead of searching through spreadsheets for rates, or simply using the same transportation suppliers regardless of destination, now the local logistics managers compared the rates provided by the different carriers from the different regions. If it was cheaper to hire the transportation from the destination site, they would do so.

Contract transparency and supplier reduction were key steps in global cost savings for any commodity. By reducing the number of transportation suppliers, and consolidating volumes, it was now possible to reap the benefits of an optimization solution. However, in general there was no single European carrier that could provide both cost-effective and high quality transportation across the entire European market. Regardless, it was evident that there were key pan-European transportation providers that would be stakeholders in any optimized solution developed for the European network.

The foremost suppliers for transportation across Europe were as follows:

- **Supplier A**, a key supplier for Sweden, Norway and Finland,
- **Supplier B** – a key supplier active in western Europe from Sweden to Spain
- **Supplier C** – a key supplier very effective in Eastern Europe

The majority of the negotiations and partnerships were with Supplier C and Supplier B and the potential cross-docking warehouses analyzed in the hub solution optimization study were suggested by Supplier B. It was worth noting that UPS was very eager to get into the European market, but did not yet have the infrastructure to talk seriously with ABB on this project. However, if UPS could match the quality, cost, and service that they provide in other regions of the world, they would be ideal for future projects. In addition by adding UPS as a potential global transportation provider, it would give ABB considerable negotiating leverage with current suppliers to reduce cost and increase quality.

For this project two basic trucking services were examined: Full Truck Load, FTL, and Less than Truck Load, LFL. There were intrinsic cost differences between the two models based on supplier and historical data. These differences will be discussed to greater detail in the cost model section.

3.3.2 Internal Logistical Models

There were many value added services that the transportation suppliers provided to extend their product beyond shipping material from point A to point B. Specifically, in a handful of ABB locations transportation providers had implants, which coordinated the logistics for shipping finished goods to customers. These implants then followed up to make sure the good arrived as scheduled, handling issues that result from mishandled or late deliveries.

Schematics of a standard logistics model and an external implant logistics model for a particular ABB factory in Eastern Europe are as follows:

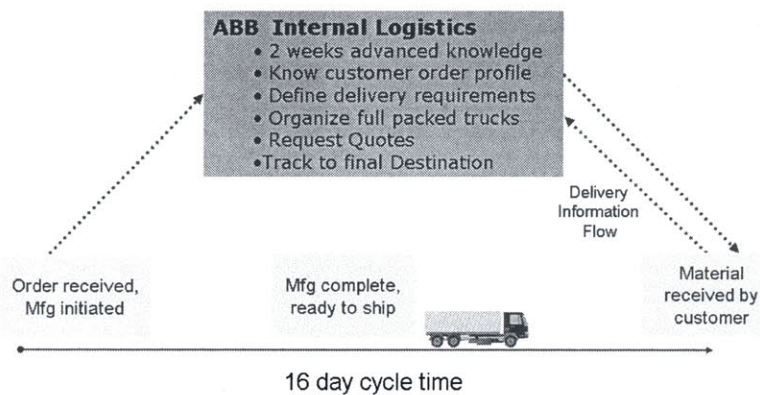


Figure 8. Schematic of logistics model where ABB coordinated, tracked and followed-up on shipping issues.

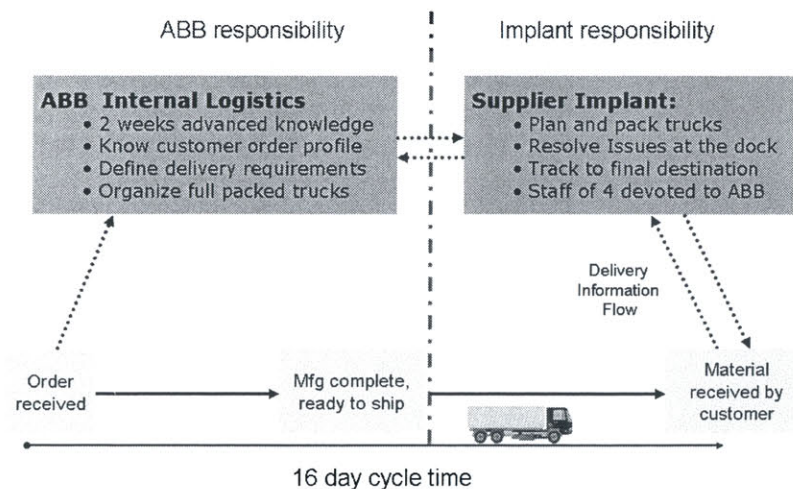


Figure 9. Schematic of external logistics model where a supplier implant coordinates, tracks, and follows up on shipping issues

In both models the cycle time for shipping was 16 days, but in the implant model, a hand-off of responsibility to the transportation provider occurred at the ABB shipping dock. The implant provider

then packed the trucks to take advantage of economies of scale and tracked the delivery and ensured timeliness and high quality. Although the price of the implant was rolled back into the price of transportation, having this service allowed ABB to cut back on its logistics staff to focus on its core competencies. The downside of an implant model was that by handing over the responsibility for systems development and logistics management, there is a potential for the ABB location to lose its talented people and experience in managing its own logistics. In addition, the implant logistics provider gained considerable more bargaining leverage to increase prices in the future.

There is also danger that the implant model may be inflexible and contractually tied to particular manufacturing locations. Thus, companies that are planning a considerable shift in their factory layout or supplier base should be wary of entering into binding and inflexible agreements with logistics providers. In this respect a logistical solution should reflect the overall strategy of the company. ABB had a strategy to move its supplier base and manufacturing to match with product demand, which was in the US and developing nations. It followed that ABB should choose a logistics strategy which was more flexible; they should either choose flexible contracts with logistics implants or maintain internal capabilities to handle logistics and transportation at the local sites.

4 Optimization Solution Development

Summarize up to this point in the thesis, it is difficult for engineering led companies to change both strategy and culture to focus on controlling costs. In order to achieve this, ABB segmented all direct and indirect commodities and set up teams, which were at a global level responsible for setting goals and achieving cost savings on a particular commodity. The formation of virtual teams did not address the cultural issue of complacency but focused the ABB supply chain network to gather data on costs and create metrics.

The optimization study was designed as an example of thinking unconventionally to achieve commodity cost savings and the results would be shared with the local sites. The goal was to provoke out of the box thinking in the supply chain to re-invent the way that ABB managed its cost. In addition to incremental savings through contract negotiations, the group level supply chain organization wanted to determine if cost savings could be achieved by changing the system.

The focus of this study was only on optimizing transportation, and not on changing product or factory characteristics. This chapter was designed to discuss the various optimization solutions which were studied after the acquisition of supply chain data from the local organizations. In addition to the potential optimization options, this chapter will outline a cost model that was developed after talks with numerous suppliers, which was subsequently used to analyze each of the optimization options.

4.1 Optimization Options

Logistics surveys had been completed by a subset of the European factories that included representation from each of the business areas. Previous survey information was a good starting point as it provided the revenue and expenditure on transportation and logistics for a small subset of sites across the divisions. This information provided a reality check for the optimized solutions being considered, as the data allowed for some rough global assumptions about overall spend and traffic. With this survey knowledge, it became clear that **consolidating material** for transportation was the key to reducing the transportation spend without changing manufacturing and purchasing procedures.

The network optimization problem was broken down into three subsets for study. The thought was that it may be too complicated and convoluted to only consider a global optimization. However, breaking down the overall problem would allow for further insights into the local regions and the overall system and may uncover pockets of inefficiency that would yield considerable savings. The optimization was thus divided into factory level transportation inefficiencies, regional transportation inefficiencies, and pan-European transportation inefficiencies.

Specifically, the three optimization schemes that were mathematically modeled and tested for economic feasibility were as follows.

- Flow Balancing
- Milk Runs / Shuttles
- Hub / Cross-Docking Solutions

4.1.1 Flow Balancing

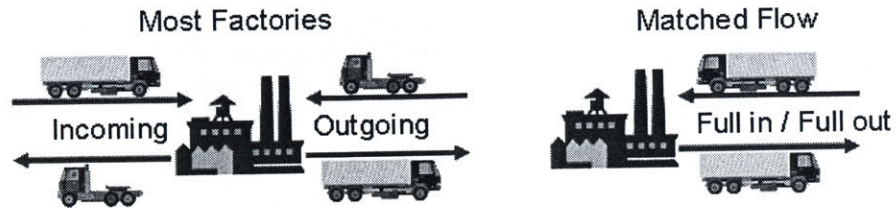


Figure 10. Schematic of current and future states for the flow balancing solution

Supply was delivered to ABB factories in the morning in full trucks. The trucks unloaded the material and left the factory with an empty payload. Trucks then arrived at the factory in the afternoon with an empty payload to pick up finished goods. In this system ABB not only paid for two empty legs, but also paid the overhead associated with the coordination and planning to schedule an additional truck.

The vision was that in an efficient system material supply would be delivered and finished goods removed all in the same visit to the factory. This solution would be beneficial for the transportation providers who would save on costs, and for the factories that would negotiate rate reductions. This solution had been implemented in other industries, such as the auto industry, and had been found to be highly cost effective (John Walker).

Stakeholders for this solution were the local logistics manager, and the transportation provider. There were additional stakeholders internal to the factory, such as planning and scheduling, but it was assumed that if the analysis yielded considerable opportunity, then the local logistics manager would pull the solution into the factory, using influence and local networks to change the internal factory practices. The data requirements to study the economics of balancing flow were at a factory and local transportation provider level. Consequently, the opportunity for flow balancing at each factory was considered independently of any other. Implementation would be at a factory level, independent of the other factories in the region and the network.

4.1.2 Milk run / Shuttle Solutions

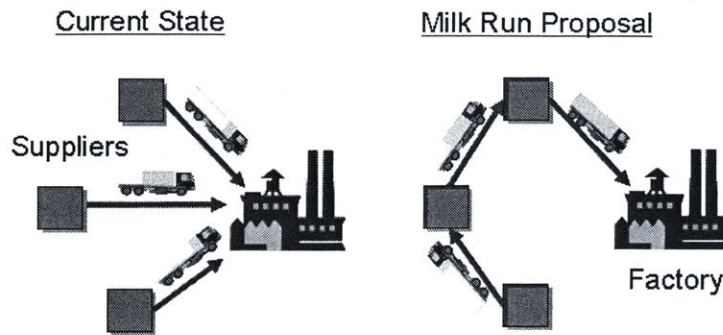


Figure 11. Schematic of milk run/shuttle optimized solution

As mentioned earlier, ABB factories tended to source a considerable amount of material locally. Because of the size and variation of shipments from each supplier, each supplier hired trucks and delivered the material at LTL, less than truck load, rates. ABB was then paying for this inefficiency either by directly paying for the transportation, or by having the transportation rolled into the cost of the supplied goods. Few single suppliers had enough supply volume to fill an entire truck. However, localized groups of suppliers had supply enough material to yield positive economies of scale.

The vision for the milk run solution, named so because it was reminiscent of the milk man days of old who would deliver milk to all the customers as opposed to having each customer travel to the market to buy milk, was that ABB factories would hire a full truck that would travel to all local suppliers on a regular basis to pick up supply. ABB would get much more favorable rates than smaller suppliers because of ABB's overall global shipping quantities. In addition, the ability of ABB to manage the consolidation of supply into a single truck had potential to save a considerable amount of money. The design of a shuttle was similar to that of a milk run. A single truck would travel to each ABB facility to pick up finished product and would transport the finished product to the nearest airport / seaport.

Stakeholders for this solution were the local logistics manager, the transportation providers, and additionally the suppliers. The data requirements to study the economics of this option were at localized level. Consequently, groups of suppliers and groups of factories needed to all be aligned in order to sustain positive savings. Although each party would gain financially, factories and suppliers would have to cooperate to consolidate, which proved to be challenging.

4.1.3 Hub / Cross-Docking Solutions

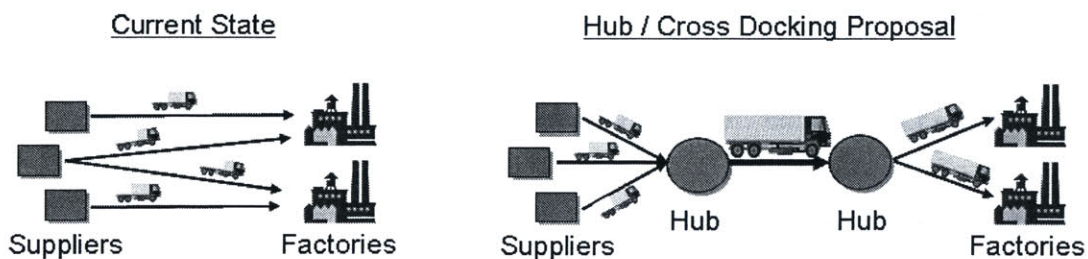


Figure 12. Schematic of a hub / cross docking optimization solution

Many suppliers and customers for ABB European factories were not localized around the factories. Often, the material shipped long distances from these non-localized suppliers and to non-localized customers was not enough to fill a truck to get the economies of scale. This material was shipped through transportation providers who would perform a value-added service and consolidate the material for shipping. By performing this value-added service for ABB’s network, the transportation providers were demanding higher costs – this concept will be elaborated on in the cost model section later in this chapter.

The vision of this solution would be that ABB had multiple hubs across Europe to facilitate cross docking material and to reduce costs by consolidating both supply and finished product for pan-European shipments. Initial data showed that the volume of material that ABB ships between Sweden, Spain, Italy and Poland was large enough to allow for consolidation and economies of scale. ABB would neither own the hubs nor the trucks and so it was critical to find a transportation supplier or group of suppliers that had the capability to offer high quality shipping to all of Europe.

Stakeholders for this solution were the logistics managers from PP-TR facilities across Europe, one and possibly more transportation providers, and many suppliers scattered across the European landscape. Data requirements were considerable and from many different sources that included factories and transportation providers in different European regions. Before the solution could be effectively analyzed all of the data would have to be collected and in order for the solution to be economically viable all of the stakeholders would have to participate.

To summarize the three optimization solutions:

	Scale	Stakeholder Involvement	Change Magnitude
Flow Balancing	<i>Local</i>	<i>Localized</i> (Local logistics managers, one transportation providers and local suppliers)	<i>Independent</i> (Factories can implement independently)
Milk Runs / Shuttles	<i>Regional</i>	<i>Semi-localized</i> (Regional logistics managers, one transportation provide and local Suppliers)	<i>Interdependent</i> (Multiple suppliers and/or factories must coordinate)
Hub / Cross – Docking	<i>Pan-European</i>	<i>Global</i> (European logistics managers, multiple transportation providers and suppliers)	<i>Universal</i> (Participating European suppliers and factories must coordinate)

Figure 13. Scale and change magnitude for the different optimization options.

4.2 Cost Model Development

In order to compare the various optimization schemes it was necessary to understand and model the underlying costs involved in running a material forwarding business. Variable factors that affect the costs of any particular shipment were determined to be load factor and distance, as well as traffic on the route

out and on the return. Fixed costs which had to be allocated to each kilometer traveled by the truck (full or empty) included the costs of personnel, fuel, depreciation, insurance, maintenance and overhead.

Before going in to the details how the underlying costs and variable factors affect the price per kilogram, it is valuable to understand the difference between full truckload shipments, FTL, and less than truckload shipments, LTL:

4.2.1 Full Truck Load (FTL), Less than Truck Load (LTL) and Groupage

As the name implied, shipping by FTL, means hiring a full truck to drive material from node to node. The truck itself was not necessarily full, but the fixed costs and variable costs were paid by a single client. Generally, FTL shipments had a single loading and unloading associated with the shipment and there was no consolidation performed by the forwarder. A full truckload at maximum load factor was 24,000 kg in Europe. Dimensional weight was tabulated for low density items - think bulky shipments, with low weight, such as packaged insulation.

Less than full truck load shipments were divided into two categories, LTL and groupage. Both of these shipping methods were routed through shipping hubs for consolidation. Because of this inherent in this mode of shipping was a longer distance, as well as a longer lead time. The handling depended on the size of the shipment. Shipments larger than 2.5 tons were considered LTL, and were not removed from the truck at the hubs. Instead, other smaller loads were added to the truck by the forwarder to increase his economies of scale. Shipments less than 2.5 tons were considered groupage and were removed from the truck and cross-docked into other line haul trucks.

The following figure provides a summary of the differences between FTL and LTL/groupage shipping modes:

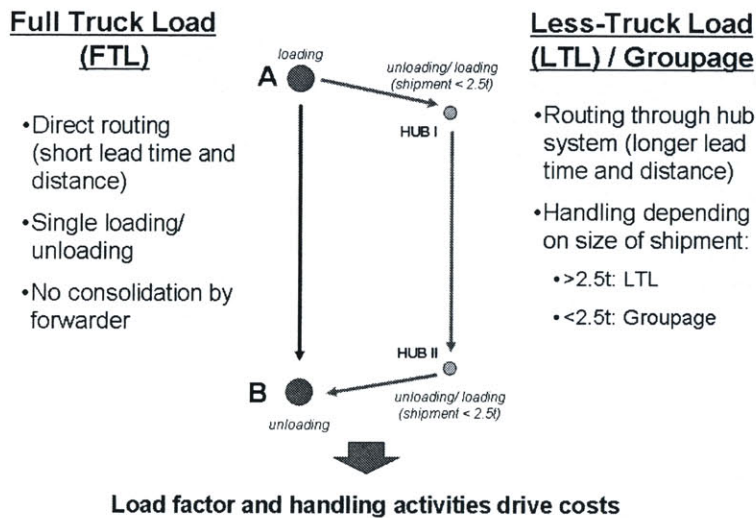


Figure 14. Characteristics of full truck load (FTL) and less than truck load (LTL) shipping

LTL and groupage shipping costs were higher per kilogram than FTL shipments, and prices were up to 5x higher than FTL shipments. The following data on the comparison of FTL to LTL prices was tabulated by Andrey Kaplan, an ABB summer MBA intern, using actual ABB contracted trucking rates at constant distances:

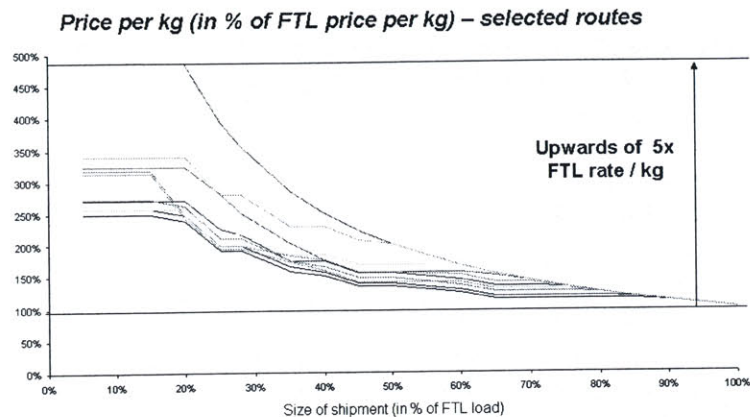


Figure 15. LTL shipping cost increase as compared with FTL shipping

The high price of LTL and groupage shipping allowed for a considerable opportunity in cost savings through consolidation and was the basis of the choices for the optimization study. The next section will discuss the cost drivers for the two shipping models.

