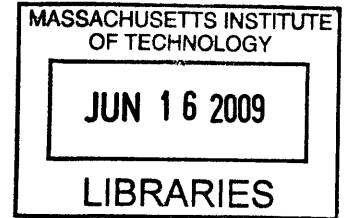


# CHINA PRODUCTION EQUIPMENT SOURCING STRATEGY

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

**Master of Business Administration  
AND  
Master of Science in Mechanical Engineering**

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## ABSTRACT

This thesis recommends a China business and equipment strategy for the Controls Conveyor Robotics Welding (CCRW) group at General Motors. The current strategy is to use globally common equipment through predetermined global suppliers. The GM facilities in China, which are jointly owned with non-GM entities, believe that a local sourcing strategy would reduce lead times, transportation costs and increase the level of nearby service and support. These factors are catalyst for GM to reevaluate the current global common strategy.

This thesis will provide an overview of the CCRW organization and discuss how the sourcing strategy has evolved through globalization. Due to the large variety of production tooling, this thesis will narrow the focus to two case studies: the first being a Main Control Panel (MCP) and the second being a weld controller. These case studies are used as a method to determine the pros and cons of the current sourcing strategy, where the MCP is a highly integrated design maintained by CCRW HQ and the weld controller is a “blackbox” which CCRW defines the functional specifications and procures “off the shelf” from a predetermined global supplier.

Through local China visits, literature review and preliminary cost assessments, it was determined that while local sourcing may be a viable option for both the MCP and weld controller, there is not enough determinate information to commit to a sourcing change in the case of the Main Control Panel. From onsite visits to potential MCP option suppliers in China, it appears that likely “local” arrangements exists, however, further company analysis and validation will need to be conducted to adopt the change. As for the weld controller, the local product variation with the current global supplier (based locally) is recommended and was validated by CCRW weld engineers by the completion of this internship.

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<sup>1</sup> The term “Local” will be used throughout this thesis to refer to “China,” meaning solutions that are derived from internal to China.

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Lastly, thank you to my family and friends for their love and support.

## ACRONYMS

Bill of Equipment (BOE)

Bill of Material (BOM)

Bill of Process (BOP)

China Compulsory Certificate (CCC)

Conformité Européenne (CE)

Controls, Conveyors, Robotics and Welding (CCRW)

Electrical Cabinet Standard (ECS)

Global Common Components List (GCCL)

Global Common Controls Hardware Design Standards (GCCH-1)

Global Manufacturing System (GMS)

Global Weld Standard (GWS-2P)

Human Machine Interface (HMI)

Input/Output (I/O)

Main Control Panel (MCP)

North American Common Components List (NACCL)

Programmable Logic Controllers (PLC)

Shanghai Automobile Industry Corporation (SAIC)

Shanghai General Motors (SGM)

Shanghai General Motors Wuling (SGMW)

Total Cost of Ownership (TCO)

Total Landed Cost (TLC)

Underwriter's Laboratories (UL)

Value Added Tax (VAT)

# INTRODUCTION

## 1 Introduction

This thesis recommends a China business and equipment strategy for the Controls Conveyor Robotics Welding (CCRW) group at General Motors. The CCRW group, Headquartered in Warren, Michigan, is responsible for the design and specifications of production tooling in vehicle manufacturing plants worldwide. The current production tooling strategy for General Motors is to use globally common equipment through predetermined global suppliers to take advantage of economies of scale. Over the past decade, General Motors has experienced growth in emerging markets, particularly in China. The GM facilities in China, which are jointly owned with non-GM entities, believe that a local sourcing strategy would reduce lead times, transportation costs and increase the level of nearby service and support. The pressure to reduce cost and increase speed and flexibility of supply chain operations continues to increase as the valuation of the dollar relative to the Yuan decreases and the cost of fuel and raw materials is escalating. These factors are catalyst for GM to reevaluate the current global common strategy.

This thesis will provide an overview of the CCRW organization and discuss how the sourcing strategy has evolved through globalization. Due to the large variety of production tooling, this thesis will narrow the focus to two case studies: the first being a Main Control Panel and the second being a weld controller. These case studies are used as a method to determine the pros and cons of the current sourcing strategy, where the Main Control Panel is a highly integrated design maintained by CCRW HQ and the weld controller is a “blackbox” which CCRW defines the functional specifications and procures “off the shelf” from a predetermined global supplier. Through almost one hundred interviews with subject matter experts in areas such as logistics, engineering and purchasing, a list of questions was developed for further investigation in the form of literature reviews, benchmarking and more interviews. Such questions include:

- **Automobile Industry Globalization trends:** What is the general trend for GM and globalization? Is China losing manufacturing competitiveness and does it makes sense for GM to remain in China?
- **Level of centralized decision-making:** Given the geographical distance between CCRW HQ in Michigan and the facilities in China, what is the appropriate level of control to

maintain over decision-making. Since Make-buy decision-making looks at in-house/outsourced decision-making, are there similar theories or outcomes that can be applied to the question of whether to retain control of drawings/specifications or to decentralize/loosen control?

- **Sourcing Matrices:** Similarly, the dispersed nature of the sourcing chain drives the question of level of control to retain in decision-making. What sourcing decision tools are available to determine the best method (local, regional or global) of supply chain?
- **Cost Models:** What cost models can be used in making sourcing decisions and what are the limitations. What are the concerns with transportation, taxes, and tariffs?
- **Supplier Relationships and Collaboration:** Are there solutions to ensure a win-win for supplier and buyer?

The lessons learned in attempting to answer the previous questions were then tied into the investigation for location sourcing alternatives. Preliminary cost assessments and on-site interviews in China, with both potential suppliers and local GM CCRW employees, were conducted. What was determined through local China visits, however, is that although the literature review and preliminary cost assessment indicate that local sourcing may seem to be a viable option for both the Main Control Panel and weld controller, there is not enough determinate information to commit to a sourcing change in the case of the Main Control Panel. From on-site visits to potential Main Control Panel option suppliers in China, it appears that likely “local<sup>2</sup>” arrangements exist, however, further company analysis and validation will need to be conducted to adopt the change. As for the weld controller, the local product variation with the current global supplier (based locally) is recommended and was validated by CCRW weld engineers by the completion of this internship.

First, this chapter focuses on CCRW HQ and will provide an overview of CCRW’s current global production tooling equipment strategy as it started from the original North America focus to the shift to global standards that aligned with General Motors Global Manufacturing System (GMS) initiative. This chapter will then describe CCRW’s decision-making process through Bill of Equipment (BOE), Bill of Process (BOP). Second, this chapter will focus on China, with a

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<sup>2</sup> The term “Local” will be used throughout this thesis to refer to “China,” meaning solutions that are derived from internal to China.

discussion on globalization trends in the automotive industry in recent decades, the GM China organization and its unique joint venture structures, markets, and products. Third, this chapter will summarize the problem statement and define the thesis goal. Fourth, and final, a methodology for the remaining chapters will be presented.

## **1.1 GM Global Production Equipment Strategy**

### ***Original North American Focus***

GM's Controls, Conveyors, Robotics and Welding (CCRW) Group, which is headquartered in Warren, MI, sponsored this project. The organization is responsible for the design and/or specifications of production tooling used in vehicle manufacturing plants. They provide oversight to GM facilities such as GM China which also houses full time CCRW engineers, and will be later be discussed in further detail. In 2000, the group completed its first attempt to consolidate the number of component suppliers used in North American operations. This list, known as the North American Common Components List (NACCL), was derived through the implementation of common equipment architecture to reduce design variations and the number of validations needed. Using open standards not only allowed increased supplier competition, but the volumes from standardization drove down cost.

### ***GM's Strategy Shift for Global Standards***

As GM's global market greatly increased, particularly in Latin America and Asia Pacific, the company defined a standardized set of principles for the manufacturing process, called the Global Manufacturing System (GMS). Employees are trained in the same GMS elements and associated tools and methods such as the Bill of Process (BOP), Bill of Material (BOM), Bill of Equipment (BOE) and Manufacturing Footprint, which will be described in more detail later in this chapter. GMS can be compared to the Toyota Production System as a unified culture and way of thinking for the entire organization.

### ***CCRW Alignment with Global Strategy***

In alignment with the GMS, the vision of the CCRW organization shifted to becoming a global integrator of manufacturing engineering systems through the following:

1. Leveraging GM's size to reduce cost,

2. Enabling fast execution of global programs,
3. Adopting technical best practices worldwide, and
4. Increasing manufacturing flexibility.

All CCRW equipment engineered by the CCRW group has a set of established standards, which are published in a document called Global Common Controls Hardware Design Standards (GCCH-1). GM North America Manufacturing Center and GME International Technical Design Center sponsor the GCCH-1. As with any standards, the purpose is to provide clear and concise guidelines for designing the control hardware for GM CCRW systems. According to the GCCH-1, “The objective of these requirements is to provide lean, flexible and cost effective control systems that enhance both the productivity of the systems and the quality of the products produced. “Furthermore, the application of this standard shall result in common systems that:

1. Assures safe operation of industrial equipment.
2. Increases productivity of systems by increasing the mean time between failures (MTBF) and decreasing the mean time to repair (MTTR).
3. Introduces common systems to all areas of the manufacturing facilities.
4. Reduces tool construction costs.
5. Leverages engineering resources.
6. Provides flexible designs to accommodate changes to the product or process.

Any deviations from the specifications require the advanced written approval of the GM CCRW representative responsible for the project in question. Any approved deviations shall only apply to that specific instance, and it shall not be considered a change to the standard.

As part of CCRW’s mission, in particular to reduce costs through volume, the CCRW group created the Global Common Components List (GCCL), which specified global suppliers and pricing agreements for ancillary components. As part of the GCCL agreement, suppliers provided global pricing for all regions over a three-year minimum contract, with the inclusion on engineering support services. According to a CCRW study, the GCCL resulted in 35% savings over the NACCL and the common spare parts volume also resulted in a total MRO savings of 4.5 million dollars.

**BOE and BOP**

CCRW is involved at the various stages of decision-making equipment design as well as factory equipment requirements. Reviews, such as the Global Peer Review, are designed as a discussion forum for determining strategic goals. Reviews are triggered for reasons such as a Greenfield plant, a change in Technology, or a Bill of Equipment (BOE) change. The BOP (Bill of Process) and BOE (Bill of Equipment) are other processes critical to a global CCRW.

The BOP provides a globally common, balanced and documented approach for manufacturing and vehicle assembly. The BOP affects the build sequence, operation content, dimensional strategy, subassembly design strategy and major tool and equipment interfaces for the product. The BOP is globally common and does not change. The BOP does not prescribe specific equipment, level of automation, manpower or floor layout, which is described in the BOE.

The BOE describes nine different equipment sets including level of automation or manpower, system or cell layout and makeup or conveyance type, all dependent on labor rates and production volume (Figure 1.) As indicated in Figure 1<sup>3</sup>, General Motors Asia Pacific (GMAP) has differing requirements from General Motors North America (GMNA).

Production Rate (NWR) High Medium Low	7	8	9
	LAAM	GME	GMNA
	4	5	6
	LAAM	GME	GMNA
	1	2	3
	GMAP	GMNA	GMNA
	Low	Medium	High
	Labor Rate		

Figure 1: Nine Solutions Based on Labor and Production Rates. GMAP has differing requirements from GMNA as the labor rates are lower and the production rates are lower.