4.2.2 FTL Cost Drivers

Shipping by full truck loads was the most economical method to ship, if there was enough material to fill a truck. FTL shipping also offered the smallest lead time of any of the ground transportation options and had the least amount of handling associated with filling a truck. The costs associated with the shipment were the costs of personnel, fuel, depreciation, insurance, maintenance and overhead. If there was considerable traffic going each direction then the costs could be distributed among the two directions, else a single customer also had to pay for the empty backhaul.

The cost model for FTL shipments was simply a tabulation of all of the associated fixed costs per kilogram. The exact formulation for the FTL model, as shown below is simply 0.7 euro / kilometer for emerging countries or 1.07 euro / kilometer for industrialized countries. Because of the simple approach to modeling FTL shipping, there was considerable model inaccuracy at less than 200 kilometers. This was acceptable, however, because most of the optimization schemes used the LTL cost model which will be developed later in the thesis.

The FTL model was used to show the difference in cost base between eastern and western trucking providers. The following was data collected and tabulated by Andrey Kaplin:

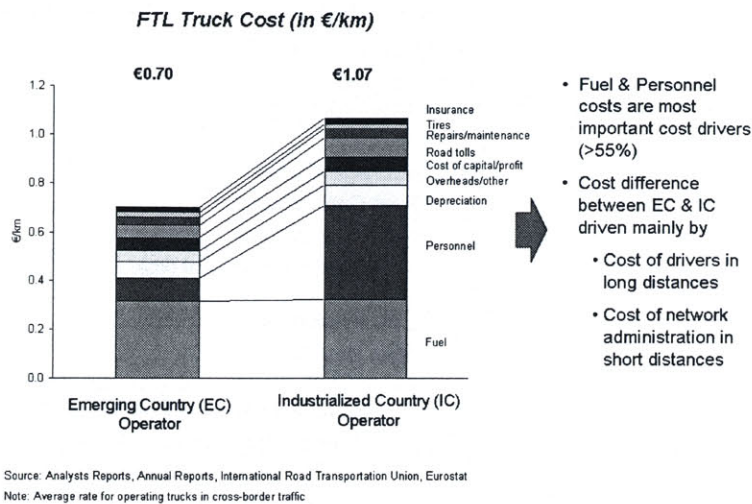


Figure 16. Trucking cost drivers for emerging country (EC) and industrialized country (IC)

The largest cost drivers for FTL shipments in both emerging country (EC), and industrialized country (IC) shipping were found to be fuel and personnel. The difference in the cost per kilogram between EC and IC trucking was considerable and driven by personnel costs. For short distance shipping this difference was driven by the cost of network administration and for longer distances the difference is driven by the relative cost of drivers. For reference, examples of EC European countries are Poland, Slovakia, Hungary, Bulgaria, Romania, Croatia, and Turkey, whereas, IC European countries are Sweden, Finland, Norway, Germany, France, Spain, Switzerland, Italy, and Portugal.

The magnitude of difference between EC and IC trucking was astounding. Although beyond the scope of my defined optimization project, it was clear that in a commodity business like trucking, switching to EC suppliers can save considerable cost with minimal impact to quality and timeliness.

4.2.3 LTL Cost Drivers

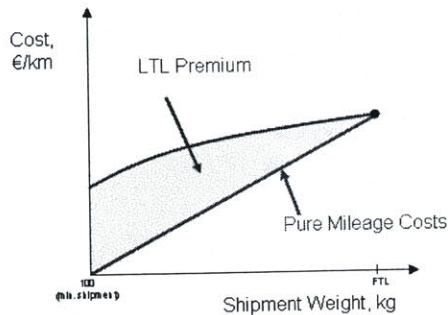
LTL shipping was considerably more complicated to model because of the dependence on both load factor and shipping distance. The simple, linear cost model of cost / kilometer was augmented for use with LTL and groupage shipping. The issues was that with the flow balancing and milk run/shuttle optimization schemes, distances were relatively small, and thus a linear cost model had high error and would be extremely inaccurate. Thus, another model was developed which factored in the fixed network administrative costs and non-linear handling costs associated with shipping partial loads.

The LTL model was broken into three distinct costs:

- Distance costs
- LTL Premium Fee
- Access and Handling Costs

Distance costs were assumed to be a linear function of distance and weight, with the maximum cost equal to that of hiring an FTL for the same distance. The main cost drivers for distance costs were distance and the shipment weight. LTL premium fee was the value added service charge that the forwarder charged the customer for the ability of the forwarder to consolidate with other volume and ship. This premium

represents the risk that the forwarder was assuming by taking on a less than full truck load that the truck would not be filled. Thus, the fixed cost allocation per kilogram was increased and this risk was passed on to the customer. The smaller the shipment, the larger the risk involved with not filling the rest of the truck. The following figure was a graphical representation of these two costs:



(1) **Mileage Costs**

Main Cost Drivers:

- ❖ Distance (km)
- ❖ Weight of shipment (kg)

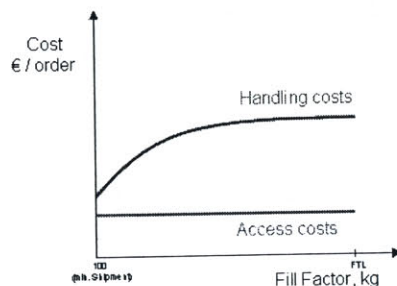
(2) **LTL Premium**

Main Cost Drivers:

- ❖ Risk for trucking company not filling the truck (decreasing with larger shipments)
- ❖ Value-add service charge

Figure 17. Representation and explanation of distance and LTL premium costs

The third category of costs was the handling and access costs. These costs were separated out because they were fixed costs per order, varying only with the fill factor and not the distance traveled. As shown below, handling fees were found to be increasing with shipment size, leveling off as the size of the shipment reached a full truck load. The reason for this non-linear increase was that smaller loads took more time and effort per kilogram. To simply stop the truck and get the fork lift for a small load was less economical. Access costs referred to the fixed cost associated with ordering a truck. These costs encompassed the overhead associated with managing the network, and scheduling a truck for delivery. To hire a truck to transport material from one side of the plant to the other, cost in addition to only the handling and unloading charges; this addition charge, associated with administration and scheduling, was the access fee.



(3) **Access and Handling Costs**

Main Cost Drivers:

- ❖ Access (fixed / truck) :
 - ❖ Administration / Scheduling
 - ❖ Provision of empty truck
- ❖ Handling (per shipment):
 - ❖ # of handlings (pick-up, hubs, delivery)
 - ❖ Weight of shipment (kg)

Figure 18. Representation and explanation of the access and handling costs drivers

In the models, the relationship for the LTL premium, the handling cost and the access costs were derived from three locations: freight calculator, historical data, and by querying the transportation carriers.

Freight calculator was an on-line database containing all of the contract rates that ABB had negotiated with all of the transportation providers. Although this information was the price of shipment, and not the cost, the cost structure could be inferred, assuming margins of 10-20%. Historical shipping data was also used as an additional source of information. This data was parsed such that similar shipping distances and locations were only included in the regression. This ensured an apple to apple comparison.

Lastly, and most importantly the forwarders were consulted. This was a crucial step because the forwarders actually know their costs, although they only presented estimates. However, actually saving money by implementing optimized transportation solutions would only come after price negotiations with forwarders. Thus, it was important to determine how much the optimized schemes would be worth to the forwarders.

For example, for handling costs, the actual data clearly showed a non-linear decreasing function.

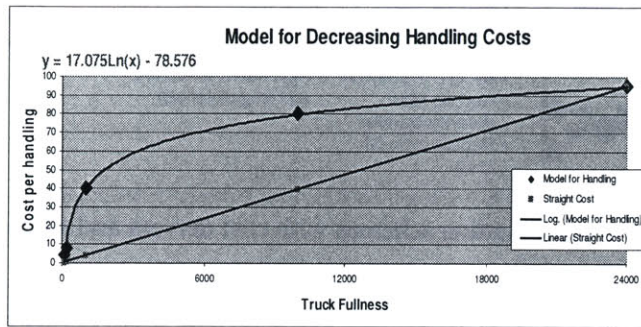


Figure 19. Model for exponentially decreasing handling costs vs. fill factor

After conversations with the internal stakeholders and the transportation providers, the cost drivers and success factors for each optimization scheme were summarized. For the flow balancing in the factories, the activity cost drivers for savings are simplifying administration activities, reducing empty rides and reducing total distance traveled. Success factors for flow balancing would be the ease of changing the timing and factory planning within the factories and would require a high traffic of non-specialized trucks. For milk runs / shuttles, the cost drivers for savings are the avoidance of the LTL premium, and the reduction of handling costs, and the reduction of the total distance traveled. Success factors for the successful implementation of milk runs would be fill factor and total distance traveled as well as the ease of implementation and cooperation from the participating suppliers. Similarly, the cost drivers for hub / cross docking are the avoidance of the LTL premium and the reduction in total distance traveled and the reduction in the handling costs. Success factors for hub implementation are high pan-European traffic, fill factors, long distances, and support from participating local logistics managers across Europe, support from suppliers across Europe and support from pan-European transportation providers.

The following is a summary of the cost drivers and success factors for the different potential optimized solution:

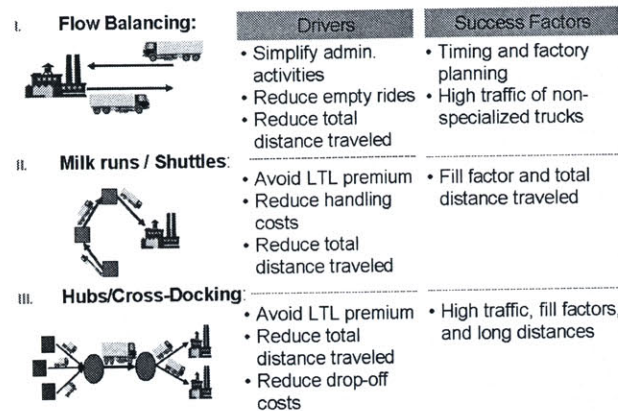


Figure 20. Summary of optimization schemes with cost drivers and success factors

4.2.4 FTL and LTL Model Statements for Milk Runs and Flow Balancing:

The exact formulation of the FTL model is shown more clearly in figure 4.2.4. It is the sum of distance costs, LTL premium fees, and additional handling costs and access fees. The model uses the FTL model as a base and calculates additional charges based on a decreased fill factor.

For flow balancing the model simply multiplied the savings due to not having to coordinate an extra truck to the factory times the possible number of trucks saved. The cost of coordinating a truck to a factory was found to be a portion of a fixed access fee, which was found to be about 50 dollars per truck scheduled, plus a cost for the extra distance traveled by the empty truck at a cost of 0.7 euros / kilometer

For milk runs, the savings was seen as a sum of three categories: Distance savings, removal of LTL premium, and access and handling fee reduction. Distance costs savings were the distance costs for a new milk run minus the costs of the original option, which was shipping from each supplier as a portion of a full truck used by the shipping companies. Milk run costs were the total distance times the cost per mile times an LTL / FTL distance factor, which was originally assumed to be 1. Original costs were total original miles times the fill factor of the supplier shipment times the cost per mile which was assumed to be 0.7 euro per mile. The assumptions were later validated.

The savings due to the removal of the LTL premium was calculated by determining the multiple per kilogram times an FTL cost due to fill factor and multiplying times the cost per kilogram times the kilogram per shipment. The multiple times FTL cost was determined using existing cost data as $1.126 * \text{fill factor}^{-0.17}$. The cost per kilogram was determined by using existing cost data from the Swedish and European markets. This amount would be the cost savings of shipping as an FTL shipment versus shipping as an LTL shipment through consolidators. The consolidators charge an extra amount per kilogram due to their value added consolidation.

The access and handling cost savings were calculated by determining the access and handling costs for each supplier if done by a forwarder and subtracting the costs if done by a single FTL. The access costs were assumed to be 50 euro per supplier and is the cost to get a truck to the supplier to pick up a shipment. Handling costs were determined using a log relationship which had decreasing cost / kilogram as the shipment approached 24,000 kilograms, or a full truck load. Specifically, the relationship which

was determined was $17.075 \cdot \ln(\text{load factor}) + 78.56$. In the original case this was multiplied by 2 as there would be separate trucks and operators which handle the load at pick up and delivery. In the milk run case there would only be one access fee, and although there would be no savings in the pickup fees, there would only be one delivery. This consolidated delivery would save considerable costs.

The following is a mathematical description of the FTL and LTL trucking models.

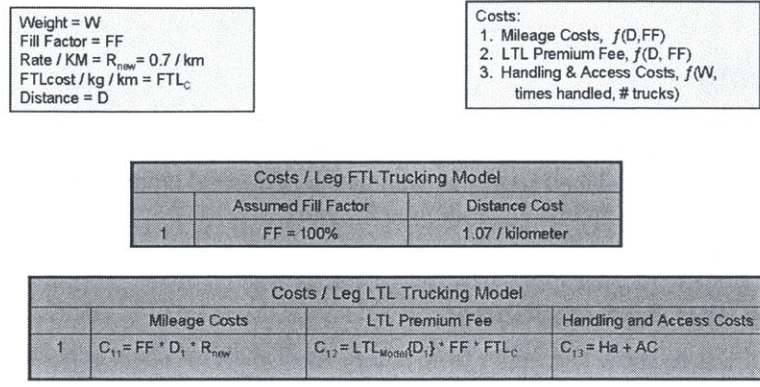


Figure 21. FTL and LTL model parameters. The FTL model is a simple model based on distance that is accurate if distance > 200 km; the LTL model is based on distance costs, an LTL premium for less than full trucks, and handling and access costs.

5 Optimization Model Analysis

This chapter presents an analysis of the optimization solutions and describes the inputs and assumptions built into the models to determine the economic viability of each option. Recommendations based on the model results are included at the end of the chapter.

5.1 Flow Balancing

As stated previously, balancing flows was the ability for a factory to have finished products removed from the factory on the same trucks that the supply was delivered. This approach would eliminate the scheduling of a truck to pick up the finished supply as well as the additional empty distance that the truck drove to get to the plant.

5.1.1 Model Inputs and Assumptions:

The purpose of this model was to show feasibility from a high level and thus some general assumptions were made regarding trucking patterns and costs. These assumptions were validated by the local sites as good first pass estimates of the actual factory conditions.

The most important assumption was the cost that the forwarder would save by not having to schedule and drive an empty truck to the factory to pick up supply. The forwarders claimed that they would be able to save 5-10% per order on shipping by not having to schedule an afternoon pickup for finished product. This estimate was a good starting place, but it was determined that the savings would be a fixed number based on the administrative cost of scheduling a truck and the average distance traveled to reach the factories, as opposed to a percentage of the total delivery cost. Based on previous shipping data, the fixed cost was projected to be about €50 per truck that arrived at the plant. The administrative costs that would be saved by not having to schedule an additional truck were assumed to be 40% of these costs. Distance savings were estimated to average 25 kilometers at €0.7 per kilometer per truck that could be eliminated.

Additional assumptions were made about the carriers used for supply and finished product transportation. Initially, it was assumed that the carrier which dropped off the supply would be the same carrier scheduled to pick up the finished goods. This was not always the case, but was a good first test assumption in the initial tests for feasibility. It was assumed that no special trucks would be needed for finished product shipping, and that the supply truck would be empty and able to pick up a full truck-load of transformers.

The number of trucks that delivered supply and picked up finished goods per week was given by the local sites, but the matching availability was a variable which was assumed and adjusted for sensitivity. In addition, the cumulative amount paid per week for transportation was given by most factories and was assumed for those who could not provide that data to be comparable on a per truck basis to like-factory types, i.e. distribution, power, or insulation. The following table lists the number of trucks per week that enter and leave each participating transformer factory:

Factory	Final ABB Product	Std Trucks in (weekly)	Std. Trucks out (weekly)	Minimum Matching
A-1	Distribution	27	46	27
B-1	Distribution	26	20	20
C-1	Distribution / Power / Kits	40	40	40
A-2	Large Distribution	16	4	4
D-1	Large Distribution	26	20	20
E-1	Large Distribution	13	13	13
F-1	Special Distribution	44	27	27
G-1	Power / PTPH / Comp.	29	26	26
B-2	Power	13	4	4
G-2	Insulation	21	20	20
G-3	Insulation	10	12	10
B-3	Insulation	10	12	10

Figure 22. Average weekly trucks for supply delivery and finished product removal.

The minimum matching number was taken as the minimum number of trucks that were non-specialized and currently delivering supplies or picking up finished product. The number was low for power and large distribution transformers because special trucks were required to ship the finished products that could not be used for balancing flow.