<sup>3</sup> SGM is higher labor and production rate than SGMW, however, GMAP still ranks at a lower box than GMNA.

With various vehicles being made in various regions, the CCRW creates and categorizes a list machinery and equipment purchased for every project and program. This corporate strategy allows GM to have a globally common BOP with nine different manufacturing solutions that allow GM to be competitive in all regions. Some of the advantages include driving regionally common processes and tooling strategies, which can improve cost, manpower and floor space.

This section focused on CCRW HQ strategy and processes. Section 1.2 will describe China in the auto industry, introduce CCRW in China and will discuss how they differ through Joint Ventures and the vehicles produced.

## **1.2 Automotive trends in Emerging Markets**

The automotive industry continues to experience growth in emerging markets, increasing from 20 percent of industry unit sales in 1997 to 38 percent in 2007.

Some key points regarding emerging automotive markets (Franks, 2008):

- 2007 was the sixth consecutive year of record sales for the global automotive industry – about 71 million units worldwide. In the next five years, it was projected that global sales would grow to about 84 million
- In 2007, 38% total industry global sales came from emerging markets
- In 2007, 59% of GM sales from outside the U.S
- In Q1 2008, 64% of GM sales from outside the U.S
- It is estimated that by 2012, 45% of total industry global sales will come from emerging markets

### ***GM in China***

In 2007, the Chinese market was the second largest behind the US, with GM volume of 1,031,974 million out of an industry volume of 8, 474,832 China has been successful in vehicles sales exceeding projections (Figure 2). Even with the economic crisis, which has resulted in plants closing and worker lay-offs, China has become the fastest growing automobile market in the world. In 2009, GM sold 665,000 cars and trucks in China, and according to an MSNBC report, “for now, only 1 in 100 Chinese own a car, compared to 9 in 10 in the United States (Alexander, 2006).

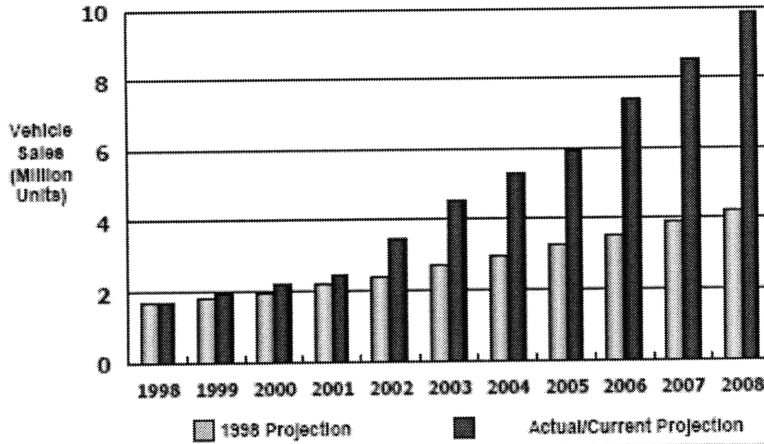


Figure 2: Vehicle Sales have exceed projections

Some of the factors driving industry growth include expansion of foreign brand portfolios, introduction of ambitious local brands, a downward pricing trend, making vehicles more affordable, and the rapid development outside Tier 1 cities. There is still a lot of room for growth within the domestic Chinese market. Only 1 in 100 Chinese own a vehicle compared to 9 of 10 in the United States (Alexander, 2006). As Figure 3 indicates that the vehicle density in China is expected to increase by 2015, exceeding developed countries such as the UK, Germany and the US.<sup>4</sup>

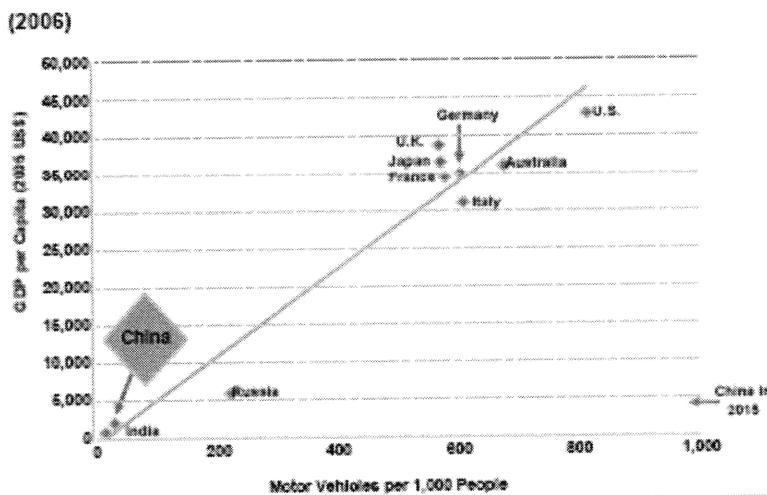


Figure 3: Very Low Vehicle Density in China

<sup>4</sup> Based on GM Internal Documentation

### *GM China and Joint Ventures*

In order for GM to be a manufacturing entity in China, the Chinese government requires a Joint Venture with a Chinese-based entity. GM has two main joint ventures (Figure 4), Shanghai General Motors (SGM) and Shanghai General Motors Wuling (SGMW). SGM is a 50-50 joint venture between GM and Shanghai Automobile Industry Corporation (SAIC), and was established in 1997. SGMW is joint venture, with 50.1% SAIC, 34% GM and 15.9% Wuling. CCRW engineers have a presence in SGM, SMGW and GM China. Although GM’s investment in China through the Joint Ventures has been profitable and necessary for growth, GM does not have full control over the decision-making.

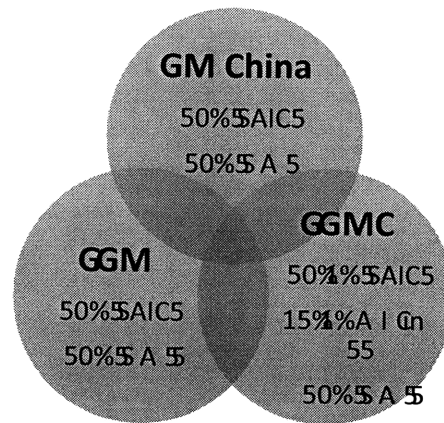


Figure 4: Joint Venture structure within China

As Figure 5 indicates, GM facilities are spread throughout China, and cover a diverse market. GM China, whose headquarters is in Shanghai, is designed to be the common communication link between the joint ventures, with the global headquarters and with external organizations. Although the common communication link exists, it was determined through interviews and local site visits, that differences in local market needs, culture and language quickly erode intended effectiveness of this communication hub.

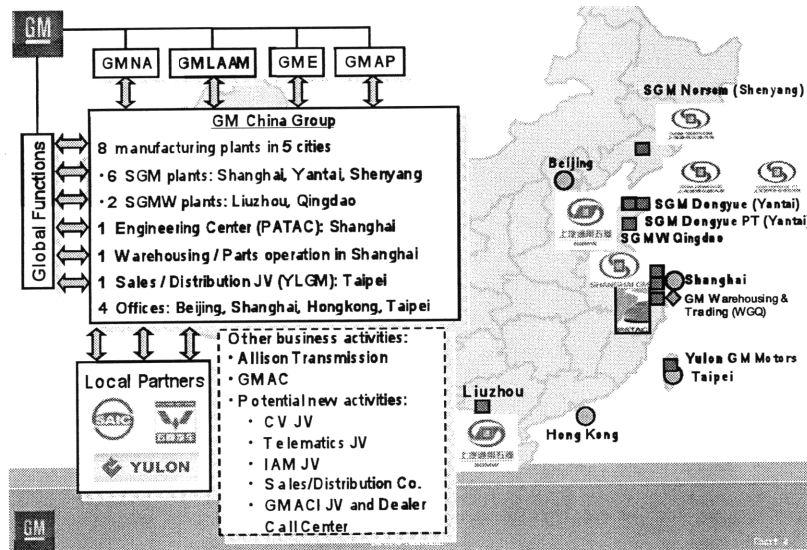


Figure 5: GM operates in a complex multi-plant, multi-partner environment in China.

### *Differences within Chinese Market*

During the course of the internship, site visits at various GM facilities within China were conducted in Shanghai and Liuzhou's East and West Plants. In the case of the SGM, whose most successful product is the high quality Buick (Figure 6) which sells for \$17,000 USD, the facility operates at a high level of automation (**Error! Reference source not found.**). The Buicks and other SGM products such as the Cadillac, offer luxury back-seat features which target the chauffeur-driven executives. The Buick and the Cadillac are a status symbol equatable with success.

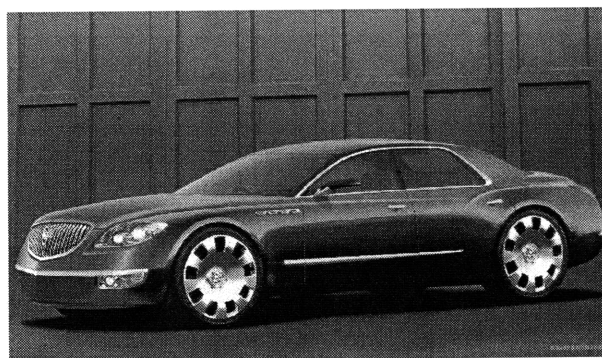


Figure 6: China's popular Buick

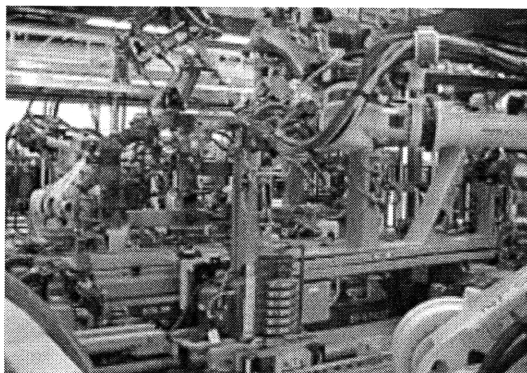


Figure 7: High Automation Facility

The Liuzhou facilities in southern China (Figure 8), on the other hand, manufacture the lower end commercial vehicles, rear box mini-vans, mini-passenger cars such as the Spark, and pickups such as the popular Wuling minivan (Figure 9) require a low level of automation and sell for \$3700 USD. These products are more closely aligned with the average Chinese income of \$3000 a year. At a cheap labor rate of \$4 per hour, which is half the rate of Shanghai, the company spends \$100 per vehicle on labor (Schiffers, 2007). The factory works three shifts and has room to grow as the Wuling division reported a 19% increase in January 2009 sales over the previous year (The MacGraw Hill Company, 2009).

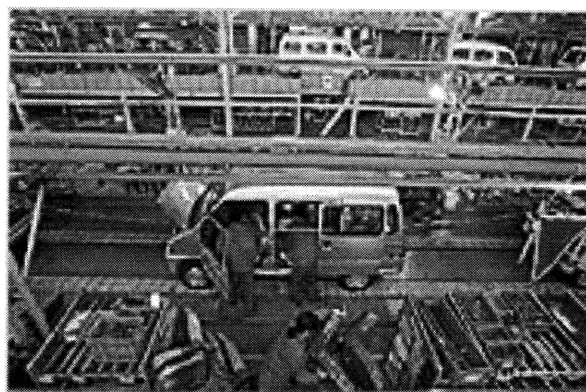


Figure 8: Luizhou Low Automation Facility



Figure 9: The Popular Wuling Minivan Built in Luizhou, China

The next section will summarize the problems that arise with developing a strategy that works for GMNA and GM facilities in China.