5.1.2 Interpreting the Results

The results of the flow balancing study were summarized in the following graph. The savings per factory was split out at two possible matching sensitivities. In addition the percentage savings for each individual factory was listed below each factory name:

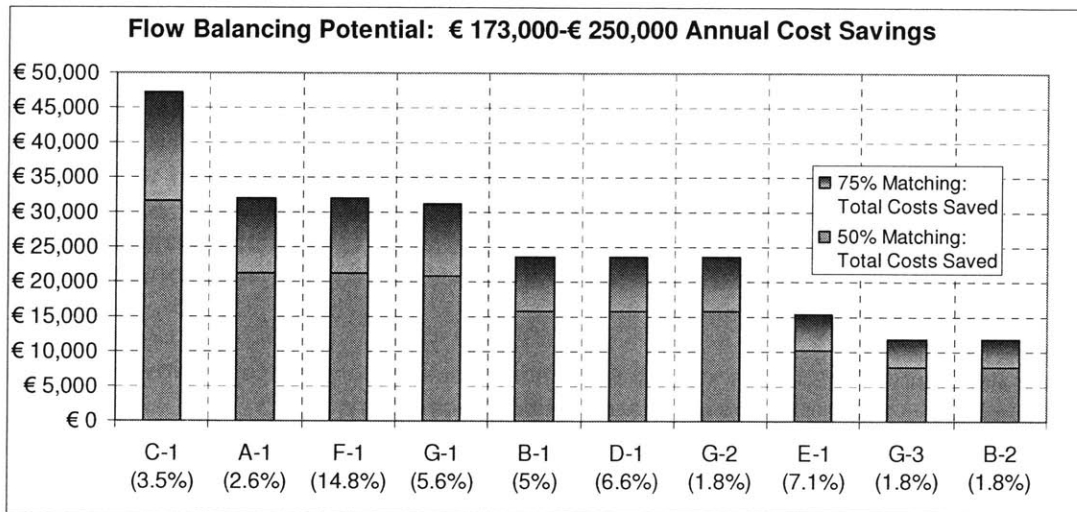


Figure 23. Results from modeling flow balancing for the local sites (percentage savings included below site)

Implementing a flow balancing solution would offer approximately a 2-7% savings for individual factories. This result was rather surprising in that it was considerably higher than expected. The beauty

of a flow balancing solution was that if successful at a small subset of factories it could easily be copied by other transformer sites and by other factories from other divisions.

5.1.3 Success Factors and Challenges with Implementation

Because of the local nature of this solution, the implementation strategy would be to choose a couple of key factories and pilot it to work through the challenges and to prove economic value. There would be three key success factors for a flow balancing implantation:

- Coordination and control of flows
- Ease of set-up
- Disciplined processes (to avoid expediting / late deliveries)

Coordination and control of transportation would be essential for this project. If ABB cannot choose which transportation providers were to be used to deliver supplier or remove finished product, then it would be exceedingly difficult to coordinate the balance of material flows. To ameliorate this issue, ABB could limit suppliers or customers to a handful of “approved” transportation providers and solicit agreement from the providers to deliver material to each other’s warehouses for consolidation. This may prove to be a very difficult challenge because many ABB factories had a hands-off policy to dealing with supply delivery. Thus, it would go against local strategy to limit the suppliers into using a specific few transportation providers.

Ease of setup would limit the implementation of this solution. Currently, at most factories, supply was delivered in the morning, and finished products picked up in the afternoon. Planning at each factory would have to be changed such that either supply would be delivered for the following day in the afternoon, or finished product would be picked up in the morning. The production schedule may have to be changed as well as the role and work timing of the shipping and receiving people, who were often the same people. Shipping costs were relatively small with respect to the price paid for on-time delivery of the finished product and the penalties paid for late deliver by ABB. Thus, if it becomes too much work for the current staff, or impacts the manufacturing or delivery, flow balancing would not be a viable solution.

The third success factor would be the ability to maintain a disciplined process. Because penalties paid by ABB are in excess of 5% of the total invoice price per week, it was critical to have products arrive at the customer site when promised. If after factories implement a flow balancing solution, they were late in completing finished product, either do to process variability, tool downtime, poor quality, etc., such that they missed the scheduled pick-up time, these factories would now have to expedite material at high cost, eliminating all of the savings reaped by the flow balancing. In addition, transportation providers must be disciplined in meeting their delivery promises.

The challenge and beauty of this option was that the solution would be coordinated and driven at a local level, and the immediate cost savings would be seen daily by each factory.

5.2 Milk Runs / Shuttles

Milk runs / shuttles refer to the coordination of supply pickup / finished product drop off using a full truck that was driven to each supplier / factory to pick up material at a scheduled time on a day to day basis. To clarify this option would not affect the suppliers who already shipped by full truck loads, as FTLs are the most efficient trucking mode. However, suppliers with considerable weekly LTL and groupage shipments were studied and a model was build to determine potential milk runs, potential suppliers, and the order in which the truck should pick up supplies to minimize cost.

5.2.1 Model Inputs and Assumptions:

The inputs required to successfully analyze the economics for milk runs included cost per km for full trucks and LTLs, as well as handling and access costs. The linear cost per kilometer for full trucks was derived from previous shipping data from Switzerland, Germany and Sweden. This data was then used to estimate the linear cost for partial trucks as well as the non-linear portion of LTL premium based on potential fill factor. Handling costs were estimated based on fill factor and the access cost was assumed the same fixed amount as in flow balancing.

Initially, there were some restrictions from the transportation providers that were derived from their previous experience designing and implementing milk runs. Two specific requirements that were initially taken as assumptions, and then later validated were based around minimum effective fill factor, and total milk run distance. Rules of thumb stated that anything less than a 60% fill factor would not be economical to run as a milk-run or shuttle. Also, any distance greater than 500 km would not be attainable in a single day.

Supplier and factory locations were obtained to estimate distances and graphed on a map as a reality check. The longitude and latitude locations of the supplier factories and warehouses were acquired using Google earth (www.googleearth.com). The following equation was then used to determine the distances between suppliers and the factory (Simchi-Levi):

$$D_{ab} = 69 \text{ Sqrt } \{ (\text{lon}_a - \text{lon}_b)^2 + (\text{lat}_a + \text{lat}_b)^2 \}$$

Because the driving distance was longer than the straight line distance, a factor was needed to equate these. Simchi-Levi recommends 1.14 to compensate for driving distances versus actual straight line distances, and the regression of distances versus actual distances found using map24 (www.map24.com) showed an offset factor of 1.116.

The model was spreadsheet based, and could be automated in the future to more easily detect viable milk run options. The footprint of ABB's supply and customer base was always changing and so the model was created such to ease the use and upgradeability. Steps to use the model for a new factory were as follows:

1. Collect the supplier and customer information, such as average weekly shipment data.
2. Plot the location of each customer or supplier node and input the latitude and longitude coordinates on the spreadsheet
3. Check the assumptions, such as cost / km, to ensure accuracy for the factory or region of interest
4. Input the milk run for testing

The following was a map of a Spanish distribution transformer site with their top 20 suppliers plotted. By plotting maps it was easier to recognize trends and visualize potential opportunities

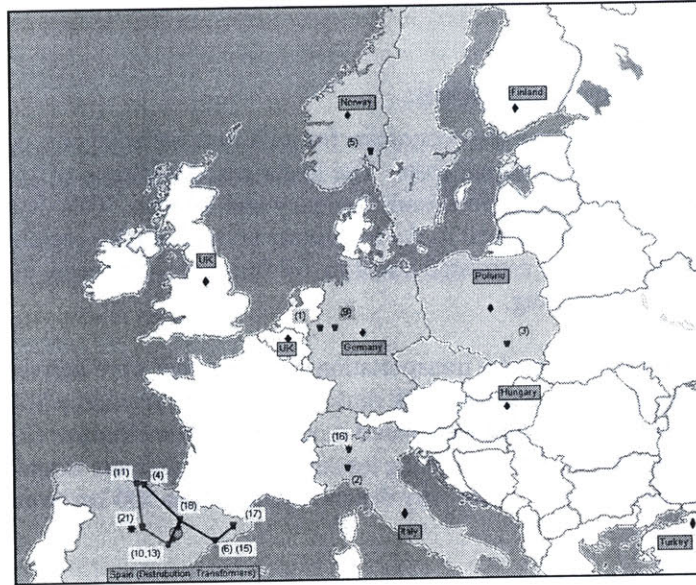


Figure 24. Map of Spanish distribution facility with top 20 European suppliers.

The following chart is a sample model input for a milk run to be tested:

Initiating Supplier	Destination Supplier	Distance (km)	Critical Load Factor	Fill Factor (24000 kg)	LTL cost premium for savings	Straight Distance to Factory, km	Milk Run Summary Data	
							Distance	Load Factor
11	4	2.6	1.0	0.0%	6.3	312.5	354.4	32001.0 133.34%
4	18	304.8	20000.0	83.3%	1.2	310.6		
18	13	38.5	4000.0	16.7%	1.5	30.3		
13	0	8.5	8000.0	33.3%	1.4	8.5		

Figure 25. Sample milk run input

The user simply filled out the left two columns with a sample milk run. In this case the truck drives from supplier 11 → 4 → 18 → 13 → 17 to the factory. This particular milk run had a total distance of 354.4 km and a load factor of 133.34%. The load factor would either necessitate multiple trucks, or in this case one of the suppliers delivered semi-weekly. The total distance if each supplier hired a truck, or used a company owned truck to deliver the supply would have been ~650km at a minimum, up to ~1300 if all suppliers used company trucks and had to return to the factory empty. Thus, in this case, 4 trucks, and up to ~1300km were reduced to 1 truck traveling 354 km.

The cost model was broken into three sections to understand how the different cost drivers will be affected by sending one full truck to all of the suppliers instead of sending multiple trucks from each supplier to the factory. The first section represented the savings based on the distance costs. The second section represented the savings based on the reduction of the LTL premium. The third section represented the savings derived from a reduction in handling and access fees. An example of the milk-run model for a Spanish factory was included in Appendix A.

5.2.2 Interpreting the Results

Savings for a milk run are derived from the elimination of LTL premium fees as well as the reduction in handling and access fees. Straight distance fees were predicted to be more expensive because originally the material was shipped LTL and thus originally assumed a smaller allocation of the fixed distance fees. In the model attached in appendix A, the savings based on distance costs was negative due to the reason above. However, the savings based on the elimination of the LTL premium and the reduction in handling and access fees outweigh the added expense and give an overall savings. The result was interesting and showed quantitatively the qualitative recommendation by the transportation providers that there were fill factor limits, at ~60%, which bounded the viability of the milk run.

Below is another map that was created to visualize milk runs in a transformer factory in Germany. After speaking with the local factory logistics manager and determining the transportation quantities and frequencies, the following two milk runs were proposed and entered into the model for analysis. One of the milk runs proposed getting supply from 7 different suppliers, and the other milk run proposed pickup up supply from 4 different suppliers. Each milk run would run 2x per week and both were found to be viable, however the milk run with 7 suppliers had a much greater percentage savings due to nearly 80% truck fill factor.

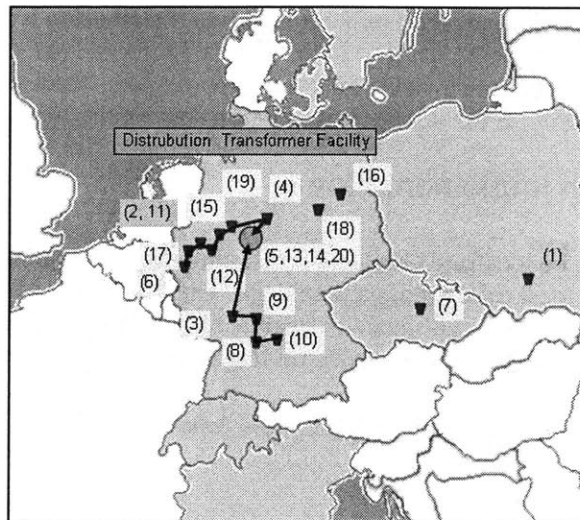


Figure 26. Two proposed milk runs for a German facility.

The following graph was a summary of the analysis for 9 different potential milk runs at three factories across Europe. It was evident that not all milk runs would be cost saving ventures mainly because of the number of suppliers it would take to reach an adequate fill factor. Inadequate fill factor was due to either a spread out supplier footprint or to a small aggregate supply weight.

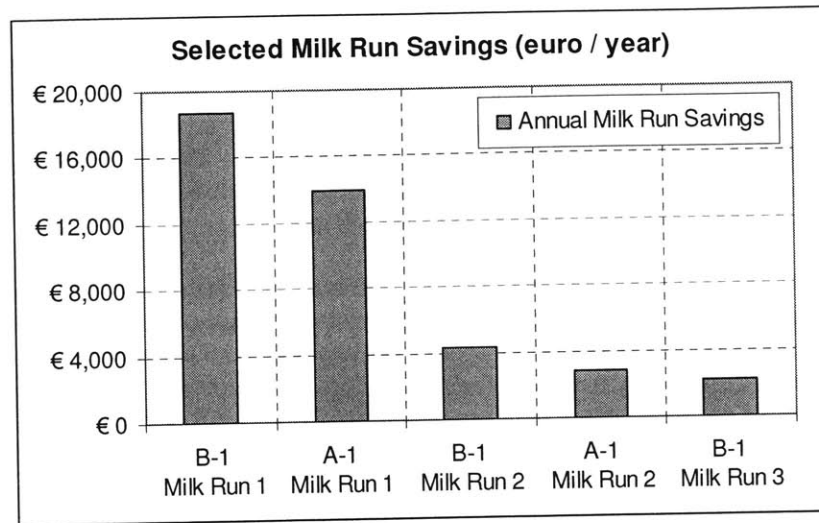


Figure 27. Results from potential milk runs at two distribution transformer sites.

This summary shows that there were two viable milk run opportunities. On a percentage basis, these milk runs would save between 10-25% of the yearly transportation cost for the applicable suppliers.

5.2.3 Challenges with implementation

Milk runs were considered to be localized or regionalized solutions, and required the coordination of local factories, local suppliers and local transportation providers. These solutions offer some interesting and challenging opportunities to the sites, and should be evaluated and driven by the sites. Specifically, three items were identified that were critical to the successful implementation of proposed milk runs:

- Control of shipments:
- Scheduling / Standardizing delivery frequency and times
- Supplier Support

The local sites must have control of shipments in order to be able to implement milk-runs or shuttles. Control was an issue because the delivery of supply was almost exclusively the responsibility of the supplier. The supplier would manufacture and deliver the product to the local sites, wrapping the costs of delivery into the piece cost. In addition to the local sites viewing supply deliver as “free”, many local sites have policies which force suppliers to handle the delivery of supply. Thus a milk run implementation would involve changing the policy and implicit assumptions about supply delivery.

In order for milk runs to be successful, the local sites would have to implement standardizing delivery frequencies and quantities. This would present an opportunity to reduce the inventory in the factory by running milk runs every day with small quantities of supply from each supplier. However, this opportunity would require that factories could purchase supply at a standard frequency and in a standard quantities.

The last challenge for implementation milk runs would be supplier support. Suppliers would have to relinquish control over the shipping, which is most likely a cash cow for them, and would need to agree to have supply ready for pickup at a standard time and frequency. In addition, the suppliers would have to agree to cut the piece price now that shipping was no longer included. Milk runs require reliance on a

group of local suppliers to meet the fill factor required for economies of scale. Thus, each applicable supplier must support this solution in order for money to be saved.

An additional concern existed for ABB because of their evolving supply base. ABB was migrating their supply base from localized suppliers to eastern European and other low cost suppliers. Because of this the distances between the suppliers and factories will increase considerably. In addition, a few eastern European suppliers may be supplying the entire European network with materials, and thus there may be fewer LTL shipments. As the supply base migrates, the economic viability of the milk runs must be continually validated to ensure economical fill factors. As the lines of supply increase, ABB should consider moving from milk run solutions to the next optimization solution – Hubs and Cross-Docking.

5.3 Hub / Cross-Docking Solutions

The hub / cross-docking solution would allow for material traveling long distances across Europe in partially filled trucks to be consolidated and the shipped in full trucks. The value add provided by the transportation provider was the network of trucks and the volume moving across the network, which could be used for consolidation and economies of scale. With a dedicated hub or center for cross docking, ABB would need to have enough consistent volume to guarantee high fill factors upon consolidation. Similarly to the milk run option, this solution would not affect FTL shipments. Once again, ABB did not want to own trucks or enter the transportation business, but if the company could organize material consolidation in European shipping, the value-add of the transportation provider would be reduced.

5.3.1 Model Inputs and Assumptions:

The inputs and assumptions for this model were similar to those for individual milk runs, such as distance, handling and access costs as well as supplier locations and shipping quantities. However, a different characteristic of this solution was that for the hub/cross docking to be successful, it required integration of the entire network of suppliers, factories and customers. Thus, information requirements for this model were supplier and factory locations as well as shipping quantities, frequencies, and other special requirements on shipping. In addition assumptions had to be made about handling prices, access costs, and LTL premium fees for the entire network.

The first step was to identify and map suppliers across Europe. Figure 7 in the supplier profile section shows a map of ABB factories and European suppliers. The factories were represented as colored circles and the suppliers were color coded to the factory to which they delivered supply. It was evident that the local factories had local and pan-European supply bases; however, cooperation between factories to reduce costs across the network was limited. Because of this, a cost savings opportunity existed for consolidation of pan-European supply.

The solution had ABB utilizing existing supplier hubs; the analysis was performed examining options using existing European transportation provider hubs. The four options that were proposed by the suppliers and examined for feasibility (disguised for presentation) were: Sweden; Germany-A; Germany-B; and Austria. More than one hub would be required to support consolidation and then disbursement of material. Based on the data received from nine transformer factories across Europe, each pair of hubs was analyzed. Then an optimized hub location was solved for using one of the provided hubs and a linear program to determine the optimal location to maximum the consolidation opportunities.