### 1.3 Problem Statement and Thesis Goal

Thus far, this chapter has discussed the role of CCRW HQ to design and specify production-tooling equipment. The current CCRW strategy involves the use of a global common components lists which specific suppliers. As GM has continued to expand in markets such as China, the growing resistance has also been felt. Part of the challenge with CCRW in China, is the control over decision-making is limited as these are part owned by Chinese Joint Ventures. Those in favor of changing the current method among local believe that regionalization will reduce lead times, transportation cost and logistics cost while increasing the level of nearby service and support. The opposing view, such as that of CCRW HQ, believes that a truly global supply base provides economies of scale and deeper pockets for establishing worldwide training and support. With cost drivers such as the devaluation of the dollar relative to the Yuan and escalating costs of raw material and the high cost of logistics and tariffs, it is essential for GM to adjust its sourcing strategy to effectively compete.

As a predecessor of this thesis, a study was conducted between CCRW and supplier A to determine if cost savings could be established through a local strategy. During this, subject matter experts within global and local CCRW and well as representatives from the supply chain organization, met with supplier A in Beijing for several weeks to discuss challenges and provide constructive feedback on areas of potential improvement on the Main Control Panel. The design of the Main Control

Panel, which is the brain of manufacturing cells, is determined and maintained by CCRW headquarters. Components dependencies increase the product complexity, making design and sourcing changes a challenge to CCRW HQ. Although there are cost benefits of sourcing the metal enclosure locally, there is resistance within CCRW to change the Main Control Panel design because of the component dependencies. This thesis will be a continuation of the previous study. The next section will describe the goal and methodology of the internship and thesis, which will provide a roadmap for the reader to navigate this thesis.

### *Thesis Goal*

The ultimate goal of this project was to recommend a business and equipment strategy for CCRW in China, which at a high level resulted in favoring local opportunities where they are appropriate such as the case of the weld controller where GM CCRW HQ does not maintain designs. As this thesis will describe in more detail, there is not sufficient data at this point to determine the most effective strategy for the Main Control Panel and therefore it is recommended that the current course be maintained while continuing to investigate cost savings alternatives. In arriving to this goal, the following methodology was used.

### **1.4 Methodology**

In order to narrow the scope of the project, two case studies for production tooling were chosen: the Main Control Panel (ie, ECS-4213) and the weld controller. As the supplier contracts for the weld controller and main control panels came to their termination period during the timeframe of this internship, these case studies will be used to determine if local sourcing should replace global. While CCRW HQ owns the designs for the Main Control Panel, CCRW purchases a “black box” weld controllers based on a functional specifications. Through these case studies the goal is to provide a clearer picture of the strengths and weaknesses of the current strategy to provide an opportunity to begin brainstorming alternatives.

Chapter 3 will provide a literature overview on subjects such as globalization, model development and discuss some best practices. Chapter 4 will discuss analyze design and supply chain alternatives, looking at preliminary cost assessments of total landed costs. Chapter 5 will provide the final

recommendation, which is a culmination of the literature review, site visits, cost assessments, and 80 plus interviews with subject matter experts.

## 2 Case Studies on Main Control Panel and Weld Controllers

Chapter 1 provided an introduction to CCRW HQ's role in defining production tooling as well as the growing pressure from GM CCRW China to adopt a local strategy. This Chapter will be to assess the opportunities and challenges of the current global sourcing strategy through the cases of the Main Control Panel and the weld controller. Through these case studies, which involved almost one hundred interviews with CCRW North America and interviews conducted during travel to China, a list of questions was formulated which was later used for further literature review, interviews and benchmarking. These questions will be described in Chapter 3, and then lessons learned will be applied to the two case studies in Chapter 4.

### 2.1 Introduction of Main Control Panel

This section will introduce the first case of the Main Control Panel. The typical automated body shop cell layout found in North America or Shanghai General Motors is depicted in Figure 10.

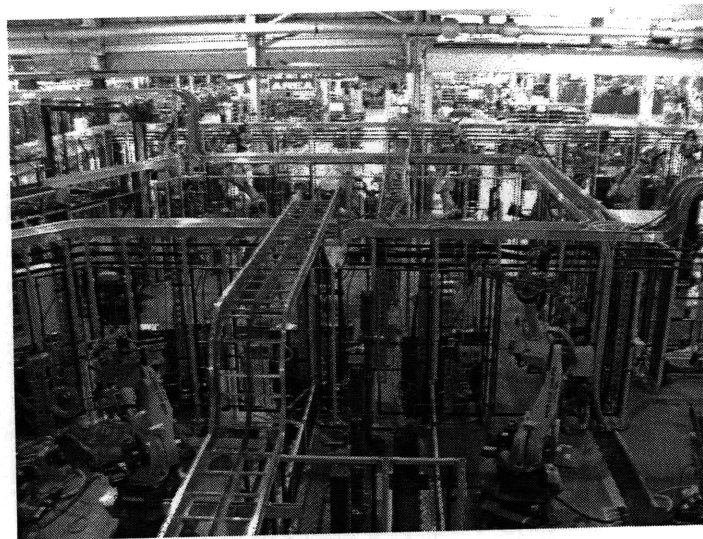


Figure 10: Typical Body Cell Layout

The Main Control Panel (MCP) is the focal point of the cell (Figure 11). They contain Programmable Logic Controllers (PLC) and other network interfaces needed to control the cell.

Since there are over 150 types of Main Control Panels, this thesis will focus on the ECS-4213. CCRW headquarters is responsible for the design and maintenance of the design of the ECS, which are all located on the GM supplier body website. Each ECS has a BOM and a specific GCCL. The GCCH-1 specifies the hardware design, the GCCB-1 standardizes the build and, finally the Panel Checklist standardizes the panel buy-off process. The Main Control Panel is comprised of 50+ components. The cost driver breakdown is as follows: 48% PLC, 3% Safety I/O, 14% Labor, 13% Enclosure, 8% Human Machine Interface, 4% Receptacles, 2% Power Supplies, and 8% miscellaneous. According to CCRW HQ engineers, component dependency particularly surrounding the PLC makes design and sourcing a challenge.

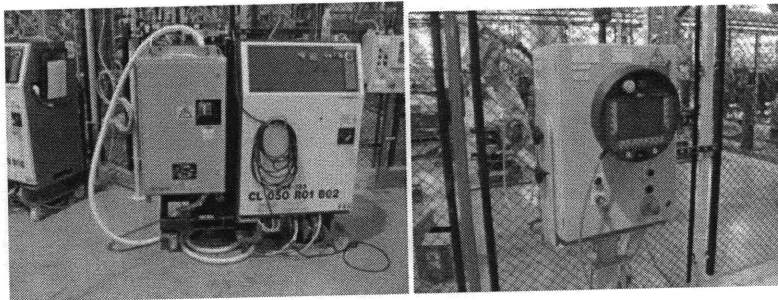


Figure 11: Version of the Main Control Panel

### ***Current Global Main Control Panel Supplier***

When the GCCL was created in 2005, Company A received the global three-year blanket contract with GM for main control panels, where the ECS-4213 was locked in at an agreed upon price and a fixed exchange rate of 1 Euro to 1.2 USD. Company A has facilities in Georgia (USA), Chemnitz, Germany and Beijing, China and established service, sales and support departments. Part of this thesis was to determine a course of action pending the completion of the contract in December 2008.

### ***Challenges of Global Strategy***

Through interviews in the US and China, challenges of the global strategy for Main Control Panels were highlighted, such as the following:

1. **Single source solution:** The current global solution is a single source Supplier A. Supplier A's Germany facility suffered a backlog a few years ago and had to shift production of the to their US facility. The backlog not only caused delays, but significantly increased the shipping costs, ultimately negatively impacted the company's reputation.
2. **Seamless coordination within company:** Much like any large, geographically dispersed organization, there are internal and external coordination issues that arise. Although Supplier A is global, the communication between their Korean and German office, for example, has indicated that there are coordination problem for reasons such as geography or language differences internal to the same company. This problem is further complicated when supplier A is attempting to coordinate with General motors, which similarly has internal communication challenges inherent to being a large global corporation.
3. **Dependency on other suppliers:** Company A provides less than 50% of the content for the Main Control Panel and is highly dependent on the success of the other specified suppliers, such as Company B who provides the Programmable Logic Controller (PLC). Company A is required by CCRW HQ to use the specified suppliers as well as the pre-negotiated prices, which does not provide sub-tier suppliers incentive to create value or further reduce costs.
4. **Differing Design Requirements:** The local CCRW engineers believe that the enclosure is overly designed for use. For example, the global solution requires both the 110 and 220 volt requirement, but the 110 volt requirement is only applicable to the US. While the US believes that 220 volts is a safety concern, the remainder of the world uses 220 volts for daily common use. For equipment used in China, the extra transformer required to obtain 110 volts is seen as an unnecessary expense, particularly since the equipment is likely to stay in China. The use of a local standard and supplier could more closely match the needs of the region. The local CCRW engineers also believe that there are better alternatives for a control system. The current struggle is that when the logic controller is connected a computer for a diagnosis, an automatic update occurs instead of prompting whether an upload or download is preferred. This has resulted in the loss of the "good" software in the past. Although an alternate source will not inherently solve this problem, it is used as evidence that the current global source is not perfect. Through the joint venture, the local CCRW has experience using a preferred alternative source for the logic and desire a deviation from the global requirement.

5. **Language Differences:** There are often language differences between CCRW HQ, CCRW organization local to China, and suppliers who operate on a global scale. As evidenced while conducting site visits in southern China, working across countries becomes particularly challenged when dealing with local labor who are likely to hold a lower education level. The GM personnel that know English, for example, tend to be more formally educated and therefore have leadership positions. It was communicated that the leadership often has to spend time translating between the workers and the suppliers. This not only creates a different management style but also requires leadership to shift their focus on tactical details.
6. **Cultural Differences:** Another example of a cultural difference in safety is how North America operations require electrical cabinets to be locked to prevent unauthorized access. The main control panel cabinet, however, were not designed with a locking device, so an additional padlock is added to the door latch, which is not designed to handle the additional weight of the lock. As a result of this regional operations cultural difference, many of the latches broke. This stimulated a redesign of the latches and a global replacement to all cabinets regardless of the lock out procedures. Over \$160K USD was spent on the simple redesign with the use of a local design. In this case, a single design was also a single point of failure.
7. **Service and support expectations:** The global solution also means that service and support personnel often come from outside of China. During interviews, several stories were communicated regarding work Visa complications for out-of-country personnel coming in for installation. It is believed by locals that the \$1000 a day rate could be reduced with a local installation crew and ramp up would be minimized. Also, service and support expectations seem to differ in various regions. One of the suppliers indicated that although the global contract stipulates that service and support outside of initial installation of a piece of production equipment, there is an expectation within China, particularly in the more rural areas, that the supplier will be available free of cost for troubleshooting and for on demand maintenance on the plant floor. A decentralized approach to sourcing could ensure that a contractual service and support agreement could be reached that is acceptable for the supplier and for GM.
8. **Shipping Cost:** The heavy sheet metal enclosure of the Main Control Panel provided by Company C (and sourced to Company A) also incurs hefty shipping costs, which is particularly true when the enclosures are shipped to multiple countries for integration. The current global

supply chain also has hefty logistics cost associated with it and are continuing to rise with fuel costs.

9. **Customs:** Customs issues occur frequently, which adds significant timing to an already compressed fifty-four week project schedule. The customs hold ups occur if the paperwork does not match the shipment, for example if a part of a larger system is shipped separately but the paperwork still has the name of the system. Customs hold ups also occur if there is confusion as to which party (shipper or receiver) is paying the import taxes. A local solution would reduce the amount of product imported through customs. Also, the increasing global nature of companies is also causing congested ports, and hence customs, which increases the variability of arrival time to the final destination.
10. **Currency Fluctuations:** Company A's three-year fixed rate contract was negotiated at an exchange rate of 1.2, which increased to 1.48 by the end of the three year period. Conversion to the USD can make a decision not as cost beneficial, and predicting the rise or fall of currency in a global economy is difficulty. This also causes a problem with three-year contracts that have yearly price changes. A local solution will not eliminate currency fluctuations, but it may make it easier to gauge and track.

Similar to this section, the next section will introduce the weld controller and will discuss the challenges of the global strategy from that frame of reference. The findings of the two case studies will then yield a list of questions to be answered through further literature review and analysis.

## 2.2 Introduction to Weld Controllers

This section will introduce the second case of the weld controller. GM's body group, outside of CCRW, relies heavily on weld controllers (Figure 12) for correct spot welding across a range of materials, stack ups and vehicle styles. For each project, the body group and CCRW weld engineers determine the number of weld controllers needed for purchase as a "black box" – where GM does not design or manufacture the weld controllers but determines the functional requirements. With the shift from the North American Weld Council to the Global Weld Council, the decision was made to use robotic mid-frequency DC weld controllers. This global specification, is also known as GWS-2P, which is as follows:

- a. Conforms to CCC, CE, CSA and UL requirements. CCC (China Compulsory Certificate) is required for use in China, CE is used in Europe and UL is only required for use in the US.
- b. Operates on a voltage range of 380 to 575 Volts.
- c. Has remote mounting provisions
- d. All power components are within the same enclosure
- e. All wire colors meet the international color standards
- f. The bus bar is grounded
- g. The SCR package is indirect water cooled
- h. The air regulator has proportional control
- i. There is stepper software
- j. The receptacles are on the enclosure
- k. There is an operator interface
- l. There are lockouts on water and air valves
- m. There is a touch safe design

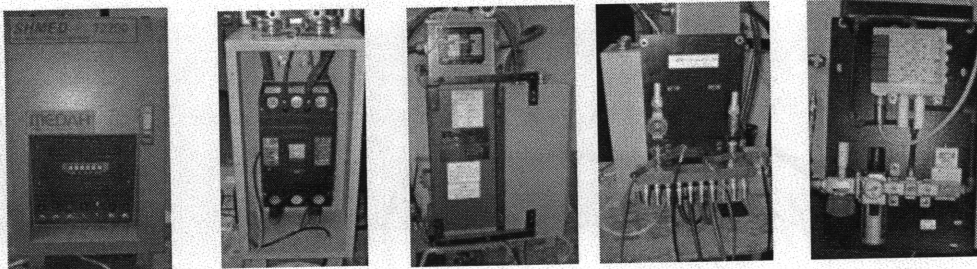


Figure 12: Weld Controllers used by GM CCRW

### *Current Global Weld Controller Supplier*

When the GCCL was created in 2005, Company E received the global three-year contract for weld controllers. The company has headquarters in the US and has facilities globally including Shanghai, China. The use of a global supplier with a product that may be over-engineered for local uses is to take advantage of economies of scale and although one solution may not be the cheapest for all areas independently, the hope is that there are savings at a global level. Through interviews in the US

and in China, many challenges of the current global strategy for weld controllers were highlighted such as the ones discussed in the following section.

### *Challenges of Global Strategy*

This section will discuss the challenges of the current global strategy for weld controllers that were highlighted during interviews and site visits.

1. **Long Lead Times:** As part of the Global Manufacturing System, both robotic and manual options are required to be available on weld controllers. The components for the weld controller are provided by Company E's Shanghai branch, are integrated in Farmington Hill, Michigan, and are then reshipped for use in China. This strategy results in an automatic ten-week delinquency on shipment, as the standard GM order placement is twelve weeks and Company E has a standard twenty-week lead-time (and an additional 2 week transit time). The long lead times motivates the local China CCRW to use legacy systems or other suppliers through the use of the joint ventures.
2. **Electrical requirements:** Similar to the Main Control Panel, the global solution for weld controllers requires both the 110 and 220 volt requirement, but the 110 volt requirement is only applicable to the US. While the US believes that 220 volts is a safety concern, the remainder of the world uses 220 volts for daily common use. For equipment used in China, the extra transformer required to obtain 110 volts is seen as an unnecessary expense, particularly since the equipment is likely to stay in China. The global design requires the inclusion of a UL certification, but the Chinese compulsory certificate (CCC) is the only electrical requirement for China. The UL certification involves additional testing in laboratories, 20K dollars for a certification, and is only needed in the US. Also, the global solution uses circuit breakers, for example, when the China solution would be content with the use of fuses.
3. **Language differences:** The language issues with the global design extend into the translation of manuals. During interviews, one of the engineers mentioned that the English instructions of "hold for six seconds" was poorly translated and interpreted by the Chinese operators who were confused on how to hold time in their hands.

4. **Service and Support expectations:** The Chinese culture expects service and support as part of the contract. However, this is not the standard global contract, which can result in some supplier relationship tension.

### 2.3 Current Strategy Assessment Summary

The previous sections identified the opportunities for Main Control Panels and weld controllers. This section will summarize the strengths and weaknesses of both cases. First the strengths can be summarized as follows:

- Higher volumes across all regions allows for purchasing power, where GM is able to negotiate volume discount.
- Under a longer-term contract, GM does not need to spend additional cost or effort in re-quoting or revalidating suppliers.
- The volume across several regions also encourages suppliers to establish service and support in smaller areas that they might not otherwise.
- A global supplier allows for a consistent product, reducing the amount of hardware or design changes that may need to be introduced into a system otherwise.
- Similarly, the inputs and outputs of functions are pre-defined and tested to work, which should result in reduced ramp up time.
- Having a uniform design allows for easier implementation of continuous improvements or updates on future projects.
- Maintenance and management of spare parts is simplified with more standardization and a smaller supply chain network. This reduces variability and risks in panels and allows for increased flexibility in the reuse of assets amongst plants.
- The global supply base allows for knowledge pooling, which is particularly useful for CCRW areas that do not have design or testing facilities.

The weaknesses of the global strategy from the two case studies include:

- Another example of a cultural differences on safety (ie, cages over moving parts, electrical lockouts, voltage differences etc)

- Logistics costs are increasing and ports are becoming increasingly congested. Similarly, delays can occur at customs.
- Service and support expectations also seem to differ in various regions.
- The global solution maintains a dependency on expertise from outside, which may inhibit local development.
- The global strategy often results in language barriers between the support personnel and the GM workers.
- The global solution has a higher labor rate and does not fully allow for opportunities to save through the use of local labor.
- Joint ventures in China add a unique challenge in the decision making power. Asia's business culture highly relies on long-term business relationship, and this difference between the US and China can create business tension.

This assessment shed light on areas of potential improvement within the current sourcing strategy. Based on these gaps, a series of questions was created and used as a springboard for literature review and industry best practices, which will be discussed in Chapter 3.

- **Automobile Industry Globalization trends:** What is the general trend for GM and globalization? Is China losing manufacturing competitiveness and does it makes sense for GM to remain in China?
- **Level of centralized decision-making:** Given the geographical distance between CCRW HQ in Michigan and the facilities in China, what is the appropriate level of control to maintain over decision-making. Since Make-buy decision-making looks at in-house/outsourced decision-making, are there similar theories or outcomes that can be applied to the question of whether to retain control of drawings/specifications or to decentralize/loosen control?
- **Sourcing Matrices:** Similarly, the disperse nature of the sourcing chain drives the question of level of control to retain in decision-making. What sourcing decision tools are available determine the best method (local, regional or global) of supply chain?
- **Cost Models:** What cost models can be used in making sourcing decisions are what are the limitations. What are the concerns with transportation, taxes, and tariffs?

- **Supplier Relationships and Collaboration:** Are there solutions to ensure a win-win for supplier and buyer?

### 3 Literature Review and Benchmarking

Chapter 1 provided a description of the varying opinions between GM CCRW HQ and the China CCRW entities. Chapter 2 introduced the case studies of the Main Control Panel and the weld controller to assess the current global strategy. Through this preliminary assessment several questions arose, and this section will provide a summary of questions for literature review on best practices and theories used in the industry. These questions include the following independent topics:

- **Automobile Industry Globalization trends:** What is the general trend for GM and globalization? Is China losing manufacturing competitiveness and does it make sense for GM to remain in China?
- **Level of centralized decision-making:** Given the geographical distance between CCRW HQ in Michigan and the facilities in China, what is the appropriate level of control to maintain over decision-making. Since Make-buy decision-making looks at in-house/outsourced decision-making, are there similar theories or outcomes that can be applied to the question of whether to retain control of drawings/specifications or to decentralize/loosen control?
- **Sourcing Matrices:** Similarly, the dispersed nature of the sourcing chain drives the question of level of control to retain in decision-making. What sourcing decision tools are available to determine the best method (local, regional or global) of supply chain?
- **Cost Models:** What cost models can be used in making sourcing decisions and what are the limitations. What are the concerns with transportation, taxes, and tariffs?
- **Supplier Relationships and Collaboration:** Are there solutions to ensure a win-win for supplier and buyer?

#### 3.1 Automobile Industry Globalization Trends

Since 2005, China's Yuan has appreciated 20% against the USD, inflation rates have remained at an artificial low of 7%, wages have increased, and employee retention has suffered (Figure 13). All of these factors raise the question of whether China is losing its manufacturing competitiveness. This section will look at trends in globalization in the auto industry.

The automotive industry has been a global industry even in the early 20<sup>th</sup> century. Pioneers GM and Ford established distribution and production companies in Europe and Asia to develop sales in potential growing markets, take advantage of low wages, and leverage the high fixed cost of vehicle R&D and production. By the mid-1960's, the "Big Three" (GM, Ford, and Chrysler) had 52% of the world market, with 90% of the 10 million vehicle demand coming from North America and Western Europe (Gottschalk and Kalmbach 47-8).

In the 1980's, the general trend in manufacturing shifted from large-scale mass production to short product life cycles to meet the general consumer demand for high quality and product variety. Since this increased the cost of capital, companies began shifting the risk of overproduction and the high capital cost to emerging markets (Berger 69). From the onset, it is clear that there is a general industry-wide confusion with how to approach manufacturing in China. On one hand, companies could take advantage of 10 to 20 times lower labor cost (Gottschalk and Kalmbach 47), but it was later reported that suppliers who off-shored to China in the 90's, reported higher operational expense due to the poor infrastructure and logistical challenges, which canceled the savings on labor (Berger 104). This was not true for all players, however, as other reports indicated that the low cost labor could provide 15 to 20% savings over the total cost of production in established markets, offsetting higher logistics cost (Gottschalk and Kalmbach 55). Perhaps best said by Suzanne Berger:

*Globalization may be the single most importance change in our lifetime, yet virtually everything people think they know about its consequences comes either from opinions, anecdotes, or very general economic theories. Analyses based on hard evidence from the experience of societies dealing with these pressures are few and far between. While facts alone will not necessarily force anyone to reach one conclusion or another about the effects of globalization, they provide an anchor and a reference in the hot debates being fought out everywhere from factory floors and corporate boardrooms to political campaigns (Berger 8.)*

### ***Take Away: Stay In China***

The question being asked from a macro-level is: is China losing its manufacturing competitiveness?