The following is a schematic of the hub solution:

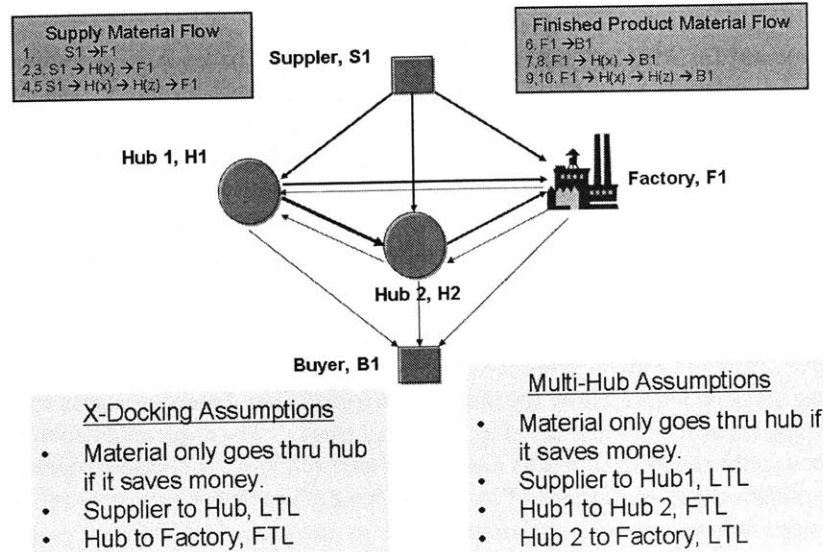


Figure 28: Schematic and assumptions of a hub / cross docking solution

With two hubs, there were five possible paths for material traveling to the local factories. Material could flow from the supplier directly to the factory, through a single hub to the supplier (cross-docking), or through both hubs in either order to the supplier. In the single hub option, material would be delivered to the hub LTL, and then would be consolidated and shipped to the local site FTL. For the multi-hub solution, material would be shipped from the supplier to the hub LTL, from hub to hub FTL, then from the hub to the factory LTL again.

The model estimated the costs for the material delivery using each of the possible paths and then chose the least expensive shipping path. If it was cheaper for material from a supplier to go through a hub to be consolidated then it was included, if not, then the supplier would continue to ship direct to the factories.

Specifically, for each supplier for each factory the location (latitude and longitude), the average shipment, and shipping frequency were recorded. Also it was noted whether the supplier shipped FTL or LTL, as FTL shipments were excluded from this model. Based on the latitude and longitude, the distance to the factory as well as to each of the proposed hubs was calculated using (Simchi-Levi)::

$$D_{ab} = 2 * 69 \sin^{-1} [\text{Sqrt} \{ \sin((\text{lat}_a - \text{lat}_b)/2)^2 + \cos(\text{lat}_a) * \cos(\text{lat}_b) * \sin((\text{long}_a - \text{long}_b)/2)^2 \}]$$

In addition, this distance was multiplied by 1.1 to more closely reflect driving distances – this was explained in more detail in section 5.2.1. Using the distance and fill factor, the models described in the previous section for LTL and FTL shipments were used to compare costs between a proposed hub system, and the current system which utilizes forwarders and LTL shipments. The distance cost savings, LTL premium reduction and decrease in handling and access fees was calculated for each supplier. If this number was non-zero and positive it was assumed that by going through the hub, the shipping cost for this supplier would be reduced. The total cost savings for all individual suppliers for each hub combination was calculated and the results are presented in the following section.

5.3.2 Interpreting the Results

It was found that two of the proposed hubs, Kassel and Malmo, were better localized around factories and suppliers. In addition, using linear programming, an optimal hub location was determined. The locations of these three hubs were plotted on the following figure:

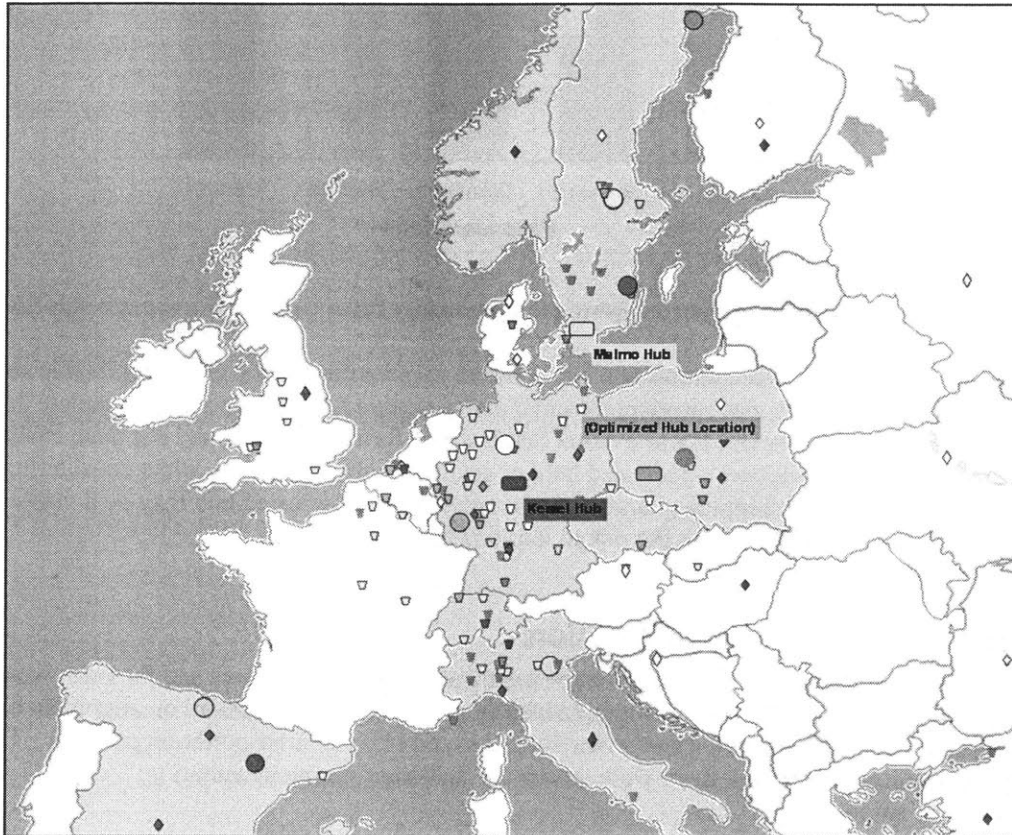


Figure 29. Locations of two proposed hubs and an optimal hub for pan-European shipping.

Estimated cost savings by pairing up two of the hubs was calculated and was summarized in the following graph. Of the forwarder proposed options, the best match would be Kassel and Vienna. However, the optimal hub location that minimized costs was determined to be in Poland near to a large supplier. The following cost savings were determined using the current supplier and factory base:

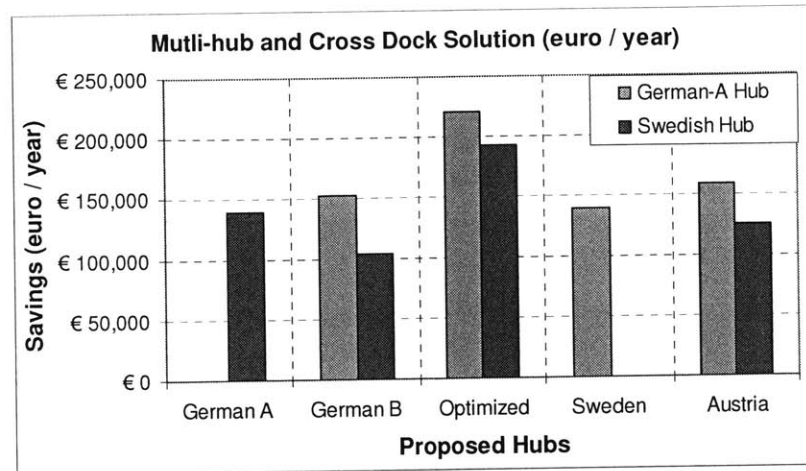


Figure 30. Model results for the cost savings opportunity for a two hub European solution

On a percentage basis, the implementation of a hub solution saved around 1.5% of the applicable shipping costs per year. This percentage was surprisingly small and was adversely affected by incomplete data from the Italian factories. However, it was evident that the transformer division may not have enough consistent supply volume to support a dedicated hub, or group of hubs. However, when considering the delivery to customers, and the shipping quantity of other divisions, a dedicated hub may be a viable idea. Currently, however, it was not be worth the risk to implement a hub solution.

5.3.3 Challenges with implementation

The implementation of a dedicated hub solution for use by all European suppliers and factories would be a formidable challenge for ABB. The economic viability of this solution depended on alignment and support of all suppliers, all European transformer factories, and from the transportation provider. The opportunity for savings existed, but there were numerous challenges to implementation:

- Control of shipments
- Scheduling
- Disciplined processes
- Coordination of the network
- Forwarder competence and cooperation

The issues of ABB control of shipments and of scheduling were similar to the challenges of implementing a milk run and therefore were discussed in more detail in the milk run section. The issue regarding a disciplined process to avoid missing shipping deadlines and expediting costs was discussed in the flow matching section.

Although little would have to be augmented from a factory standpoint, coordinating the supply network to ensure sufficient fill factors for consolidated shipments would be a considerable task. Hubs depend on having enough volume along major lines to allow for consolidation in large line-haulers. If the volume was too low or too variable there would be a major risk or shipping delays, or loss in economies of scale.

The selection of a forwarder for this project would also pose a major challenge. There were no forwarders across Europe that could offer both price and service at an acceptable level in each European region. To implement a hub solution, either a single supplier must be chosen, which would mean a service drop for some European sites, or an agreement between suppliers would have to be negotiated.

5.4 Summary and Recommendations for the Transportation Optimization Study

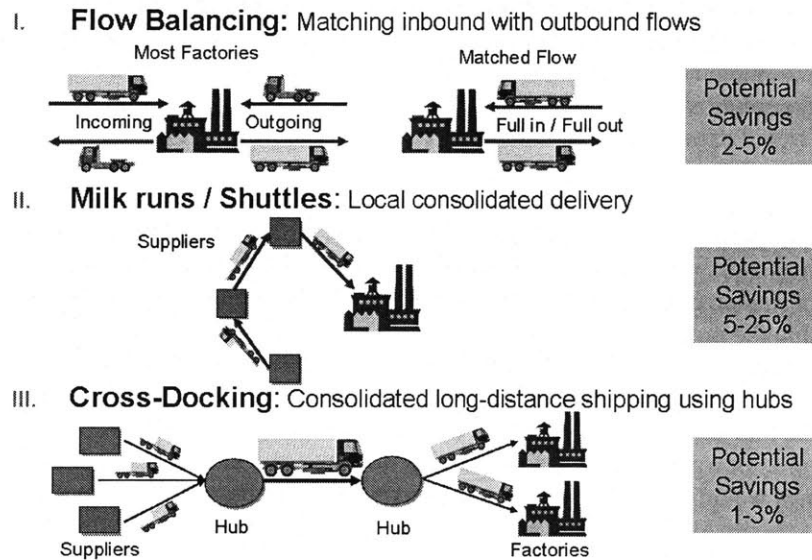


Figure 31. Summary of savings potential for the proposed optimization solutions.

The figure above was a summary of the optimization schemes that were modeled and analyzed during the author's internship at ABB with the potential percentage savings opportunities as determined by the models. The magnitude of the savings increased as the scope and risk of the optimization solution increased. The following graph is a representation of the business impact of each of these solutions, as compared to the ease of implementation.

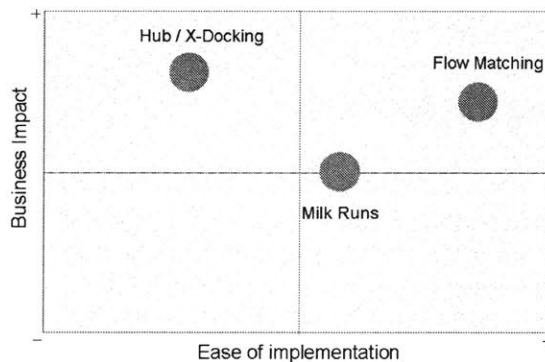


Figure 32. Ease / impact matrix for the potential optimization solution.

Because of the hierarchy of the organization and the autonomy of the local sites, any of the transportation optimization solutions would have to be driven to implementation by representatives from the local sites.

The larger the reach of the solution, the more stakeholders and drivers need to be involved for a successful implementation. In addition, cooperation between factories and divisions had been limited and will slow the implementation of complex projects. Global edicts from corporate headquarters were often ignored, and thus, the ease of implementation will be a determining factor as to whether a solution would be championed by a local representative.

Business impact was another determining factor to recruit project champions at the local sites. If the project was shown to clearly have considerable returns, it would be easier to align and motivate the logistics managers to implement. However, the profit and loss statements of each factory were reviewed separately, and if the solution did not have a clear benefit for the local sites, even if it revolutionized the global network, it would experience implementation difficulties.

To summarize:

- Major opportunities existed with flow balancing and milk runs/shuttles, as these solutions bring clear savings and only require local resources and coordination for implementation. In addition the ease of implementation and business gains would encourage the local site logistics managers to champion the projects.
- Rerouting material flows through hubs required increased volumes and discounts from the forwards to be a viable solution at this time. Nevertheless, as the supplier base moves to Eastern Europe, the hub solution may become viable and should be revisited.
- As ABB did not want to enter the forwarding business, the implementation and realization of cost savings would come through negotiations with the transportation providers. It will be critical to choose a reliable carrier who would be willing to partner for mutual gain.

Implementation recommendations are as follows:

1. Focus on implementing flow matching at the local sites. This solution produced surprisingly high business value for a localized solution.
2. Implement proven milk runs / shuttles. Milk runs are not ubiquitously applicable but have been shown to be cost saving when applicable. Thus, each factory should analyze their supplier base with the model created by the thesis author and determine if deliveries could be standardized and the 60% fill factor reached within the 600 kilometer limit.
3. Lastly, it was not economically viable for ABB to have devoted hubs; however, it was critical to work with forwarders on hub-solutions that provide exceptional price and service, which leverage the transportation provider's network and traffic.

5.4.1 Future Studies – Taking the Next Step

The purpose of this study was to show to the supply organization that by thinking creatively and by optimizing current systems there exists a potential for cost savings. This study showed the importance and potential of making data driven decisions by analyzing the current process against optimized schemes. To this point, the optimization study was successful. However, although considerable amounts of money are spent on transportation, the possibilities for saving by rerouting and consolidation were shown to be relatively small. To the contrary, the potential gains from inventory reduction and increased flexibility may be considerably larger.

The goal of optimizing the supply logistics system can take many forms. There can be four possible goals of an optimization study:

- Reduction in the total cost (TC) function

- Maximization of total revenue
- Maximization of service level
- Decreased risk.

This project focused on the reduction in the total cost function, and specifically on the transportation piece, however, in a business where penalties for late deliveries can be in excess of 5% of the invoice price for late deliveries, it may be in line with the company vision to maximize service level or total revenue.

However, assuming that reduction in the TC function was the goal, it was not effectively achieved by looking only at a piece of the puzzle. Optimizing transportation costs without considering the other inputs may not optimize the TC function, and may even increase it! A TC reduction involves transportation costs, cost of reordering, cost of holding inventory, cost of stock out, cost of obsolescence, penalties for late delivery, etc... From previous implementations of milk runs at ABB, it was found that the cost of transportation actually increased. However this increase was coupled with a large cost savings from inventory reduction.

The following are two recommendations for future logistical systems optimizations.

- Lean manufacturing: optimize inventory management within the local factories. Begin with the purchasing of raw materials and examine ordering costs, shipping costs, and inventory holding costs to optimize inventory policies.
- Manufacturing consolidation: the autonomous highly decentralized structure of ABB manufacturing allows for inefficiencies in areas such as inventory policy and response time and doesn't allow for maximizing the positive effects of economy of scale and scope.

6 Changing Minds and Mindsets

This chapter describes different models in literature to promote and cement organizational change. In the previous chapter, the results from the optimization studies were presented and were shown to be economically feasible. By thinking about problems from a different angle, cost savings can be achieved without overhauling the entire system. Using the transportation optimization study as an example, this chapter will discuss how a global supply chain group can change the culture within local supply organizations to seek out cost savings opportunities and drive organizational change to reduce overall costs. The objective of this chapter is to specifically discuss techniques to effect lasting organizational change.

6.1 Organizational Change Models

Many models have been created over time to model the organizational change process and following is a table summarizing the main schools of thought and how they have changed over time (Kanter):

Model	Process		
Lewin (1947)	Unfreezing	Changing	Refreezing
Beckhard and Horris (1977)	Present State	Transition State	Future State
Beer (1980)	Dissatisfaction	Process	Model
Kanter (1983)	Departures from Tradition and crises	Strategic Decisions and Prime Movers	Action Vehicles and Institutionalization
Tichy and Devanna (1986)	Act 1: Awakening	Act 2: Mobilizing	Act 3: Reinforcing
Nadler and Tushman (1989)	Energizing	Envisioning	Enabling

Figure 33. Models for organizational change

The organizational change process, whether it was modeled as evolving from present state to transition to future state, or from awakening to mobilizing to reinforcing, tended to be modeled in three steps with common themes:

1. First the company must be awakened from its complacency to recognize that the old approach to doing business will no longer be acceptable.
2. Second the organization needs to create and buy into a new vision for the future.
3. Finally, as new processes, practices, and attitudes are developed they must be solidified within the corporate culture.

In the context of engineering led firms, as products mature and industries change from cutting edge to commodity, the organization must evolve quickly in order to either stimulate future technological breakthroughs, or take steps to be able to compete viably on cost. These steps involve commonality of design, consolidation of manufacturing to reap economies of scale and scope, automation and reduction in direct and indirect labor as well as raw material cost and design reductions. However, most engineering led companies struggle with the change from technology and service leader to lowest cost provider. This change usually requires a strong coordinating device to align all levels of the company.