- The literature reviewed for this thesis indicates that China has a strong future worth investing in and could indicate that both the manufacturing and domestic market in China will continue to grow.

While factors such as material cost which appear to be increasing by 7.1% annually (Berger, 120), the costs are still relatively less expensive than other areas. A 2007 industry report states “companies that pursue China as both a growth market and a lower-cost labor-manufacturing hub are two thirds more profitable those others, even with these added pressures.” (Booz Allen)

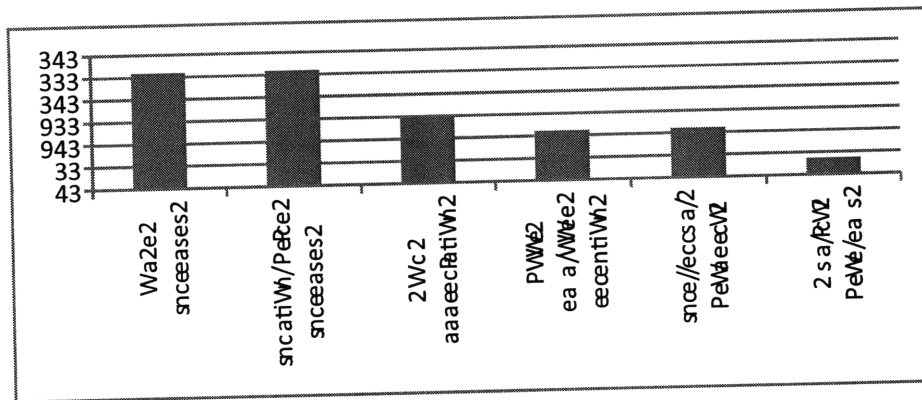


Figure 13: Top Concerns that companies believe China is losing manufacturing competitiveness (China Manufacturing Competitiveness 2007-2008: Booz Allen Hamilton)

Additionally, China also has more people who aspire to own a car, but currently do not, than any other country (Hui, 2005) In 2008, 1 in 7 cars sold in China was GM Unlike the United States, GM in China continues to expand, and can afford to because “ it has no health care cost, and pensions for its Chinese workers are minimal.” (Alexander, 2006)

### 3.2 Level of Centralized Control

In an attempt to understand the level of centralized control that should be applied within GM CCRW, similar frameworks on make-buy decision-making were reviewed. Although GM is not manufacturing the Main Control Panel or the weld controllers, they are trying to decide whether they need to retain centralized control of designs or supply chains. From the CCRW standpoint, the “make” decision is a high level of control such as the design of the MCP, and the “buy” decision would be the low level.

Eppinger and Novak looks at supply chain sourcing based on the complexity and level of vertical integration of product design in the automotive industry, and makes the major simplifying binary assumption that either a product is “make” or “buy.” They define product complexity as having three main elements: number of components specified for production, the extent of interactions between components and the degree of novelty. As expected the greater the product complexity the greater the coordination challenge, which translates to higher transaction costs. The paper goes on to discuss that the investment in skills needed to coordinate the product development – where components are first designed, then prototypes are produced and tested, and necessary changes are made. It is not possible before testing to enumerate the exact amount and nature of changes in design that will be required (Eppinger, 2001). Although there is a benefit for companies who design their manufacturing equipment to understand the equipment capabilities as well as the supplier capabilities (Fine and Whitney, 1996) the outcome of Eppinger’s statistical analysis indicates that there is no evidence of quality difference between a complex design that is maintained internally versus one that is outsourced, and similarly for a simple design. (Vasovski, 2006)

### ***Take Away: Decentralize Where Possible***

- Applying the “make-buy” assumption that there is no quality difference between maintaining a complex design that is maintained internally versus outsourced it seems to follow that decision making of equipment should be decentralized when an alternative exists.

In the case of the Main Control Panel, there are over fifty unique part numbers and complicated electrical testing and validation. According to CCRW HQ engineers, the narrow design requirements both in terms of physical adjacency and of interoperability of components and software makes changes increasingly difficult to coordinate during design and sourcing. Thus, the actual sourcing process can be more complex than “make” or “buy,” however, and such alternatives will be discussed in more detail through supplier relationship structures. Once the level of control is determined, it is then possible to look at whether an alternative supply chain exists, which leads to the questions of which region to source and which supplier to source.

### **3.3 Sourcing Matrix**

For a given product, the best sourcing strategy can be determined by asking which region to source

and which supplier to source, which has the built in assumption that there is more than one supply chain to choose from. Vasovski's thesis on a durable tooling strategy for UTC looks at two cases at opposite ends of the spectrum. In one case where the part is needed as soon as possible, a local supplier "preferably one down the street, where the manufacturing team could drop in three or four times a day to answer any questions or provide assistance" is desired. In the other case where the operating tempo is slower and the product is mature, the team can afford greater qualification and lead times. As Vasovski's states, the two cases have drastically different needs and should not be addressed by the same supply chain. His recommendation for UTC involved three different supply chains (Figure 14).

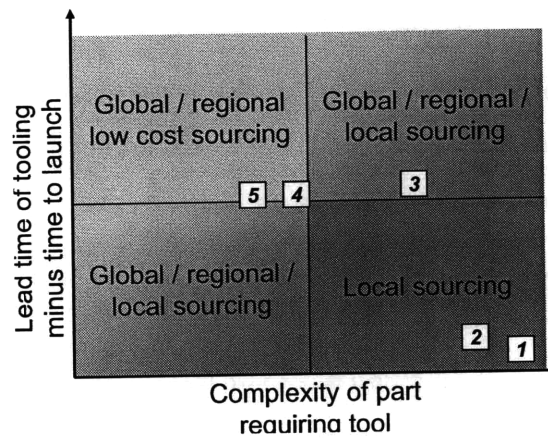


Figure 14: Sourcing matrix based on product complexity and lead time

A local supply chain is recommended in the case of rapid response (emergency repair, maintenance, etc.), unique availability (highly custom and complex) or a high level of integration is required. On the other end of the spectrum, he recommends a global source for production tools that have a high value density (cost per dimensional weight) where cost savings outweigh logistics costs and/or longer lead times are permissible. However, the existence of capable suppliers in the low cost region is a prerequisite for any sourcing initiative. Anything in between should be regionally source durable tooling to find the best combination of cost, quality and lead-time. As mentioned in the thesis, the upper left corner and the lower right corner of the matrix are easier decisions to source. The lower left and upper right require more analysis through the use of tools and the use of good judgment.

### *Sourcing Matrix Take Aways*

- Local supply chain is recommended in case of rapid response, unique availability.
- Global supply chain is recommended in case where production tools have a high value density, high logistics cost or long lead times.
- For uncertain situations, it is necessary to determine potential supplier capabilities and comparable costs.

There is no shortage of literature that indicates that there is a trend amongst companies considering the change of their supply chain strategy (Fine, 1998), and there is a “need to balance quantitative financial considerations with less-easily quantifiable strategic issues.” Determining the best sourcing solution from among the four options listed above requires detailed analysis, including determining the list of potential suppliers, assessing their capabilities, and determining comparable total costs amongst the options, which brings about the next question of which total cost models make sense to apply.

### **3.4 Cost Models**

This section will discuss cost models that take into consideration transportation and duties. This section will also discuss supplier software that can be used for this model. Particularly in the last decade, however, there have been several models developed to assess the risks and costs of global sourcing. Total Cost of Ownership (TCO) models take into account a life cycle view of a product through Activity Based Cost Accounting (Hollmann, 2006), and provide a method for evaluating the supplier performance over time. When trying to understand the long-term cost of production tooling, this method would be favorable, however there are limitations when the sourcing process is still in the preliminary phases of the supplier identification – such as the case of this thesis. At the completion of the internship, there was not enough information on the potential suppliers or the associated costs to be applied to this model. Since the TCO cannot be used, a good first pass at cost modeling is and is commonly performed by purchasing is that of landed cost, where:

$$\text{Landed cost} = \text{purchase price} + \text{customs costs} + \text{shipping costs}$$

Where customs cost includes duties and other fees and shipping costs involve freights and fuel surcharges. As other theses such as those of Feller and Obermeyer, indicate that landed costs, however, should not be the basis of a sourcing decision, as it does not take into consideration any hidden costs. Quantifying the true cost is difficult, particularly in an emerging market where it is unclear who the suppliers are, if they have a viable product or relevant purchase price, and hidden costs that arise from inventory, quality or schedule issues have yet to be determined. Although this model normally applies to commodities and not capital equipment, it is a good starting point since it for global sourcing to be well executed, a company must consider the impact of transportation cost and customs cost. The next paragraphs will discuss the factors that increase transportation cost, such as the increasing cost of fuel and the increased congestion of ports, as well as tariffs and taxes.

### *Transportation and Customs*

Increased transportation cost are some of the most favored arguments for going local. The tipping point for this “near shoring,” according to MIT’s Simchi-Levi, is directly tied to the price of oil. Higher fuel prices have pushed the shipping cost of a 40-foot container to the US to around \$8000 up from \$3000 a few years ago. Once oil reaches a certain threshold, companies may benefit by sourcing closer to home, which in this case means regionalized or localized Chinese suppliers. This is particularly relevant for GM’s China operations, which serve the domestic market. Similarly, increased congestion at ports and shipping lanes, inadequate number of dockworkers, limited container space, truck shortages, congestion at rail hubs, increases the lead time variability and operational delays (Chaina: The Magazine for Global Supply Chain Leaders, 2008) all favoring towards local sourcing.

Customs costs, such as Value Added Taxes (VAT) and Harmonized Tariff Schedule (HTS) also increase the transportation cost, and thus the landed cost. VAT is collected fractionally via a system of partial payments whereby VAT-registered businesses deduct from the VAT they have collected the amount of tax they have paid to other taxable entity on purchases for their business activities. This mechanism ensures that the tax is neutral regardless of how many transactions are involved. VAT is generally applied in most countries, with the US being the exception. The Harmonized Tariff Schedule (HTS), which is maintained by the Trade Commission and varies for each country, also impacts the transportation cost. The tax schedule contains everything from live animals to

textiles, machinery, or artwork. The HTS code can then be multiplied by the purchase price to determine the duty owed. Determining the appropriate HTS is sometimes difficult, however, as will be addressed in the case of the weld controller in Chapter 4.

Prior GM internships have studied the issue of duty payments and have resulted in international Commercial Terms (Incoterm) matrices for various countries. (See Appendix). With an extended supply chain, it is also imperative for organizations to clearly understand the contractual agreements involved in sourcing. Incoterms define the respective roles of the buyer and seller in the arrangement of transportation and other responsibilities and clarify when the ownership of the merchandise takes place. Incoterms are determined between GM purchasing, with the guidance of the tax office, and the supplier. There are several Incoterms available, such as the following which were are from internal GM documentation.