Such a powerful coordinating device is currently available to companies such as Ford, GM, and Kodak and recently existed at ABB as recent as 2 years ago when the company narrowly avoided bankruptcy. Survival from bankruptcy, plant closures, and loss of jobs is a powerful coordinating device and employees will be willing to sacrifice and change old and ineffective patterns in an attempt to survive. Resistance to change is predictable, but is not always an unreasonable fear of the unknown. To the contrary, it is usually grounded in pragmatism (Kanter, 1985). Common reasons why recipients resist change were the following:

- **Loss of control** – corporate change can often be mandated by edicts from corporate headquarters and thus, too much is done to people and too little by them.
- **Surprised by change** – Often full systems are rolled out without preparation or background. For example, at ABB, an application called catalogue buyer was attempted to limit the local purchasing people to purchase on-line and from a limited number of approved suppliers. This failed miserably because of ease of use issues because the local purchasing agents were not fully involved in the design.
- **Costs of confusion** – many people in the organization would like to change, but since so much is changing simultaneously, it is difficult to know the new and correct method to get things done.
- **More work** – often change projects require more energy, more time, more meetings, and more activities not directly related to product manufacturing. Such was the transportation optimization project. The local sites were inundated with requests for data to promote global projects and thus push-back because of the considerable demand on their time.
- **Past resentments** – Local sites managers have witnessed many great programs, which they have supported with their time and efforts, not be implemented within the organization. Thus, when requests come through they are very skeptical that the process will actually change and often decide to “wait out” the request.
- **Real threats** – Outsourcing may be the best option for ABB, but is a threat for the local sites that have been operating in Europe because they fear that any change projects threaten their existence of their factories.

These are very valid fears for members within an organization and must be dealt with in order to enact lasting change. (Kanter, 1985) The first step is the evolution of a common coordinating device. The second step is the creation of a shared vision which is embraced by the entire organization, from top to bottom. Often this vision can be created within the organization, but in ABB’s case, they had to hire outside the company to find someone who could drive the vision without being mired in the company culture. When trying to enact change quickly within an organization, it is often necessary to replace key people who are unwilling or unable to buy into the new shared vision.

In the case of ABB, the main challenge was that, although the company had narrowly avoided a bankruptcy only 2-3 years earlier, cost complacency had historically been an acceptable model for success, and the autonomous structure of the organization never put direct pressure on any of the local autonomous sites. Even though a very powerful coordinating device had existed, it had not been effectively utilized to change the corporate culture because no vision existed at the time for cost consciousness and aggressive cost control. With the hire of the new global supply manager, a vision had finally been developed, but the company was no longer in danger of bankruptcy. Thus a new coordinating device based on cost comparisons to competition and fear of losing ground in outsourcing needed to be developed to focus the organization toward staying competitive.

The final aspect is cementing the new desired attitude or behavior within the organization. The key to achieving lasting change is the alignment of the vision and the new desired behaviors with the incentive system of the employees. Employees, when it is all said and done, will eventually do what they are paid to do, and if the incentive system has not changed, their actions will not change (J. Burns).

Accountability is also required in addition to the alignment of the incentive systems with the desired behavior. Even if the employee and the incentive systems are aligned behind a new shared vision of future prosperity, if there is no accountability, eventually employees will lose focus and act for personal interests.

Rosabeth Moss Kanter discusses a common “ten commandments”, which often accompany the three-step change process. The following list summarizes a script of activities performed in numerous companies for executing organizational change (R. Kanter, 1985):

- **Analyze the organization and its need for change.** Managers should understand the cost and operational drivers of a corporation as well as the strengths and weaknesses of the company with respect to the competitive environment. Thus, even at a basic level of meeting the status quo, managers should be able to detect the need for change. At ABB the need for change was identified when the company was almost taken into bankruptcy. However, it was unclear what needed to be done.
- **Create a shared vision and common direction.** As discussed before, a central vision and philosophy of cost control was required not only to focus the employees within supply organization, but also to clearly explain to other parts of the company why cost management was critical to the success of ABB. A vision was critical for aligning the employees behind a common goal.
- **Separate from the past.** Disengaging from the current pattern and traditions is often extremely difficult, but is necessary to take a step forward and implement lasting change. Activities that are no longer effective must be isolated and changed. Examples of this at ABB would be the use of paper spreadsheets to look up prices for material shipping. The new software, freight calculator, provides more robust and more current pricing data and allows the user more functionality, however, until the local logistics managers throw away their spreadsheets, the change to freight calculator will not be complete.
- **Creating a sense of urgency.** When the need for action is not generally understood or accepted it is very difficult to enact change. In the words of Andy Grove, “Only the Paranoid Survive”. The sense of paranoia allow for a constant sense of urgency to improve and evolve and change, and fights stagnation.
- **Support of a strong leader is necessary for a large cultural change.** Often in companies, this leader must either be a “outsider on the inside”, as Jan Klein would say, or a true outsider who brings fresh ideas and energy to the table, without being bogged down by the existing organizational culture. The challenge of the new leader is to garner the organizational support without succumbing to organization pressures to conform.
- **Lining up political support** is especially challenging for the “outsider on the inside”, or the new leader in the organization who has not had the time to develop the network of followers, helpers and drivers of the new organization philosophy. For ABB and other large organizations, this means aligning the organization, building a network, and integrating the vision of cost maintenance within the product design organization, the sales and marketing organization, the manufacturing organization, and the logistics organization.
- **Crafting a strict implementation plan** with goals and milestones achievable by the organization is taking the first steps toward changing. Within ABB, this has begun to take hold within the commodity teams as they are all given cost savings target onto which they are held accountable.

In order to reach the targets each commodity team is made to write down the necessary actions to attain the goal. This simple act of aligning the actions of the teams to the vision of the manager is a powerful coordinating device and allows for accountability.

- **Developing enabling structures** such as studies, pilots, and training sessions for all levels of the organization will further align the organization behind the values and beliefs behind the vision. The transportation optimization was one such study which will help to enable a change toward cost awareness and control.
- **Communication** is the key to any large scale change process. As discussed earlier, a rationale for reacting negatively to change is being surprised by it. By communicating the change vision and the desired effects, champions will surface within the organization to drive the change, and issues will be highlighted and resolved before they undermine the change effort. Open communication channels are critical for any process or organizational change.
- **Reinforcement and institutionalization of the change** must occur in order to make the change sustainable after the focus of the organization has moved on to other activities. Key to this effort is the restructuring of incentives for employees to reward actions which are in-line with the new change vision.

These ten commandments are not only tactics but capture the essence of the advice typically offered by industry change agents (Kanter, 1985). In addition they are sensible and valuable guidelines for any sustainable organizational or process change.

To summarize, organizational change usually involves three stages: identification that the current processes are ineffective in the changing business environment, creation and acceptance of a new corporate vision, and then fortification of the changed processes and culture by corporate training, communication and the alignment of incentives to the vision. Resistance to change within the organization, due to plausible and pragmatic reasons, is predictable but not unavoidable if the change effort is managed correctly. Finally the ten commandments for enacting change are a good summary of universal knowledge on change management and can be used as a script to guide the implementation of change efforts.

The Ten Commandments for Enacting Organization Change
1. Analyze the organization and its need for change.
2. Create a shared vision and common direction
3. Separate from the past
4. Create a sense of urgency
5. Support a strong leader role
6. Line up political sponsorship
7. Craft an implementation plan
8. Develop enabling structures.
9. Communicate, involve people and be honest
10. Reinforce and institutionalize the change

Figure 34. Ten commandments for enacting organizational change

7 Organizational Change and Leadership Analysis

This chapter uses the results from the transportation optimization project as well as the management of the European electrical energy commodity team to perform an organizational change and leadership analysis for ABB. This thesis work is first examined from the three perspectives of organizational processes (also referred to as organizational behavior) for analyzing organizational change – strategic design, political, and cultural. An assessment is then made of the leadership style used by the thesis author while conducting this work at ABB, focusing on the challenges of influence and distributed leadership framework. Finally, the chapter concludes with an evaluation of the change process in transportation and logistics, as well as several recommendations for continued success at ABB

7.1 Using the Three Perspectives on Organizational Processes

As John Carroll writes, “Systems don’t have root causes; they have causal relationships.” The three lenses is the technique that the author of this thesis is using to try to explain the complex interdependencies that make it difficult for engineering led organizations to change to focus on costs. Specifically, the author uses his experiences with ABB to try to explain many of the interdependencies that are aiding and preventing ABB to reorganize its supply chain management to become cost competitive.

The ultimate success of ABB as an organization to change from an engineering led firm focused on growing the top line to a firm focused on controlling expenditures, streamlining supply, and cost competitiveness can be evaluated using the three perspectives or lenses framework from the MIT Sloan Organizational Processes (OP) class. These three perspectives – strategic design, political, and cultural – provide a well-rounded structure for the organizational and change analysis performed in this thesis work. In performing the following analysis, the author was able to not only pull from the current LFM thesis work, but also from three other LFM theses based on work at the ABB across the globe (Jason Smith in Shanghai 2004, Chris Kilburn-Peterson in Germany in 2004, and Brian Sieferting in Germany/Italy in 2005).

The three lenses allow for three distinct ways of distilling the essence of an organization. Each represents a different paradigm, a different lens through which to view change, and the people who are affected by it. Each lens gives new insights into the organization and a richer picture of what drives initiatives within an organization to be successful or to fail.

The three lenses are as follows:

- The Strategic Design Lens
- The Political Lens
- The Cultural Lens

Briefly, the strategic design lens assumes the organization is a group of inputs strategically designed to achieve goals by carrying out tasks. To the contrary, the political lens views the “organization” as a contested struggle for power among stakeholders with personal interests and different goals. The cultural lens views the actions that people in an organization take as a function of the meanings, constructed from social norms, which they assign to situations.

In addition to the lens analysis, the author will take a look into sources of influence within ABB and discuss the challenges and successful techniques implied while leading a virtual team with varying levels of commitment and experience.

7.1.1 Strategic Design

The strategic design perspective assumes that organizations are a kind of machine that has been designed to achieve goals by carrying out tasks. This perspective is emotionless, pragmatic and analytical and assumes that organizations are designed with a strategy or purpose based on a rational analysis of capabilities and opportunities. People, money, equipment, and information are seen as inputs and are transferred across an organization to maximize efficiency, effectiveness and utilization. This model assumes that given the inputs, a plan of action can be developed that rationally optimizes the organization toward achieving its goals. Within this viewpoint, resources are grouped strategically and alignment mechanisms are developed to coordinate and motivate employees towards the organization's common goals.

7.1.1.1 Matrix Organizational Structure Development

The strategic advantage of the autonomous, matrixed structure of ABB is its ability to service local markets, rapidly adjust to changes in these markets, and cultivate an internally competitive environment where each local unit must financially justify its existence. ABB historically has gone through many strategic organizational changes over time and in the following section, the development and structure of the current organizational design will be analyzed and the effects of the new organization redesign that will begin on January 1st, 2006 will be discussed. The effects of the matrixed structure of the supply chain group will be analyzed and organizational performance measurement systems and individual reward and incentive systems, common to the organization, will be discussed

ABB was formed in 1987 by the merger of Asea of Sweden, and of Brown Boveri of Switzerland. Before the merger Asea, under the management of Percy Barnevik, had redesigned its corporate structure, dividing the company into a number of separate profit centers and radically decentralizing decision-making. The results of this action were 136% increase in sales and a return on sales increased from 1.3% to 4.8%. At the time of the merger, Brown Boveri had decreasing return on sales, down to 0.4% from only 1%. When the companies merged, Percy Barnevik was made the CEO of ABB and he propagated the very successful decentralized structure across the new company, which was now the largest European company in the industry.

In addition, ABB began making large purchases to stimulate growth, two examples of which are Westinghouse's power distribution and transmission business for \$700 million and Combustion Engineering for \$1.6 billion. These moves rapidly extended ABB's international reach into North America and Eastern Europe, and the speed at which these companies were integrated into ABB was attributed to the flexibility of its organizational design. (Westney)

The original organizational structure of the new company was decided by a task force of five top managers from Asea and Brown Boveri. The structure was to be an international matrix of business units and geography, a design that had been widely touted in the 1970s as the organization of the future. However, this design was unable to be implemented by multinational companies, such as IBM and Citibank. The basic organizing principle for ABB was to create highly focused local companies reporting both to a worldwide business manager, who was responsible for the product lines and growing the business units, and to a country manager, responsible for country specific actions such as electrical energy purchases, taxes, etc.

A key to the decentralized structure was the creation of ABACUS, a software system which collected monthly performance data from each unit, and made it available for comparison. This is crucial because it allowed top management to “dig down” into the performance numbers of autonomous units, and placed a very high importance on finance people throughout the company – this will be discussed in further detail in the political section.

Below is a schematic of the organization and the location of the LFM intern within it:

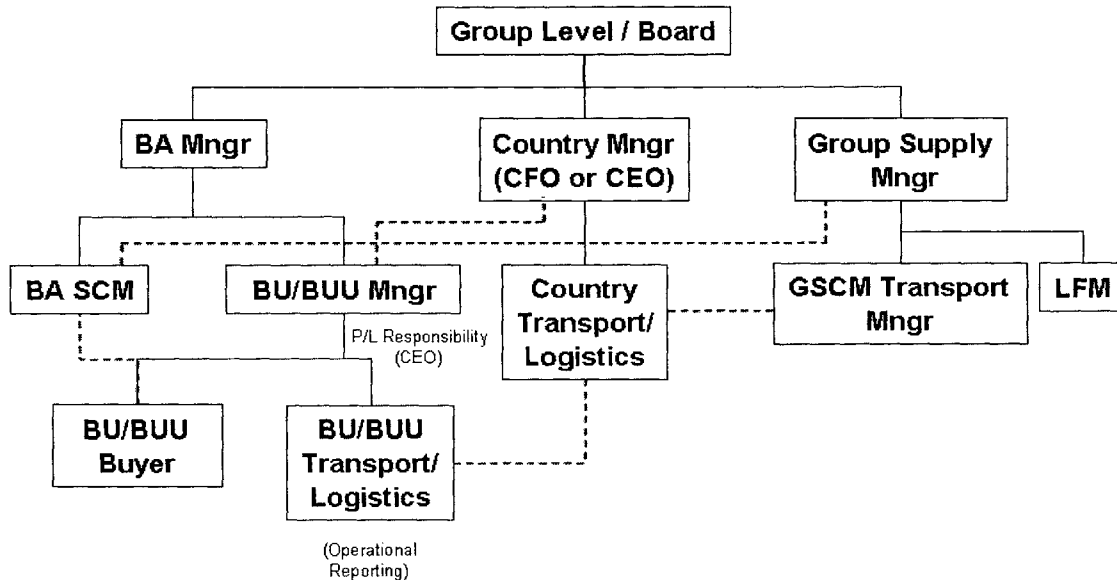


Figure 35. Organization chart showing group supply chain management and the location of the LFM intern relative the country and business unit organizations

7.1.1.2 Business Units and Focus Factories

The basic building block of ABB was originally the local business units, or LBUs, which were the profit centers for ABB. Each LBU was accountable for the performance of the center to the manager of the local operating company, or business unit, BU. The business unit was from the beginning and continues to be the key unit of ABB’s organization. Managers of the business units were like CEOs of their units. Ghoshal and Barlett described the role of one such manager:

“As president of ABB Relays, Inc., a separate legal entity created by ABB, he assumed full responsibility not only for the profit-and-loss statement but also for his balance sheet. This meant that he had to focus on managing cash flows, paying dividends to the partner company, and making wise investments with his retained earnings...It also meant that he could borrow locally...in short he began seeing his job not simply as implementing the latest corporate program but as building a viable, enduring business.” (Ghoshal and Bartless 1998, p.27)

But in one important respect, the heads of the local operating companies continue to differ from independent CEOs. They report to two managers: the business area manager, and the country manager.

In order to better align the local operating units and prevent competition between ABB factories, manufacturing of products was consolidated into focus factories. The number of products each factory manufactured was reduced, and coordinated such that local operating units were no longer producing similar products to other ABB factories in other countries. This decision was supported by consolidated product designs, which increased the robustness of the products, reducing the manufacturing variation, and allowing the sites to better take advantage of the economies of scale to reduce the manufacturing costs.

To tie this back into the supply chain organization, each business unit has a logistics person who manages the flow of material to and from the organization. They effectively decide which transportation carriers they are going to use and how often. Although contracts are negotiated on a country level, the local supply chain people make critical decisions, such as whether the factory will take control of supply side shipping, or make the suppliers deliver, or if they will hire mostly full trucks, or partial trucks to avoid expediting charges.

7.1.1.3 Business Areas

The business area, BA, manager was responsible for the worldwide strategy and performance of a business. His responsibilities included coordinating R&D and technology development, coordinating manufacturing of similar products in “focus factories”, deciding on transfer prices among local operating companies, capturing economies of scale, and most importantly allocation of export markets to the BUs.

Percy Barnevik described the BA manager as, “(the person who) decides which factories are going to make what products, what export markets each factory will serve, how factories should pool their expertise and research funds for the benefit of the business worldwide.” (Taylor, 1991 p. 95-6) However, Goren Lindahl, Barnevik’s eventual successor, was keen to point out that “although the BAs play a vital role in setting strategy, only the local companies can implement the plans and achieve the objectives.” (Bartlett, 1993, p.3) Two vital roles of the BA managers are the identification of key talent within their divisions, as ABB constantly needs new international managers to run BUs around the world, and the dissemination of best known methods, BKMs, across the entire organization.

The local logistics managers do not communicate directly to the BA managers, but instead report up through the BU managers. Because of this there is limited logistics coordination within ABB divisions, and virtually no logistical coordination across divisions, unless to divisions are collocated within the same local operating unit. Logistical coordination occurred, if at all, at the country level.

7.1.1.4 Country Level

The BU managers also report to the country managers, who are responsible for the profit-and-loss for all ABB activities within the country. The country manager was tasked with realizing the potential synergies across local operating companies, presenting a “local face” to the countries, providing legal and political infrastructure to the operation, and ensuring that the local political and social environment is understood and considered properly in business decisions.

Percy Barnevik described the importance of being a national company as, “The governments (our clients) wouldn’t, and shouldn’t, trust some faraway foreign company as a key supplier to those (power and gas) operations.” (Taylor, 1991, p.95) It is the role of the country manager to not only build an efficient distribution and service network ACROSS product lines, but also to maintain productive relations with the top government officials.

The local logistics managers report to a country logistics manager, who attempts to coordinate at a country level the purchase of indirect material, such as transportation, cell phones, hotels, and electricity. Because of their non-tactical roles and encompassing roles these country logistics managers have the ability to coordinate projects between factories and divisions, within specific countries. They fall short however, of coordinating across borders, which is critical for pan-European logistics projects, and the new structure which ABB is proposing for January 2006 attempts to address this issue by creating regions, and regional managers as opposed to just country managers.

7.1.1.5 Alignment

To summarize, the supply chain organization at ABB starts with the logistics managers within the local business units. These logistics managers have two reporting structures. The first is up through the BU manager to the BA supply chain managers, and his incentives are aligned to that of the BU manager. Thus, it is the local logistics manager's job to ensure that the factory supply is delivered and that the product is removed at the lowest cost for the factory.

However, the second reporting structure is up through the country logistics managers. The incentives of the country logistics managers are to support the local units and ensure that from a logistical standpoint ABB is cost effective across the network of factories within a country. This objective is not always aligned with the BU manager's objective of lowering factory costs, and in these cases a local minimum and limited coordination and cooperation exists.

ABB group supply chain management, run by John Walker, the project sponsor, is also in a support role to the local units to ensure that logistics and purchasing costs are controlled across the global network of ABB facilities and to assist the local sites by leveraging ABB's economies of scale and scope with suppliers. The BA supply chain managers and the country logistics managers report in to group supply chain management and thus are aware of the global logistics efforts for ABB. Although group supply chain management has the ability to sign global contracts and negotiate global deals, as Goren Lindahl alluded to in a previous quote, the local BUs have the final decision as to whether they want to use the global contracts or go out on their own to find contracts which better meet the needs of the sites.

7.1.1.6 IT Infrastructure

There were many information technology tools which enabled the organization to create metrics and to judge the performance of the organization. The first is ABACUS, which was talked about previously, and which leveled financial reporting across the global organization. In addition, multiple IT solutions were developed for the supply chain organizations which allowed for spend and contract visibility.

Three pieces of software that are critical to the supply organization's performance are

- E-smart
- Freight Calculator
- ASCC

E-smart is ABB's spend intelligence tool, allowing for spend analysis on all of ABB's factories and suppliers. This tool, which provides transparency into each factory spend, is critical for a supply organization to be able to analyze and solve supply based issues. Freight Calculator is a web based tool that provides transparency into ABB contracts, such that the local units can find the lowest transportation contract negotiated by any ABB site and supplier. For example, this allows a unit in Spain to contract a shipment to Sweden based on the Swedish shipping price, if it is cost-effective to do so. ASCC, which is still being developed, is a portal which will provide ABB-managed transparency to select ABB suppliers.

In essence, each IT solution adds to the transparency in the supply chain and resolves the inefficiencies that are produced from unequal knowledge. The issues with each of these solutions is that they are not fully deployed and accepted by each organization within ABB because the local business units do not always see clear value for themselves in doing so.

In summary, group supply chain management influenced both the country logistics managers as well as the business area and business unit logistics managers. Although the group supply chain management group was only weakly matrixed, with no opportunity to affect employee reviews, they still had the ability to set strategic direction and influence strategic direction in the supply chain within the BAs. They sat in a unique location, in Zurich, Switzerland, and had visibility to all business areas and countries. This visibility meant that they were in a more effective position to negotiate global contracts, collect global numbers for benchmarking and analysis, and lead initiatives for cooperation.

7.1.2 Political

The political perspective assumes that “organizations” are fundamentally comprised of contested struggles for power among stakeholders with different goals and underlying interests. Coalitions are formed among employees and groups based on similar interests and goals to advocate common ambitions. Decisions are then negotiated among top interest groups. From the political perspective, power is the ability to move resources and get things done. Different individuals and groups have different sources of power, or power bases, which include positional power or formal authority, control over scarce resources, information and expertise, alliances with others, skill at manipulating symbols, adeptness at persuasion and negotiation, and personal charisma. Organizational changes are not solely rational moves to increase effectiveness and accomplish goals but are also threats to those who hold power and opportunities for those who want more power.

7.1.2.1 Sources of Power

To begin to examine ABB as political system, one must identify the key elements of power and politics, which include, but are not limited to: interests, conflict, competition, coalition building and negotiation; these will be discussed in the following paragraphs. Sources of power in the ABB supply chain organization are evolving, but historically the power bases are been: formal position and informal networks. This has evolved somewhat with new group supply chain management organization, as most of the team was less than 9 months with ABB, to include knowledge of the numbers. Thus, the IT solutions, such as E-smart, freight calculator and ASCC serve to increase the power in the group supply chain management organization, and specifically for John Walker, the VP in charge of it.

7.1.2.2 Formal Positions

The BU supply chain managers held considerable direct power in the organization, and even though they reported to John Walker at the group level, there was no formal accountability to group supply chain management. The BA supply chain managers affected the reviews of the local logistics managers, which gave them considerable leverage within the supply organization to enact initiatives. However, the BA supply chain managers rarely micro-manage the local logistics managers and were sometimes unaware of the tactical activities and issues as well as the quantitative figures of individual factories within their organization. Country logistics managers also held power within the organization, but similar to the group supply chain organization, the country logistics organizations existed to support the local logistics managers with country specific initiatives.

Interestingly enough, sitting at the company headquarters often had the opposite effect and initially degraded the author's power base to many of the local logistics managers. These local logistics managers were often seasoned ABB employees who had seen multiple group supply chain organizations come and go and, thus, the local managers had very little credibility for the group supply chain organization and the people in it. Solutions developed out of corporate were often seen as difficult to use and adding little value to the local organizations.

7.1.2.3 Informal Networks

Informal networks were the largest source of power within the ABB supply chain network and could enable projects to be successful or undermine any corporate initiative, regardless of merit, if not carefully considered. The BA supply chain managers were mostly seasoned veterans to ABB, who have been in BA supply manager position for quite some time. They all knew each other and had worked together for a considerable portion of their careers. In addition, the local supply chain managers knew each other as well as the country managers and the BA managers. They also had worked with each other for a considerable portion of their careers and had solid relationships.

Unfortunately the group supply chain management organization was relatively new when the thesis author arrived. John Walker, the group manager, had only been in charge for 9 months and most everyone else was hired after him. Thus, the group SCM organization had no formal power, and no informal networks yet established. Similarly, when the author arrived, the author had no formal power, had no informal networks established, and had very little support from the group SCM group, as they too had limited networks and had not established the necessary credibility for organizational leverage.

An example of how informal networks can stifle good projects was when a coworker in the group supply chain organization was trying to convince a "labor friendly" country organization to consolidate suppliers. The country logistics manager, who had been in the position for a number of years and was nearing retirement, was not receptive of the idea and refused to cooperate. The coworker in the group supply organization could not remove this roadblock for two reasons: first because the group organization did not have the formal power to do so, but also because this employee was nearing retirement age and he was legally shielded from being removed from his position by law. The colleague in the group SCM organization then attempted to circumvent the authority of the country manager by calling all of the suppliers and telling them to deal directly with the group level and no longer with the country manager.

This action was done out of desperation, but was very short-sighted. Because of the extensive informal network that the country manager had developed not only within the company but also with most of the suppliers, he found out rather quickly what was happening and he countered not only leveraging his internal network within the country, but also with the threat of a lawsuit. The project eventually was agreed to, but, needless to say, the relationships between group supply chain and the local country organization were strained and the credibility of the group supply chain organization was damaged.

7.1.2.4 Visibility to Numbers

As discussed in the previous section, the group supply organization had little formal power and initially few informal networks to leverage. Thus, the organization created a power base around scarce and valuable information, namely supply chain data, and its effect on the financials of the organization. The effect of the supply organization was not initially well understood because in the past the focus of the ABB was not on cost management, but on top-line growth. However, when it became clear that the

margins that ABB was receiving for similar products sold to similar customers were not comparable to its competitors, the focus on cost management increased.

A very simple example that was used often by the supply organization to drive home the importance of managing costs was proposing the question, which would improve the variable margin of ABB more, to boost customer sales by 8-10%, reduce direct labor by 10%, or cut material costs by 5%. The following was data from a mix of ABB operations used in this example

Table 2. Finance example to show the effects of varying the cost levers within ABB

	Annual Spend (k USD)	percent of sales
Product sales	55 000	
Direct material	28 000	50.9 %
Direct labor	8 200	14.9 %
Freight	2 800	5.1 %
Variable cost margin	16 000	29.1 %

	Impact (k USD)	Variable Margin improvement
+8 % Product sales	= 4 400	0 %
+8 % Product sales (with 100k USD incremental fall through)	= 4 500	+ 0.18 % boost
-20 % Freight Costs	= 560	+1.02 % boost
-10 % Direct labor	= 820	+ 1.49 % boost
- 5 % Material Costs	= 1 400	+ 2.55 % boost

This very simple finance example shows that by decreasing costs, ABB can increase the margin percentage by a larger amount than by increasing sales. This was in contrast to ABB historical culture that rewarded top-line growth above all else.

With an increased interest in reducing the material and production costs, the organization began to focus more on the business unit numbers, but it was not understood exactly what the associated supply chain costs and levers were, until some of the IT systems, and specifically, e-smart, was created. E-smart provided a user-friendly system to query and filter associated supply costs. Costs could easily be filtered down by division, business area, business unit, supplier, country, date range and item description. With this information, the group supply chain organization for the first time had the data to compare the supply costs associated with different business units, and create metrics accordingly. The cost data and the metrics were initially received with skepticism, but the very transparent and logical nature of the data as well as its usefulness evoked curiosity from the business units and then agreement and support. Having control of the cost data from the various business units gave the group supply chain organization leverage and influence within the business units, which in turn increased the support for group level projects and the overall power of the group supply chain organization.

Another method in which the supply organization used numbers to increase power and influence was by building and showing the value of using cost models. In negotiations for raw materials, ABB had been first asking for the price of the good and then they negotiating downward based on order volume. Contrarily, it is much more effective to understand the underlying costs involved in the manufacturing of the raw material, and then starting the negotiations at the manufacturing cost, and negotiating upward based on acceptable margin. An example of a cost model is attached:

Summary				Annual volume		33,333			
Part name	xx			Annual Weight (kg) (Shipped Parts)		1,000,000			
ABB-identification	xx			Currency		euro, €			
MDF-Code	pending			Annual spend		776,628			
Net weight (kg)	30								
Supplier	Chongsing Industries								
				Total costs (per part)		23.299			
Procured Parts (Sand, Resin, Moulds & external subcontracted services e.g. machining)									
Name of part or service	Supplier	Purchase price / part	Admin costs (%)	Procured part or service (Cost/part)					
Resin		0.231	0.00%	0.231					
Coating		0.000	0.00%	0.000					
Alcohol		0.177	0.00%	0.177					
Floated sand		1.088	0.00%	1.088					
Liquid Oxygen		0.284	0.00%	0.284					
		7.6%	Subtotal 1	1.781					
Raw Material									
Definition	Description	Gross Weight	Price / part	Admin costs (%)	Material costs (Cost/part)				
Pig Iron (IC)	Supplier:	12.41	3.97	0.00%	3.971				
Scrap Iron (IC)	Supplier:	18.61	3.91	0.00%	3.909				
Coke	Supplier:		0.34	0.00%	0.338				
		35.3%	Subtotal 2	8.218					
Process (Value-Add)									
Process	Productivity (parts/hour)	Labor (Rates / month)		Labor (# needed)		Labor costs (Cost/part)		Depreciation production equipment	Process costs
		Direct	Ind	Direct	Ind	Direct	Ind	Cost/part	Cost/part
Labor Pay		750.00 €	1,150.00 €	15.83333333	9.33333333	4.28 €	3.86 €	1.28625	9.43 €
Scrap and Pig Iron melted in furnace		Black Box Manufacturing							
Iron kept molten in electrical furnace									
Mold prepared									
Iron poured in mold									
Fan Cooling									
Sand removed (tool)									
Finished with Water									
Deburring									
QC + Final Inspection (Manual)									
Packaging and logistics									
	Means of transport	Transport distance	Stock-holding	Packaging costs	Transport costs	Customs costs			
	Name	Km	Cost/part	Cost/part	Cost/part	Cost/part			
packaging for 100kg of steel @ 1 euro	Packaging			0.300		0.300			
	Trucking	2700 Km			0.677	0.677			
	Shipping	0			0.000	0.000			
				4.2%	Subtotal 4	0.977			
Overhead (incl. SG&A)									
Name	Engineering	Administration	R&D	Building overheads	Insurance				
	Cost/part	Cost/part	Cost/part	Cost/part	Cost/part	Cost/part			
Electrical Energy and mfg costs		0.94			0.00%	0.936			
Administrative / Indirect (SG&A)						1.103			
Warehousing						0.300			
				10.0%	Subtotal 5	2.339			
Working Capital (Inventory + Payment Terms)									
Description	Qty of parts per mold	Description	holding cost	Misc. cost / part					
Factory (Inventory, WIP, FG) at supplier site	CT = 74 days	10278 Parts / day Inventory	17,657.66	0.530					
Additional inventory due to shipping	Ship time = 4 days	556 parts / day in transit	954.47	0.029					
Payment Terms	0 days due to financial payment terms	0	0.00	0.000					
			2.4%	Subtotal 6	0.558				
Company		Chongsing Industries		Date of Visit					
				9/22/2005					
Summary									
	Cost	of Total							
Procured Parts	1.781	8%							
Raw Material	8.218	35%							
Process (Value-Add)	9.425	40%							
Packaging and logistics	0.977	4%							
Overhead (incl. SG&A)	2.339	10%							
Working Capital	0.558	2%							
Total	€ 23.30								
Total with Margin	€ 25.32								

Figure 36. Sample iron casting cost model used to identify cost drivers

Using assumptions about the industry it was possible to construct cost models for the same flange manufactured in different locations around the globe. Having the information on supplier manufacturing costs was extremely valuable in price negotiations. Understanding the cost drivers in the industry as well as the potential savings by purchasing from low cost countries was vital information that should be well understood by any responsible purchasing agent.

In summary, from the political perspective this project leveraged two sources of power – formal position informal networks – to enable the collection of the data and the transportation optimization analysis of the transformer division at ABB. Formal position, although it provided an introduction to contacts, often was a hindrance, as projects that initiate in the corporate headquarters in Zurich are often looked upon by local sites with skepticism. Because of this skepticism, the development of informal networks was critical to the success of this internship project and will be vital to the success of any initiative that is developed within the group supply chain management group. The influence of group supply chain management within the local sights must be cultivated through the building of trust, data driven decision making, and the development of value added tools and policies for the local logistic managers.

7.1.3 Cultural

The cultural perspective takes the view that people in organizations take action as a function of the meanings they assign to situations. In organizations culture is a way of life; it is a summation of the norms of a company, the customs and laws of the region, the role models and beliefs of the workers, and especially the historical experiences of the organization and the employees. Cultures develop over time as organizations solve important problems, pass on their traditions, and develop shared symbols, stories, and experiences. Underlying the visible aspects of culture are a set of articulated attitudes and beliefs. Culture in an organization is “what we do around here and why we do it.” From a cultural perspective, organizations are social systems in which people must work and live together, and, therefore, the management of meaning during an organizational change is as critical as the management of money and production. (John Carroll – 2002)

The most defining aspect of the ABB culture was a history and culture of autonomy, growth and overall success, which had permeated through the entire organization. This culture makes the employees proud to be working for such a great organization, but also complacent about continual improvement. This was a surprising culture, because only 2-3 years prior, ABB had nearly gone bankrupt. The company was saved only by a creative financial restructuring and elimination of non-profitable and non-core business units. Little has been done to increase productivity, streamline production, and manage costs. Very few companies emerge from near financial doom with the complacency of ABB.

An example of this complacency and ambivalence toward cost management comes from the travel commodity group, and specifically from hotel management. A particular hotel in Zurich, which was very close to the corporate headquarters, charged ABB employees, who were traveling to headquarters, different rates, some of which were actually higher than the normal rate. The reason for this is twofold. First, the hotel had considerable experience dealing with ABB, and understood that ABB was disorganized to the point that ABB employees wouldn't know or care that they were being charged higher rates. Second, they knew that ABB could do nothing about it, because every employee makes their own decisions on which hotel to stay in, and are not held accountable to anyone. That being said, ABB spent 400 million dollars last year on travel related expenses, a considerable portion of total profits.

In addition, this feeling of complacency and ambivalence was inadvertently supported by the company's website, which never articulated the tough competitive environment and financial difficulties that ABB

was having. Although this reflects the culture of continuous success, by not focusing on the fact that they were closing plants around the globe and losing ground to competition in terms of costs, ABB corporate wasted a very powerful coordinating device. Employees of ABB may have changed their complacent behavior if they were openly threatened with competition and potential plant closures. In his book “Only the Paranoid Survive”, Andy Grove, the former CEO and Chairman of the Board at Intel Corporation states that fear is not always negative and is a great motivator. Intel, on its intranet, consistently has news about AMD and Samsung to remind the employees that the competition is ever present. It is worth noting that ABB did close 2 transformer facilities in the 6 months that the thesis author was there, but this seemed to have little effect on the attitudes of the autonomous local sites in Figeholm, Sweden, Brilon, Germany and Monselice, Italy, because they never felt the threat.

Another strong culture in ABB was that of hierarchy. In Zurich there was a very structured hierarchical culture, with the CEO and Vice Presidents on the 5th floor, and the outsourced IT people and the travel people on the bottom floor. In the course of the six months in Group supply chain management the group was moved from the 4th to 5th floor at corporate, which prompted a quip that “supply chain was getting more important at ABB”.