- **FCA (Free Carrier):** The seller delivers the goods into the custody of the first carrier, and this is where risk passes from seller to buyer. The buyer pays for the transportation.
- **DDU (Delivery Duty Unpaid):** The seller pays for all transportation costs and bears all risk until the goods have been delivered, but does not pay for the duty. The buyer is responsible for import Duties and Taxes.
- **FOB (Free On Board):** Seller pays for transportation of the goods to the port of shipment, plus loading costs. The buyer pays freight, insurance, unloading costs and transportation from the port of shipment to the factory. The passing of risks occurs when the goods pass the ship's rail at the port of shipment. This means that the seller has the goods ready for collection at his premises (Works, factory, warehouse, plant) on the date agreed upon. The buyer pays all transportation costs and also bears the risks for bringing the goods to their final destination.
- **CIP (Carriage and Insurance Paid To):** The passing of risk occurs when the goods have been delivered into the custody of the first carrier. This means that the buyer bears all risk and any additional costs occurring after the goods have been so delivered. Seller is required to obtain insurance only on minimum cover; additional coverage is responsibility of buyer or must be agreed between seller and buyer. Under CIP seller is also required to clear the goods for export.

Knowledge of these Incoterms is important for several reasons, and can:

- Allow GM to avoid overpayment. For example, if the seller is the Importer of Record (IOR), they can transfer a higher customer to the buyer through a higher purchase price.
- Allow delays and confusion at customs. When there is confusion on who is paying or when there is an error in the HTS classification, an item can be held up at customs and potentially delay operations.
- Avoid loss of recoverable duty. For example, if the IOR is not a government registered entity, they duty is not recoverable, and this results in a 17% tax. This also is important when a local supplier purchases spare parts, and absorbs the VAT for products that are not sold off. This eventually is transferred on to the purchase price that GM pays.
- Allow GM to make an educated decision on whether to handle logistics or to outsource.

### *Software Applications*

Literature review also indicated that there are many commercially available software applications for analyzing Total Landed Cost. Through internal GM documentation, it was discovered the GM's Supply Chain Engineer group developed customized Total Landed Cost software. With the use of the TLC software and as part of the purchasing process, the buyer will submit a Request for Quote. While the price is negotiated and the Exworks quote request form is filled, the tax support staff is contacted for duty classification and cost (Figure 15) This software also allows for the creation of studies, which involves looking at various volumes, delivery methods, and locations prior to sourcing (Figure 16)

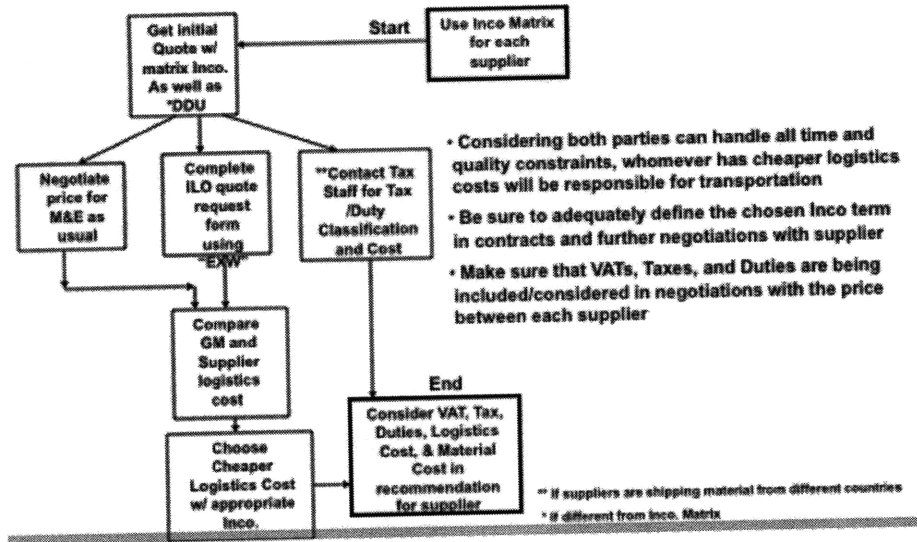


Figure 15: Buyer Process Flow for VAT, Duties, Logistics, and Material Costs.

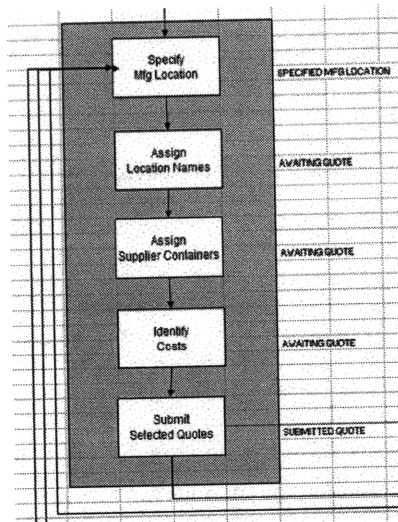


Figure 16: Scenarios can be created with TLC software to alter items such as manufacturing locations or form of shipment

### Cost Model Take Aways

- TLC is a good first pass where Total Landed Cost is purchase price, transportation cost and customs.

- Higher fuel prices and congestion suggest that near shoring (local) is advantageous.
- VAT are collected fractionally via a system of partial payments whereby VAT-registered businesses deduct from the VAT they have collected the amount of tax they have paid to other taxable entity on purchases for their business activities. This mechanism ensures that the tax is neutral regardless of how many transactions are involved. VAT is generally applied in most countries, with the US being the exception.
- Incoterms define respective roles of the buyer and seller in the arrangement of transportation and other responsibilities and clarify when the ownership of merchandise takes place. Incoterms are important to know for reasons such as avoiding overpayment, avoiding delays and confusion at customs, and avoiding loss of recoverable duties.
- Total Landed Cost Software is available to test scenarios prior to making a sourcing decision.

As discussed in much of the literature reviewed, answers cannot be fully based on quantitative models but in a more subjective approach. The next section will discuss supplier collaboration as a method to develop a win-win solution.

### **3.5 Supplier collaboration**

In a search for answers on how to move forward with equipment sourcing, we can look at the leaders in the automotive industry as a benchmark. One such leader, Toyota, is renown for trying to understand their supplier's business and they have a control system to constantly monitor and analyze the supplier performance (Kwai Sang Chin, 2006). A Supplier Production Manager (SPM) is assigned from the purchasing department to proactively help suppliers with their production systems and a fixed set of Toyota engineers are permanently assigned to a project to rectify problems before they occur. Toyota also organizes regular meetings and conferences to promote the systematic sharing of best practices between its component suppliers. Toyota's approach to design is also valuable. In a MIT Operation's Strategy lecture provided by a Toyota leader Jamie Bonini, it was discussed that the company is aware the investing in suppliers means that they are also helping their competition, but the fear of competition does not prevent them from investing.

Selecting suppliers purely on the basis of cost might let GM save money in the short term, however, the long term drawbacks could weigh heavier, such as choking off innovation, and undermining quality or safety. The activities that ultimately succeed over time are, in contrast, those that build on continuous learning and innovation. These allow companies to build capabilities, brand name, long-term working relations with suppliers and customers, intellectual property, specialized skills, reputation – all of which are out of reach to companies whose only assets are cheap labor (Gottschalk and Kalmbach, 54.) If a supplier is seen as an important part of the value chain, the use of standardized technology can boost efficiency (Fine and Whitney), such as the case of the weld controller, which depends on the knowledge of the external supplier.

Since actual sourcing relationships are more complex than “make” or “buy,” there are other sourcing practices, such as product or service contracts, that can expand the future of work.

### *Product or Service Contracts*

A UK research study indicates that the popular advice to manufacturers is to sustain competitiveness, they should ‘move up the value chain’ and focus on delivering knowledge intensive products and services (Baines.) Through a product or service contract, GM could capture value through the leasing of expensive capital equipment, restructuring the risk and responsibilities associated with traditional ownership. Similarly, the supplier/manufacturer can improve their competitiveness “while simultaneously retaining asset ownership that can enhance utilization, reliability, design, and protection.”

### **3.6 Summary**

This chapter sought to answer questions that arose out of preliminary assessment of weld controller and main control panel case studies. The literature review indicates that globalization in China is not a trend and recent growth in the Chinese domestic automobile market indicate that China is work investing in despite indicators that suggest rising labor rates and inflation of the Yuan. The literature review suggests that there appears to be no significant quality difference when a complex design is maintained in house (“make”) or outsourced (“buy”). It therefore seems logical to determine if there is a feasible supply chain alternative. In determining the supply chain alternative, there are matrices that can assist by providing quick guidance on whether a local, regional, or global

supply chain is recommended. A local supply chain is recommended in case of rapid response, unique availability. A global supply chain is recommended in case where production tools have a high value density, high logistics cost or long lead times. For uncertain situations, it is necessary to determine potential supplier capabilities and comparable costs. As a continuation of potential supplier assessment, a good first pass is the Total Landed Cost analysis, where purchase price, transportation cost and customs are taken into consideration. Analysis indicates that with factors such as higher fuel prices and increased port congestion, near shoring (local sourcing) is advantageous. Also, this chapter discussed the impact of Value Added Taxes and the importance of understanding the appropriate Incoterms amongst buyer and seller relations. Lastly, this chapter discussed the importance of long term supplier collaboration and developing an organizational structure that can promote mutual cost savings alternatives. Chapter 4 will apply the concepts from the literature review to the case studies of the Main Control Panel and the weld controller.

## **4 Main Control Panel and Weld Controller Assessment**

The lessons learned from Chapter 3 such as the framework for supplier selection, will be addressed to the case studies in this chapter. This section will also discuss potential engineering design alternatives as a resolution to the sourcing problem. The third section, and second half of this thesis, will describe the weld controller alternatives to a regional solution. The fourth section will discuss the impact of taxes and tariffs and will discuss lessons learned from site visits with GM and supplier facilities. The fourth section will also provide discussion about the successful local implementation with other projects.

### **4.1 Main Control Panel Alternatives**

As part of this thesis, the local CCRW engineers at GM China were asked to suggest alternative suppliers and obtain requests for quotes for both potentially appropriate local solutions with specific deviations annotated. By the end of the internship, only two local quotes were obtained by potential local suppliers, which is insufficient for analysis, particularly since the quote was not officially reviewed by GM's supply chain organization and therefore has questionable accuracy.

While in China, site visits were also conducted at current and potential suppliers. Currently Company C's Shanghai factory has a high automation facility that produces sheet metal enclosures for the Main Control Panels. During the site visits, it became evident that Company C is a well-respected brand, so much so that lower price knockoffs were stamped with a "Company C-copy" logo. These knock-offs are impacting Company C's sales and the local plant leadership realizes that they need to work with OEMs to develop a win-win situation. As such, they expressed plans to launch a 30% reduced cost enclosure which uses 1.3 mm sheet metal, versus the 1.5 mm thickness of the global version., They also realize that they need to work with the OEMs to develop a win-win situation.