The difference between the cultures in Zurich, at the company headquarters, and at the local sites was striking as well. Employees in Zurich were known to rotate in and out of headquarters from the local sites every two to three years, whereas the employees at the local sites were sometimes in the same position for 20 years. The length of time in the same position led to an aversion to change with the attitude of “we tried it before and it didn’t work, why should we try it now?” In addition, because of European labor laws it was nearly impossible to remove an ineffective or uncooperative employee from a position. When trying to rapidly change the culture of an organization, sometimes the people that were unwilling or incapable of changing have to be either moved to a different area within the organization or removed. This was impossible in the case of ABB.

Each of the local sites was different, some acting as if they had something to prove, whereas others just existed day to day. Some had a strong evidence of a lean manufacturing culture, whereas other sites stockpiled finished inventory. The sites were very different, both in process and culture, and spoke a myriad of languages. For example in the worker’s bathroom in Italy there was no toilet, just a hole in the ground, whereas across Germany and Switzerland the facilities were equipped with porcelain. Each site was intrinsically different, with its local values, its local processes and its local customs. This fact also slowed cultural change as the local organizations desired to maintain their individuality. A common thread throughout all units was a good command of the English language among the managers.

To combat complacency, the Supply Chain Management Group was using a data driven approach. In the past, ABB was not focused on the numbers, and it took considerable effort to figure out how much a local site was spending on transportation and logistics. Supply inventory was maintained at a level such that it never interfered with production. Electricity costs, transportation costs, hotel costs, phone costs, even inventory costs were not measured and were not known. The first step in this transformation to a data based supply organization was to begin to collect the data. The second step was to analyze the data and decide which data will be measured. Once critical data is measured regularly the supply organization would arrange itself around the desired metrics and indicators.

In summary, the overwhelming culture at ABB was one of historical success and complacency. One way to slowly change the culture was to begin collecting data from the local sites and showing this data to everyone in the company. A second way would be to monitor expenditures and hold individuals accountable. Fear was a very effective coordinating device, and could prompt a change in culture by closing factories and threatening to close more, or firing ineffective or uncooperative workers. However,

in order to protect its culture of success and its image of a resilient company in the financial markets, ABB seemed unwilling to take such actions.

7.1.4 Summary of the Three Perspectives

To summarize this section, the top four insights from each of the three organizational processes perspectives are summarized below in Table 3.

Table 3. Summary of top four insights from the three OP perspectives.

Strategic Design	Political	Cultural
ABB had historically encouraged an autonomous structure with each unit responsible for profit and loss.	Three sources of power – Formal position, informal networks and data	ABB had a history of growth and success which had led to complacency
The matrixed structure of the supply chain organization led to competing objectives	Formal position provided initial contacts within the local units, but drew skepticism as the project initiated in headquarters.	The complacent culture of ABB was unchanged by the near bankruptcy in 2001/2002.
Local sites had limited accountability and group supply chain had very little control	The development of informal networks allow for much greater influence within local sites to garner commitment and support.	The corporate headquarters was very hierarchical with the CEO and VPs sitting on the top floor.
Although a project champion existed for transportation, none existed for electrical energy and the vacuum of coordination and leadership will hinder further progress	The acquisition and possession of supply chain data yielded tremendous clout and power to the group level supply chain organization.	Local sites all have unique cultures and customs and speak many different languages. At local sites, employees stay in positions for decades, creating an aversion to change.

7.2 Virtual Teams and Cross-Site Projects

At this point, I think that it is valuable to discuss the implications and challenges of working with local individual contributors on projects with global visions. It is short-sited to not consider each team member’s competing local responsibilities and priorities as well as personal interests in trying to sell and eventually implement a globally beneficial solution. The objective of this chapter is to educate the reader on the challenges, pitfalls and success stories of working with local individuals to accomplish global objectives.

7.2.1 Competing Responsibilities in Global/Local Relationship

A perfect example of competing responsibilities was seen with the thesis author’s work in managing the electrical energy commodity team. The core mission of the electrical energy commodity team was to reduce the amount paid per kilo-watt hour consumed by the country’s operations. One method was to renegotiate contracts, another method was to reduce total electrical energy usage or to reduce on-peak usage, and a third possible solution was to change suppliers in open markets to use one with more competitive costs. The team member from Spain was very eager to reduce electrical energy costs by switching suppliers from one that was charging a large premium over the competition. However, ABB is a major supplier to utility companies, and this particular electrical energy provider was a large ABB

customer. It seemed preposterous to the supply organization that a mature energy company would make large capital expenditures decisions and select equipment suppliers based on whether or not their suppliers purchased their energy. However, the country sales manager refused to let the local energy manager change energy suppliers and reduce overall ABB costs out of fear of losing a large customer. Competing priorities of the local and global organization often face off, and at ABB, the local autonomous organizations have the final decision. Thus, ABB continued to pay an outrageous premium for electrical energy.

As Jan Klein states in her work on virtual teams “A classic tension between differentiation and integration is played out between local and global perspectives within the globally dispersed teams.” This tension was exacerbated by the fact that ABB’s strategy to manage the global business at a local level allowed the decision making ability of the local sites to trump that of the global team. This tension was also apparent when working with the logistics managers to spend considerable time gathering data for the transportation optimization project instead of managing the logistics at the local sites. A key challenge to the project was to demonstrate how each local site would benefit from the global transportation optimization. A key challenge to the thesis author was not to take for granted the importance of every conversation, e-mail and site visit with each and every logistics manager. There was a tendency to gloss over questions by local site managers and give quick answers when time became critical. This tendency was counterproductive and only led to further delays and decreased interest in partnering on the project.

In addition, research has showed that dispersion has no impact on performance outcomes for teams working on high priority activities, whereas co-located teams perform better on projects with lower level tactical or strategic importance. (Jan Klein, 2001) Because the team of logistics managers was distributed among the local sites, it was a challenge to the thesis author to increase the importance of the project in the minds of the local sites. An effective way to accomplish this was to have the project champion, the vice president in charge of global supply chain management, send an e-mail to the manager of the local logistics managers. This act increased the priority level of my activities by connecting the outcome of the optimization study to an interest of the VP in charge of supply chain management, increasing the level of commitment from the local sites.

Although personal rapport and common interests helped to gain initial buy-in, ultimately, accountability and incentive systems influence the level of support by the local team members. (Jan Klein, 2001) In order to successfully lead at the local level from a position in corporate headquarters, the global supply chain organization needs the ability to hold the local site managers accountable, and must have the ability to influence the employee’s incentive system. Initially, at the on-set of the project, the global supply chain management group was in a strategic and support function and not directly linked to the country and local logistics managers. Solidifying this link must be a key priority of the group moving forward.

7.2.2 Total System Perspective

Essentially, the coordination of virtual team meetings and goals, the learning of local customs, and the overcoming of cultural and language barriers required the investment of additional time that slowed the progress of the project, but allowed for the building of trust and understanding that eventually led to the successful project analysis. The model for “Global Local Relationships” (Jan Klein, 2001) helped to the thesis author better understand the challenges that virtual teams present and how to successfully mitigate the challenges to produce a successful and accepted result. The model is as follows:

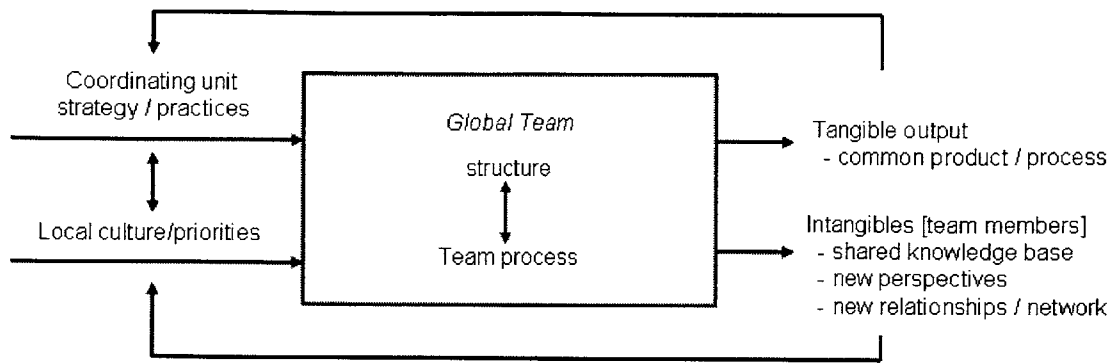


Figure 37. A systemic view of the Global Local Relationship

“For globally dispersed teams, one of the key “products” is shared knowledge and expertise.” (Jan Klein, 2001) There were three key products from the global / local stakeholder teams on the transportation optimization project:

- A valuable working relationship with each member of the team. As relatively new employees, the members of group supply chain management were relying on the relationships that the author was building with the local logistics managers.
- Accurate data to perform an effective analysis of the pan-European transportation situation, such that the results were be useful for the local sights
- Support from the local sites to pull the results of the study to the local sites.

7.2.3 Reconciling Global and Local Priorities

Reconciling global and local priorities was not a clear cut task, and often involved either constant intervention, or continuous interaction with the team to ensure that the global priorities were not being ignored. The level of task interdependence played a role in whether the team members could act independently or whether tracking and decision making had to be done in a collaborative manner.

An example of task interdependence in a global team was with the electrical energy commodity team. Each European country had rules and regulations which differed from the rest of Europe. In this case, it was unnecessary to meet as a team often because there was no need for alignment and shared decision making. However, there were important lessons learned that were shared with the rest of the members of the commodity team. Because of the relative interdependence of the tasks, a single meeting every quarter to a year was enough to effectively share lessons learned. If there was little commonality between the product or processes, coordinating decision making was a waste of time and resources for all parties involved. In these cases, local empowerment of decision making expedited the process and increased commitment from the local sites.

The following are the author’s recommendations for reconciling the disparity between global and local priorities on global virtual teams:

- **Incorporate global team activities into individual performance appraisals:** In the case of this project, the requirement of the global team was short-lived, but in the case of a full implementation of an optimized transportation solution, local support would be crucial. Thus the appraisals of local proponents driving the project would have to be adjusted to reflect their critical role in the success of the global project

- **Co-locate global teams:** Research has shown that if team members are further than 5 meters away the amount of communication between them drops considerable. Stairs make matters worse. However, it was not feasible by the nature of their role to bring local members to global headquarters. Thus, it is important to have short but standard meetings to keep open the lines of communication. This would also help to reduce the budget for travel and hotels which was unbelievably high.
- **Increasing Project Priority:** If a project is high priority, research shows that dispersed teams will still be successful. Thus, it is important to figure out which projects are critical, prioritize them correctly, and then match the team structure with the priority level, keeping less priority projects away from globally dispersed independent teams.
- **Regular team meetings and reporting:** Regular team meetings help to show the local team members that this is a project in which support or progress must be made weekly. In addition to regular team meetings, regular reporting to a high manager will show the team that this was a project of high priority and visibility, lessening the negative effects of dispersion.
- **Face to Face encounters:** The expense of traveling is often limiting, but little can substitute the commitment signaling effect and intrinsic value of a face to face encounter regarding a project. The local sites will get the message if a project is important enough to have people travel to the local sites to ensure that it is on track. In addition, there is no substitute for the rapport building effect of a face to face encounter.

7.3 Project Leadership Analysis

The purpose of this section is to evaluate the leadership role of the author within two projects: the trucking optimization project and the electrical energy commodity team. With little guidance, scope, and managerial input the author conducted an analysis of ground transportation and managed the group level electrical energy commodity team. The first section will discuss tactics involved in aligning the organization behind the transportation optimization project. This project was an analysis, and promised no concrete savings for the local organizations, but the author needed considerable cooperation from the local units in order to gather the data to proceed. The second section will discuss the author's style of leadership of the electrical energy commodity team.

7.3.1 Influencing the Organization

When one of my colleagues expressed frustration with the fact that he did not have the formal power to “make” people in the organization use a very creative and powerful tool that he had developed, his manager responded by saying, “Getting someone who you have no formal control over to do something that you want them to do is the essence of leadership.” Exploring this aspect of leadership involved understanding not only the organization, but the aspects of influence that one can and can't control. With limited formal power and informal networks, the group supply chain organization and the thesis author had to use other forms of influence to garner support for data gathering and implementation of projects. In this section various methods used to gain influence will be discussed and related to experiences in both the supply organization and the thesis author's specific projects.

In a paper “Harnessing the Science of Persuasion” and his book, *Influence, Science and Practice*, Robert Cialdini has explored six different principles that one can use to increase one's level of influence and assist in persuasion. In Cialdini's words, “...in a world where cross functional teams, joint ventures and inter-company partnerships have blurred the lines of authority...persuasion skills exert far greater influence over others' behavior than formal power structures do”. Cialdini discusses six fundamental

principles of persuasion that he believes can be mastered and applied to increase one's level of influence in an organization:

- Principle of Liking – People like those who like them back
- Principle of Reciprocity – People repay in kind.
- Principle of Social Proof – People follow the lead of similar others.
- Principle of Commitment and Consistency – People align with their clear commitments
- Principle of Authority – People defer to experts.
- Principle of Scarcity – People want more of what they can have less of.

As it suggested above, people like those who like them back, but the key to utilizing the principle of liking was to uncover real similarities and offer genuine praise. Similarities drew people together, whereas praise was a reliable generator of affection which both charms and disarms. The key was to establish the bond early in the relationship and find similarities early because it created a presumption of goodwill and trustworthiness in subsequent encounters. This principle was often used to open relationships with the local logistics managers. After reviewing of the previous year's logistics numbers, if the numbers were positive the author would congratulate the local site managers for their hard work and inquire as to what actions they had taken. In addition, the author would focus on similar interests and ideas, such as reducing transportation costs, and this would usually establish a solid working relationship.

Reciprocity was critical and often employed to acquire any specific data from the local logistics managers. People repay in kind and it was very important to give what one wanted to receive. For example, travel to many of the sites was necessary to assess the logistics situation and to gather data, but instead of simply asking for time and information, the author would bring a software package that was developed by one of my colleagues in group supply chain that would save the local contacts both time and money. This software was used to open up meetings and considerable time would be spent in training. In return many of the local sites were eager to dig for considerably more data than was had asked for.

Social proof was the idea that people will follow the lead of similar others and that peer power was considerably more effective at persuading individuals. Because there was not enough time to sell the project to everyone in the organization, a specific few key players were focused upon. After they were convinced, the support of the key players was used to garner support of other individuals in the organization who respected them.

From research and experience it was clear that people align with their clear commitments and so it was very important to make their commitments active, public and voluntary. Considerable digging and time was involved in gathering extensive data for the transportation project and it was not clear whether the sites would offer their support. Initially a small, short survey was sent around and nearly every contact completed. This survey created a small hook which influenced their future decision to help with the project further.

The principle of authority implied that people defer to experts and, thus, it was critical to expose expertise, but in a humble manner. To leverage this principle, the author would listen to the issues facing the local logistics managers and would give anecdotes of other companies that have solved the problem based on experience or academic study. If an anecdote was relevant and of value in lending insight to a particular issue, they were appreciative and usually more apt to discuss further. In addition, a more subtle attempt at exposing the author's expertise, was wearing my MIT ring. By wearing my ring, but never mentioning MIT, the author was able to influence those who knew about MIT in a positive manner, while not offending those who would see my mention of MIT as conceited and condescending.

The final principle of influence is Scarcity. People tend to want more of what they can have less of and are more apt to act if clearly shown what they have to lose by inaction, as opposed to what they have to gain by action. “Loss language” was a powerful tool and had been shown to be very effective in motivating action. In conversations with the local logistics managers information would be presented on the amount of money that they lost last month by not using particular software that was designed to save them freight costs. Nobody liked to lose money and this persuaded a number of them to use the software to avoid further losses.

Deceiving, tricking or manipulating colleagues will never be productive. However, it was valuable to understand the principles that were effective in influencing and persuading others. In addition it was worth noting that these principles of influence were much more effective when used in tandem with one another. For example, before traveling to local sites the thesis author would increase commitment by having the logistics managers agree that they would have the necessary data available. Then the author would travel long distances, showing the author’s commitment to meet with local contacts, and would initially sit down for tea with them, in an attempt to build rapport and liking. Before asking for information, the author demonstrate the software that the group supply chain organization had developed, inviting reciprocity, and highlight how much money the local organization lost last quarter by not having such software available, utilizing the scarcity principle. These principles combined were used very effectively to persuade the local contacts to spend considerable amounts of time acquiring the data that was needed to complete the transportation optimization project.

7.3.2 Distributed Leadership

One of the responsibilities of the thesis author was to manage the European electrical energy commodity team; a team formed of country representatives from the top nine spends of electrical energy across Europe. Each representative had different experience in the position, knowledge of their markets, and had multiple local responsibilities that often conflicted with the development and implementation of strategies at the country sites. Negotiating the responsibilities of local stakeholders to global commodity team was a challenge as was reconciling the differences in experience level and discipline among the country representatives.

Because of the vast difference in experience and industry knowledge, the thesis author utilized a distributed leadership style. At the onset of this project the thesis author knew very little of the regulations and restrictions of the European electrical energy market, and this proved to the thesis author that although it was useful in building credibility, it was not a necessity to be all-knowledgeable about the subject one manages. In Leadership and the One Minute Manager, Ken Blanchard describes four basic styles of leadership which should be employed for different tasks and employees:

- Directing
- Coaching
- Supporting
- Delegating

The purpose of directive leadership was to provide specific direction and closely monitor task accomplishment. Words associated with this behavior were structure, organize, teach, and supervise. It is described as largely one-way communication where one person was told what to do and their progress closely monitored.

The purpose of coaching was to build continued autonomy. Using this technique, the leader continued to direct and closely monitor task accomplishment, but also explained decisions, solicited suggestions, and

supported progress. The leader still ended up making the final decision, but solicited input from those who he was coaching.