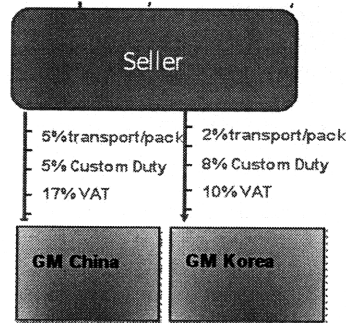
Company C's Shanghai factory has high automaton producing 300 cabinets a day. The company had new and automated machines, (such as bunch, bend, plastic wrap) in house QA and design. Currently, the company has eight warehouses in China, but only one warehouse in Korea. With the growing demand in the Asia Pacific region (not only GM), they believe that they can meet the

demand with proper notice. Although they are a global company, they truly believe that there are cost savings in a local or regional approach. They also believe that in order to expand regionally, they would need local representation for the necessary language and logistics issues. Several site visits of companies who did not provide quotes were also visited in China. Similar to the observations of Company C, it appears that there are many legitimate options locally.

In addition to the local quotes, regional quotes were provided from a supplier in Korea. The quote indicates savings by using a regional Korean supplier, who can offer the Main Control Panel design at 97% of the base price, where the global design mean the same GCCL contact and the use of the metal enclosure provided by Company C. The same company was asked to provide a regional/local quote, which came to 67% of the base price and uses the same design with the use of a local cabinet, wire, duct and terminals. This value has questionable accuracy and although it was not formally reviewed by purchasing, it appear to be an outlier. What was interesting about the analysis, however, was the impact of transportation, duties and taxes, which will be described in the following paragraphs.

### *Shipping*

In order to calculate a typical shipping scenario, the low and high range for the number of Main Control Panels purchased for a new project was obtained. At the beginning of this project, two new facilities (Green Sea and SMG-285) in China were reviewed through the Global Peer Review process – one of which was for SGMW and the other for SGM. In the higher automation facility seventy-nine Main Control Panels were needed, the most common shipment being seven at a time, and the low range being a single panel, such as in the case where a replacement is needed for a mature facility. Using these values, the transportation cost of a 40-foot sea container to/from various ports in the Asia Pacific region was obtained by the Intercontinental Logistics department. The end result seems to indicate that a 5% transport/package rate is a reasonable estimate for international use. Similarly, a 2% transport/packaging rate seems reasonable for domestic use. (Figure 17)



- Ex-works Contract – Buyer (GM) is responsible for transport and customs from seller
- 5% transport/package used as int'l average. 2% transport/package for domestic
- China has 5% import duty. Korea has 8%. There is no trade agreement.
- Full VAT is recoverable by GM if domestic Korea or China. 13% VAT is recoverable if exported from China.
- INCO terms are only relevant for international sales. Recommend DDU and GM entity as IOR.

Figure 17: Impact of Transport, Duties and Taxes

### *Incoterms, Duties and Taxes*

It also became evident that the Incoterms of the contract are critical to pay attention to as it stipulates whether the buyer or seller will pay the duties and taxes. In the case of Company A, GM uses an Exwork Incoterm, which means that the buyer (GM) is responsible for the transport and customs from the seller. The basic import duty for and ECS being imported to China is 5% (and 8% for Korea). Since Gm has an Exworks contract with Company A, GM is ultimately responsible for this payment. There are other terms that may be more applicable if GM does not wish to be a logistics entity. For example, DDP terms of sale, would make it difficult for taxes to be recovered in the case where the seller may not be registered with the country they are shipping or if they are not the IOR. The regulations vary amongst countries and it is advised that the purchasing department check with customs and logistics experts prior to signing contract terms that can otherwise result in hefty unrecoverable duties.

In addition to the import tax, GM (the buyer) must pay a VAT of 17% in China and 8% in Korea. In China, the entire 17% VAT is recoverable if the entity is registered in China. If this item is exported for sale, the entity can only recover 13% of the 17%, so the VAT tax serves as an export tax. Most countries do not impose an export tax, with the exception being China.

Based on this, it always makes sense to localize Main Control Panels. The concern, however, is the associated transaction costs that come from product complexity. The next section discusses more about such engineering costs.

### 4.2 Engineering Design and Costs

This section will discuss engineering costs assessment and the potential redesign of the Main Control Panel to an off-the-shelf solution. For the Main Control Panel, the standardized package is approximately 345 pages. Although it is certain that the global standard allows for economies of scale and learning efficiencies, it is unclear how much money has been saved. Any variability in the hardware trickles to the software and the wiring diagrams, which ultimately results in increased energy (whether time or money) at startup (Figure 18).

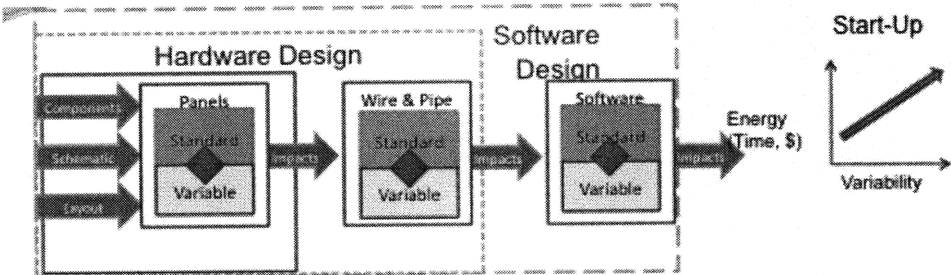


Figure 18: Design variations trick through hardware and software design, increasing time and energy.

A package of 345 pages can quickly double, and each page requires several hours of work, not to mention the hours required to maintain the varied drawings through the life of the product.

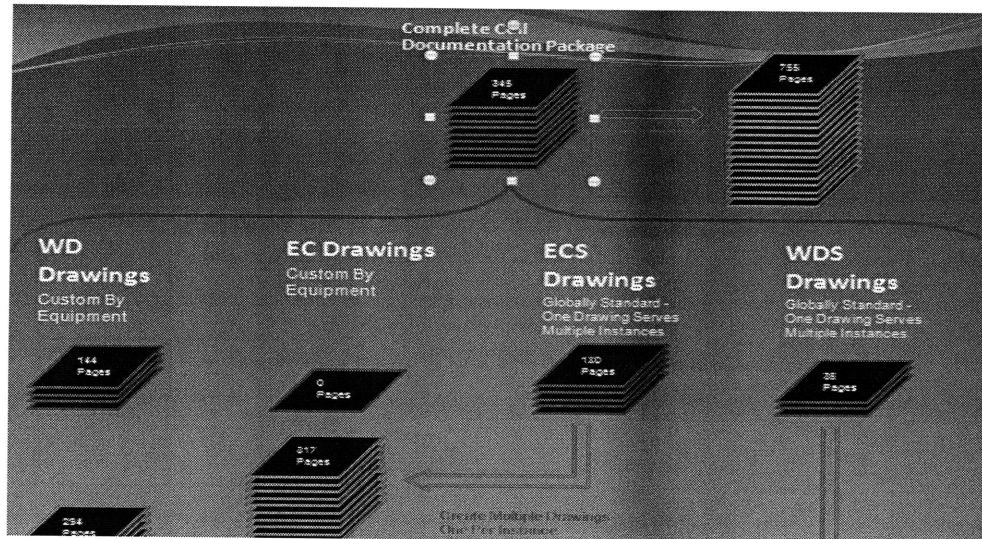


Figure 19: A 345 standard ECS package can quickly increase with design changes.

This corresponds to Eppinger’s research on product complexity and sourcing. As the literature indicates, high product complexity also results in higher transaction cost. Quantifying the transaction cost of an event that has unknown outcome, however, is impossible to determine.

### *Potential Redesign to an Off the Shelf Solution*

During the course of the internship, the CCRW team also launched an analysis for a functionally equivalent off the shelf design. Figure 20 is for a main control panel, has external power supplies and provides a cost savings of \$3900. The major advantages of this concept include:

- The elimination of the power supply in the enclosure, which eliminates the need for the heavy enclosure. This reduces weight and shipping costs.
- The off the shelf design reduces the lead-time to order as the non-custom parts are more readily available.
- The non-GM specific parts also help to reduce costs, by taken advantage of a their supplier’s customer base.
- The design also allows for lean purchase. For the example of a small cell, only the power suppliers for the application need to be purchased as current MCP’s have extra capacity. This reduces the additional 24 vdc power and receptacle waste.

- The external power supply placement also eliminates voltage drop problems. When running the MCP cables over a long distance, a 24 vdc voltage drop usually occurs. This strategy allows the power suppliers to be located closer to the loads.
- The off the shelf solution could reduce the transaction cost associated with maintaining detailed engineering designs, but the solution is still in the preliminary phases. Also, the potential local sourcing channels are undetermined at this time.

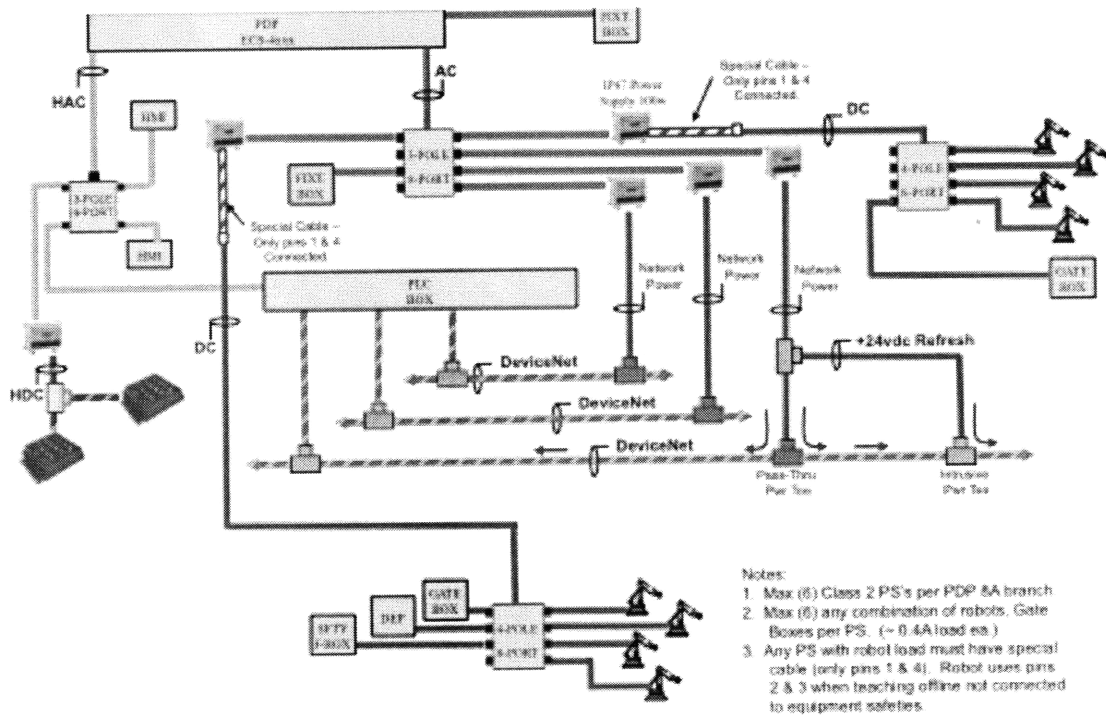


Figure 20: IP67 Industrial Hardened Strategy

### 4.3 Weld Controller Alternatives

This section will describe alternatives to the global source for local use.