By supporting, the leader facilitated and supported people's efforts toward task accomplishment and shared responsibility for decision-making with them. This technique implied a level of experience, autonomy and trust in the employee to make responsible decisions.

Delegating was where the leader turns over the responsibility for decision-making and problem-solving to others. Delegating was only an effective technique when employees were highly experienced at the task, highly capable, and highly motivated to bring about the correct result. Using a delegating technique to an experienced employee on a task to which they are inexperienced, such as bringing an experienced engineer into management with little direction, was not found to be effective.

The top 9 electrical energy spends across Europe were in Sweden, Norway, Finland, Germany, Switzerland, France, Italy, Great Britain, and Spain. From the first meeting it was clear that there were two regions that stood out as far as organization, concrete goals, and a sound plan to reach the goals. The country managers for these regions were very experienced, creative in their approaches to cost savings and successful at executing on promised savings. A delegating style of management was chosen with these managers. For the rest of the group directing and coaching was required to provide a careful definition of the current state within each country, as well as a detailed picture of the critical events and actions that affected each region. It was necessary to collect pertinent data, set attainable goals, and learn more about the industry. Much of this could be done in-house, but as there was little expertise within ABB about the consumer electrical energy market, consultant firms were interviewed and selected for partnerships with various sites.

After 6 months, the electrical energy commodity team, which had been without focus, now had concrete goals and actions to be performed by each member to attain the overall goals. One page updates were put together to quickly and visually update management as to the progress of each team member. Effective data and progress reporting was a key aspect of virtual teams and of global leadership. These one page summaries turned out to be a very powerful tool; an example of one was attached as Appendix B.

This 1-page update provided management with a visual update in the bottom left corner. With a quick glance upper management could see if the group was on-track. Also in this update were the country managers, current status of the country spend, rapid developments that were affecting the local electrical energy market and a vision with quantitative next steps for the next 120 days. The documented contained agreed upon goals and next steps that were co-developed were very effective in focusing the team members and holding them accountable to the global commodity team.

7.3.3 Leadership Insights

This project was successful at completing the transportation optimization analysis, and at creating discipline and alignment with the members of the electrical energy commodity team. New leadership insights were formed mostly in the project alignment and championing areas, as previous experiences were mostly in the project implementation area. Therefore, a few dimensions were added to the thesis author's personal leadership skills and enhanced the dimensions already developed before LFM. The following leadership behaviors characterize the leadership techniques learned and developed by the author while working in group supply chain management in

- **Leading by Influence** – “High level leaders are often differentiated by their ability to affect change within an organization” – (Ed Sullivan, Cases in Supply Chain class). Without an

informal network in place, influence within an organization can be a challenge, but was not impossible. Cialdini proposed six very effective ways to build support and persuade different levels of the organization to offer their support.

- **Leading Ears First** – Listening was the first key attribute of any leader, and not just hearing, but listening to the concerns, ideas, challenges, and desires of each member of the team. The first and most effective technique to garner support was not to evangelize a project, but to listen to understand the problem and the challenges, and then explain how the project alleviated the problem and addressed the challenges facing the organization. This technique was utilized often when dealing with the electrical energy commodity team. In each region there were different policies and rules that govern the purchase and distribution. The author listened extensively to understand the local electrical energy markets before mentioning solutions.
- **One-Page Reports** – A one page report that was created and committed to by all the stakeholders was an incredibly powerful tool. It created alignment within global teams and was a simple document which everyone can read and understand. This had not always been the case at ABB. Often outside consultants have created 50 page update presentations which were not concise and were not read or reviewed by much of the organization.
- **Be Responsive to Concerns and Improvement Ideas** – If someone comes to a leader with a concern or improvement idea for a project, the leader should quickly evaluate it, try to implement it if possible, and then tell the employee the actions taken. If the idea is not implemented, the leader must still make sure to explain the reasons for this to the person who generated the idea. Quick responses to ideas will make employees much more receptive to what a leader is doing, especially at the start of the project.
- **Be Nice and Take Time to Learn the Capabilities and Limitations of Coworkers** – Leadership was actually about people. It was critical as a leader to know colleagues, to care about their lives, and to inquire about their job satisfaction. To be an effective leader, one needs to get to know people first and learn what interests them, what they are talented at, and what they are aspiring to. It is important to build relationships and understand the people in the organization before they are needed. If a leader cares about the people in the organization as much as he/she cares about implementing projects, the leader will find it is actually easier to affect lasting change.
- **Distributed Leadership Techniques**– A leader must learn the capabilities of the people around him to know when they have the skill and the confidence to correctly complete tasks, and when they need guidance. Even the most experienced people need some guidance when performing new tasks. It is the responsibility of a good leader to provide coaching or direction or to find someone within the organization, or outside the organization who can to enable the people around him to be successful.
- **Commit to the Small Conversations** – This technique was identified by Matt Vokoun in his thesis and was an extremely important factor in project success, especially in the European environment. At corporate headquarters every morning there would be a gathering of people drinking coffee in the kitchen. The author was not much of a coffee drinker, but by committing to these everyday conversations, the author learned much about the culture of the company, and was often given very important contacts in the local units. Leadership in an organization requires a commitment to the thousands of daily five-minute conversations rather than the one, big-

audience, hour-long formal presentation. The people who need to really adopt the project were rarely in the conference room with the leaders for the presentation. They were the people the leader talks to for a few minutes every day.

- **Commit to Answering E-mails Clearly, Concisely and Completely** – In the virtual environment of leading teams and coordinating data collection from corporate headquarters, the answering of short e-mails was the MOST IMPORTANT factor in my project's success. The author would normally spend at least a third of every day crafting clear responses to e-mails regarding concerns and clarifications. This behavior showed to others the commitment of the thesis author to the project and avoided the project going into limbo for the local contacts

8 Conclusions

This chapter ties together the results and discussion of the preceding chapters, highlighting the key conclusions of the thesis. The chapter also offers some perspectives on how the research completed with ABB can be applied generally to any engineering led organization that is struggling with the challenge of changing corporate culture to one of frugality and cost management.

Engineering focused companies often find difficulty in managing costs. As the innovations begin to slow and key products are commoditized these companies often find themselves far behind their competition from a cost perspective and quickly lose margin and market share. Shifting the organization towards one of cost awareness is a difficult and slow task. Large cost cutting initiatives start the process, but changing the mentality and culture of a supply organization involves more than shifting the factory footprint, reducing inventory, and taking away the free pots of coffee.

This thesis emphasized the need for engineering companies to manage commodity costs and described different activities performed within ABB to change the mentality and the culture of the supply organization from one of cost acceptance to one of cost awareness. The challenges in managing the indirect commodity spend at ABB were outlined and the need for modeling and data driven decision making to control costs and quality were shown. The difficulties and learnings from the modeling and optimization of European ground transportation were discussed in the context of using creative thinking to reduce organizational costs. The transportation optimization, combined with the management of the electrical energy commodity team and the development of cost models, was performed to challenge the complacent mindset toward managing commodity costs and to effect organizational change.

In summary, the key conclusions of this thesis are:

- **Leading cultural change begins with a strong vision, a commitment to the organization, and action** – Large organizations are similar to large ships, they do not turn quickly, but you cannot even begin to steer them until they start moving forward. Cultural change is a slow process which begins with a strong coordinating device and a vision for a brighter future. Small projects and successes prove the value of the vision and will gain momentum for the overall change. Start small with training, pilots and studies, but most importantly, start!
- **Optimizing transportation costs is only the tip of the iceberg.** – Optimizing the supply chain involves optimizing transportation, inventory and manufacturing. Transportation is only a small portion of the overall costs and cannot be drastically improved without changing inventory management policies and manufacturing. In addition, optimizing transportation in isolation of inventory and manufacturing costs will create a sub-optimal and costly system.
- **Even the best solutions have limitations.** In the highly globalized manufacturing structure of today's multi-national corporations, there are very few logistical solutions that are applicable in all regions. Thus, global solutions become extremely difficult to implement with highly variable returns. Start small and local, but standardized. Develop solutions that could be implemented locally but integrated globally.
- **Accountability begins with alignment to a vision and commitment to goals.** – Official accountability will not always exist in matrixed corporate structure with global virtual teams. However it is important to have all members of the team aligned to a common vision and working

to achieve it. The development of team goals in a group format will help to facilitate alignment, and local commitment to these goals will allow for local accountability.

- **Data is a source of power and influence within organizations** – From this project it became very clear that data was a source of power and influence in engineering led organizations. It is tough to argue with the numbers when you do not have visibility to them. Thus, when new to an organization, build access and visibility to data along with a network to increase the level of influence within an organization.
- **Leadership of virtual projects requires a commitment to the small conversations.** – True leadership is all about the thousands of daily five-minute conversations rather than the one, big-audience, hour-long formal presentation. Answering e-mails quickly and clearly is important to maintaining project momentum with virtual teams. In addition, there is no substitute for an initial face to face visit when working on virtual teams.

In closing, ABB was not alone on its transition from an engineering led company relying on technological superiority to a cost conscious company that manufactures commodity-like products. The transition was occurring slowly, but momentum was building through strong and aligned leadership and with the creation and application of cost models, optimization studies, and material outsourcing. The knowledge created by this thesis was now available to the broader scientific community, with the hope that it can provide a positive impact on the ability of engineering led organizations to navigate the perilous territory of cost management and cultural change.

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9 Bibliography

- Adamson, Ian. Runner's World Guide to Adventure Racing, How To Become a Successful Racer and Adventure Athlete. St. Martin's Press, 2004.
- Ancona, Deborah G., Thomas A. Kochan, Maureen Scully, John Van Maanen, and D. Eleanor Westney. Organizational Behavior & Processes: Managing for the Future. Cincinnati: South-Western College Publishing, 1999.
- Armstrong, Lance. It's Not About the Bike, My Journey Back to Life. New York: A Berkley Book, 2001.
- Blanchard, Kenneth. Leadership and the One Minute Manager. New York: William Morrow and Company, Inc. 1985.
- Carroll, John S.: Introduction to Organization Analysis – The Three Lenses, MIT Sloan School of Management Working Paper, 14, 1-13. Sloan Communications Office
- Carnegie, Dale. How to Win Friends & Influence People. New York: Pocket Books, 1936.
- Christensen, Clayton M. The Innovator's Dilemma. New York: Harper Business School Press, 1997.
- Cialdini (1993): Commitment and Consistency, Influence – The Psychology of Persuasion, 57-113. Quill (William Morrow & Company, Inc.)
- Covey, Steven. The 7 Habits of Highly Effective People. New York: A Fireside Book, 1990.
- Cross, R. Nohria, N. and Perker, A.: Six Myths About Informal Networks – and How to Overcome Them, MIT Sloan Management Review, p. 67-75
- Daniels, William R. & Mathers, John G. Change-ABLE Organization, Key Management Practices for Speed and Flexibility. California: ACT Publishing, 1997.
- Fine, Charles H. Clockspeed, Winning Industry Control in the Age of Temporary Advantage. Massachusetts: Perseus Books, 1998.
- Gladwell, Malcolm. Blink, The Power of Thinking Without Thinking. New York: Penguin Books, 2005.
- Johnson, Spencer, M.D. Who Moved My Cheese? New York: Penguin Putnam Inc. 1995.
- Klein, Janice & Barrett, Betty(2001). "One Foot in a Global Team, One Foot at the Local Site: Making Sense out of Living in Two Worlds Simultaneously", *Advances in Interdisciplinary Studies of Work Teams, Volume 8: Virtual Teams*, M. Beyerlein and D. Johnson (eds), p. 107-125.
- Klein, Janice & A. Kleinhanns (2003). "Closing the Time Gap in Virtual Teams", *Virtual Teams that Work*, C. Gibson and S. Cohen (eds.), Jossey-Bass
- Lewis, Michael. Moneyball. New York: W. W. Norton & Company, Inc, 2003.
- Munter, Mary. Guide to Managerial Communication. New Jersey: Prentice Hall, 1987.

Packard, David. The HP Way: How Bill Hewlett and I Built Our Company. New York: HarperBusiness, 1996.

Pfeffer (1992): Decisions and Implementation, Managing with Power – Politics and Influence in organizations, 3-31. Harvard Business School Press

Simchi-Levi, David. Designing and managing the Supply Chain. Singapore, McGraw-Hill Book Co, 2000

Westney, D. Eleanor. “ABB: From Icon to Crisis”, MIT Sloan School of Management.

Wikimedia Foundation. “ABB” Wikipedia Dictionary. February 2005. <
http://en.wikipedia.org/wiki/Six_Sigma>.

10 Author's Biography

The author is a native of Newton, New Jersey and graduated from the Rensselaer Polytechnic Institute in Troy, New York with honors and a BS Chemical Engineering Degree. From 2001 to 2002, he worked in the rotational engineering program within Intel Corporation in Phoenix, Arizona. His assignments included three month rotations in a processor manufacturing clean room, a metrology research laboratory, and in logistics. From 2002-2004 the author worked as a photo-lithography process engineer on the Pentium and Itanium processor lines. In addition he drove automation projects on the SystemX team, the first process team devoted to increasing quality and efficiency through factory-wide automation processes.

In 2004, he enrolled in the Leaders for Manufacturing (LFM) at MIT for his MBA and MS Electrical Engineering, sponsored by Intel Corporation. Upon graduation from MIT in June 2006, the author will return to Intel Corporation and work in manufacturing and supply chain management. The author can be reached at his permanent email address – jweinstein@sloan.mit.edu.

11 Appendix A: Milk Run Model Example for Spanish Factory

Milk Run 1							Milk Run Summary Data		Decreasing Handling / kg	Straight Line LTL cost / km
Initiating Supplier	Destination Supplier	Mileage (km)	Critical Load Factor	Fill Factor (24000 kg)	LTL cost premium for savings	Straight Distance to Factory, km	Distance	Load Factor		
11	4	2.6	2000.0	8.3%	1.7	312.5	354.4	23000.0	\$51.218	\$0.000
4	18	304.8	14000.0	58.3%	1.2	310.6			\$84.437	\$0.408
18	13	38.5	4000.0	16.7%	1.5	30.3		95.83%	\$63.049	\$0.117
13	0	8.5	3000.0	12.5%	1.6	8.5			\$58.138	\$0.038
0	0	0.0	0.0	0.0%	0.0	0.0			\$0.000	\$0.000
0	0	0.0	0.0	0.0%	0.0	0.0			\$0.000	\$0.000
0	0	0.0	0.0	0.0%	0.0	0.0			\$0.000	\$0.000
0	0	0.0	0.0	0.0%	0.0	0.0			\$0.000	\$0.000
0	0	0.0	0.0	0.0%	0.0	0.0			\$0.000	\$0.000
1. Savings on Mileage Costs (Cost / KM)							(Based on KM and Fill Factor)			
	Total km	Price per km	LTL / FTL Distance Multiplier		Straight Line Costs				Total Costs	
Original	661.8	variable (Fill Factor)	1		\$131.10				\$131.10	
with Milk Run	354.4	0.7	1						\$248.06	
Miles Saved	307.5							Savings	-\$116.94	
2. LTL Premium Above Straight Line							(Based on Suppliers and KG and mileage / supplier)			
	Supplier to supplier	Fill Factor	LTL cost premium (\$/kg times FTL)						LTL Premium	
11 -> 4		8.3%	1.72 x FTL cost						\$28.73	
4 -> 18		58.3%	1.23 x FTL cost						\$65.60	
18 -> 13		16.7%	1.53 x FTL cost						\$42.18	
13 -> 0		12.5%	1.6 x FTL cost						\$36.23	
0 -> 0		0.0%	0 x FTL cost						\$0.00	
0 -> 0		0.0%	0 x FTL cost						\$0.00	
0 -> 0		0.0%	0 x FTL cost						\$0.00	
0 -> 0		0.0%	0 x FTL cost						\$0.00	
								Savings	\$172.73	
3. Access Premiums and Handling Costs							(Based on suppliers and KG)			
Milk Run Savings			Added Milk Run Costs							
# of suppliers	Fixed access premium saved	Fixed Handling Fees	Savings Subtotal	Access Fee for Milk Run Truck	Additional Pickup	Handling Fees for Dropoff	Additional Fee Subtotal	Total Access and Handling costs saved		
4.0	\$200.00	\$513.69	\$713.69	\$50.00	\$256.84	\$92.91	\$399.76	\$313.93		
								Savings	\$313.93	
Total Cost Savings for Milk Run 1										
1. Savings on Mileage Costs (Cost / KM)		-\$116.94								
2. LTL Premium Above Straight Line		\$172.73		Cost / KM						
3. Access Premiums and Handling Costs		\$313.93		Constant Costs / shipment						
Total cost Savings		\$369.71		per week						
Gross Yearly Savings		\$17,746.24		per year for this shipment.						
less 15% expediting costs		\$2,661.94								
less 15% setup and maintenance costs		\$2,661.94								
Annual Savings		\$12,422.37								

12 Appendix B: Sample 1-Pager for Presenting Virtual Team Goals

Electrical Energy

Back Up

Team:

- xxx
- others TBD

Current Status:

- XX.000 MWH/year consumption
- XX factory sites, many project sites.
- \$X.X MUSD
- \$XXX.XX average MWH price
- PCMG saved \$50.000 performing invoice checking on 2 factories over last 7 years
- Working with X, using *Market Tracker* tool to set expectations in the volatile XX market which is highly dependant on fossil fuels
- Met with Carbon Trust to reduce energy usage (XX govt. funded)

Developments that could have an impact:

- Next contract in October 2006, but can purchase today
- 6 to 8 main XX sites are yet to have invoices checked.
- Carbon Trust will grant interest free funding to reduce power consumption.

Next Steps / next 120 days:

- Work with XXX and *Market Tracker* to determine optimal time to contract.
- XXXX will review invoices of additional sites (takes a couple of months to analyze sites and then more to claim money off power company.)
- XXX to perform free power and utility test to show where opportunities exist to reduce consumption and emissions.

TEAM ASSIGNED	STRATEGY AGREED	ACTION PLAN	SAVINGS ON-TRACK