In an attempt to determine alternative sourcing options for the weld controllers, local CCRW engineers were asked to identify local and regional weld controller requirements based on the GWP-WP, which were:

- Conforms to CCC, CE, CSA and UL requirements. CCC (China Compulsory Certificate) is required for use in China, CE is used in Europe and UL is only required for us in the US.
- Operates on a voltage range of 380 to 575 Volts.
- Has remote mounting provisions
- All power components are within the same enclosure
- All wire colors meet the international color standards
- The bus bar is grounded
- The SCR package is indirect water cooled
- The air regulator has proportional control
- There is stepper software
- The receptacles are on the enclosure
- There is a operator interface
- There are lockouts on water and air valves
- There is a touch safe design

The China CCRW welding engineers identified the regional requirements and suggested that the only necessary local requirements include:

- The proportional air control
- The stepper software
- The lockout on water and air valves

Seven companies were sent request for quotes. In the first round response, six of seven companies quoted weld to the GWS-2P requirement describe in Chapter with purchase price ranges from \$7000-\$14000.

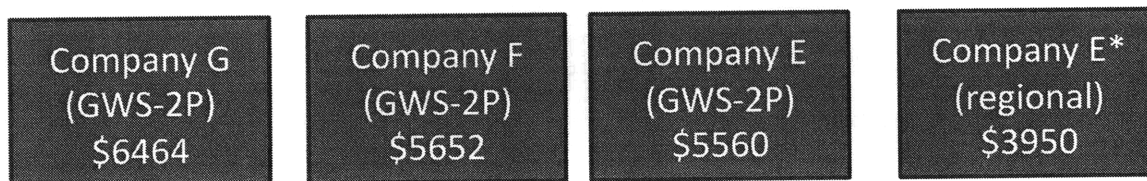


Figure 21: Round 1 Bid Weld Controller Bids

Three of these companies (Company E, F, G) quoted shipping and duties on existing equipment, and the others did not have pre-built units ready for validation. Company E was the only company that satisfied the regional requirement. This weld controller solution uses a transformer (SEWM) that is only used in China, but offers \$340 in savings. With collaboration Company E, the Global Manual Weld Team proposed the adoption of a “scalable” solution for AC cabled weld equipment.

#### **4.4 Site Visit to Company E**

During the author’s site visits in China it was identified that local weld controller engineers are pleased with the global robotic solution, but encouraged the need for a manual option. The local engineers were highly involved with working with Company E to develop a portable manual weld controller solution. During the site visit, it was observed that the same people who build the global weld controllers also build the local versions. The only difference comes from the elimination of items such as protection safety devices as well as the elimination of the UL certification. In terms of service and support, which is not included in the contract, local companies expect a high level of on site assistance. This results in Company E’s local division paying their personnel out of their budget in order to maintain the relationship with the local companies. It was recommended by local supplier’s top executives that the local weld controller engineers receive more training to be able to better understand how to troubleshoot and maintain the equipment independent of the supplier. Company E’s joint ownership challenges were communicated during the site visit. The Shanghai division of Company E has 25% ownership, which causes problems with spare parts and service and support. In the case of spare parts, the contract, which was created through Company E’s global headquarters, agrees to have 5% spares on hand. The local branch, however, not only incurs the cost of inventory holding, but also incurs the duties and VAT which cannot be recovered unless the parts are sold.

#### ***Shipping and Duties***

As part of the supplier analysis above shipping and duties were also asked to be quoted separately as the pricing for weld controllers normally includes the shipping costs. Similar to the Main Control Panel, the average shipping cost can be estimated to be 2% of the purchase price for domestic transport and 5% for international transport. Appendix A includes a matrix of shipping costs to various global regions.

As part of this analysis, the GM customs office was asked to provide the appropriate HTS classification. Surprisingly, the classification was not a simple step. In the case of the weld controller, there are four codes that need to be applied for the weld controller: 853710 for the programmable weld controller, 850433 for the transformer (no-liquid rated 200kVA at 50%), 853710 for the operator interface that is less than 1000 volts, and 851590 for the dense pack with multiple components. The Appendix shows the HTS rates for various countries. In addition to the HTS, the 17% VAT also applies, and similar to the case of the MCP, it can be fully recovered. If the product is shipped out of the country, however, only 13% can be recovered. The sourcing problem, however, is further complicated because GM has little control over the supplier's country of origin, as this falls into the realm of how the supplier can best manage the project to meet its capacity and demand requirements.

#### **4.5 Other Lessons Learned**

This section will discuss other example of successful implementation of local solutions beyond the Main Control Panel and weld controllers which were discussed as examples with leadership of GM and supplier facilities during the visit to China. One example is the large paint shop expansion project in the Qingdao, China GM facility. Since 42% of the original budget was for imported equipment, a trial that used local product resulted in a 22-25% equipment savings as well as additional savings for the use of local labor for integration. Similarly, local supply and labor was used for the implementation of a friction conveyor system for a body shop expansion project in Qingdao. (Figure 22). This lower automation project lowered the maintenance and operating cost by 20% as compared to the previous skid conveyor projects. This friction system met the design quality, saved on 15% of energy (because of smaller motors), and reduced the commissioning time as it is a simpler system. Additionally, there were no accidents during the construction or commissioning, and the project positively reinforced cooperation amongst suppliers, SGMW, and GM China. This project reinforced the local sourcing and local labor for cost savings. The global conveyor system was overly designed for the needs of the Liuzhou plant, and opening up the design requirements for the conveyence system allowed for local engineers to arrive to creative solutions.



Figure 22: Body in White local expansion project

The Liuzhou plant manager remembers being an engineer concerned on the technical aspects of the project. He underwent global training, and believes that the CCRW lessons learned provided great benefit to him. As director, he now is concerned about price. As he communicated with a laugh, “we are not making the Buick or Cadillac” but they are focusing on the low end market and simply cannot afford the global solution for production tooling. He encourages engineers to discover cost savings and he stays on top of them, as he proclaims, through the use of anger. Although he believes that a local strategy is necessary, he also is concerned that the situation will change in five years when they may need to introduce more automation. He complimented global CCRW HQ for establishing a highly reputable global standard, however, he reiterated the need to establish balance by also introducing local supply chain and local decision making. He believes that CCRW HQ can truly play a role in developing and training China GM on how to scale appropriately and continue to provide technical knowledge.

During other non-GM related plant visits through Southeast Asia, it has become increasingly evident that there is a critical need to understand the local culture and language. During a Southeast Asia Private Equity/Venture Capital study tour, the author of this thesis had the opportunity to present and discuss lessons learned with the CEO of Malaysian Airlines, which currently is the only non-negative airline in the world. He believes that it is critical to understand the local needs and leverage on the local strengths. For example, there was a period of time when the company standardized meals on all flight paths. When they realized that the expensive lamb biryani was not eaten on a particular flight path that was mostly frequented by Muslims (who do not eat lamb), they were able to provide a local vegetarian alternative. This change not only reduced costs but improved customer

satisfaction. As a side note, this company is also looking at aircraft leasing models instead of purchasing hefty capital equipment. Google in Singapore was also another company that was visited during the study tour and is a good example of a company that communicated the importance of understanding local culture and language. While Google is the main search engine in the United States, Google Asia has not been as successful. They realize that the direct translation of words is not enough to meet the local needs, and they are looking at alternative products to address this market. Prior to the site visits conducted locally in China and southeast Asia, the author had the expectation that a global solution is best for all, which is no longer the belief.

This chapter provided an assessment of the Main Control Panel and weld controller. Through the local site visits of potential Main Control Panel suppliers, it appears that a viable local solution exists, although the preliminary quotes seem inaccurate, have not been formally reviewed, and more validation is required. The chapter also discussed the potential redesign of the Main Control Panel, which place power supplies external to the enclosure, thereby increasing modularity, decreasing weight, and providing an off the shelf solution to increase flexibility of supply chain. This chapter also assessed the weld controller strategy, which looked at quoting a regional solution. The end result was the use of a local solution with the current global supplier who has offices in Shanghai. The local solution eliminates design elements that not essential for local use, resulting in cost savings. The use of a local supplier also results in transportation and customs costs savings, while also improving the level of service and support. This solution also maintains long term collaboration with the global supplier.

## 5 Recommendations

This chapter will tie in the lessons learned from previous Chapters and will provide China CCRW business and equipment recommendations. The current leadership message within CCRW is on the right track: deploy scalable standards that range from a high level of automation to a very low level of automation to reduce investment and increase flexibility, without sacrificing functionality and reliability. In order to successfully accomplish this in China, GM CCRW must continue to develop local talent to build self-sufficiency and encourage communication with China CCRW to develop mutually beneficial solutions. This solution involves seeking alternative suppliers, such as was completed in this thesis, to the current global sourcing strategy where it is believed to be appropriate.

In arriving to a recommendation specific for the weld controller and main control panel, the following process was used, and it is recommended that similar questions be asked when developing a sourcing strategy in the future.

### *Assess Industry Trends*

The first step is to determine the macro-trend and determine whether the local market indicates strong short and long term viability. In the case of China, the domestic market continues to grow and is an increasingly profitable division. Even with the effects of the global economic crisis, China operations are expected to remain strong in the long term. Joint ventures, such as SAIC and GM in China, make for a complicated organizational structure where influence and decision-making is shared. For the case of China, the joint ventures are essential of continuing to act as a manufacturing entity in China as well as for ensuring the daily operations are as smooth and as successful as possible. As such, all parties involved should embrace the opportunity to learn from internal best practices, and be as open to suggestions as possible. This involves continuous communication to determine areas for improvement such as providing training to workers on the proper use or maintenance procedures of production equipment or improving sourcing decisions.

### *Assess the level of control*

The second step is to assess the level of decision making control that is needed. This thesis looks at “make-buy” theories as an attempt to answer the similar question of level of centralized control. In the case of “make,” central control is retained, whereas in the case of “buy,” control is decentralized.

Although GM is not manufacturing the Main Control Panel or the weld controller, the similar concepts apply, where it can be assumed that there may not be a distinct quality advantage with maintaining the designs in house (“make”) as opposed to outsourcing designs (“buy”) with a supplier. There is, however, reluctance for CCRW to use a turn-key approach for reasons such as loss of future knowledge or the sharing of intellectual property with potential competitors. The question becomes: is the product design a core competency that adds direct value to the bottom line. Given the increased need to cut cost to remain competitive, it is suggested that only essential complexities remain. Literature also suggests that higher product complexity also increases the transaction costs due to higher interoperability or dependency of components. There is also an incentive, therefore, to drive down product complexity. For the case of the Main Control Panel, CCRW HQ has already begun a redesign to allow for an off the shelf solution that would increase supplier flexibility and reduce CCRW HQ’s burden of maintaining complicated designs. In the case of the weld controller, an outside supplier already maintains the design. In both cases, a local versus global specification should be determined by CCRW HQ along with local CCRW, which can then be used as a starting point of communication with suppliers who may have an off the shelf or low cost solution to meet the same criteria.

#### *Assess form of supply chain (global, regional, local)*

A third step is to assess the form of supply chain. As suggested in the previous section, CCRW HQ should continue to serve as the central hub for making sourcing a specification changes. Based on the two case studies used in this thesis, CCRW HQ can always assume that it is a less expensive option from the logistics standpoint to source locally. In general, for products where there may be a potential to capitalize on local labor service and support, reduce the logistics cost, or to develop local talent, it is recommended that a database of potential suppliers be developed.

#### *Assessment of potential suppliers*

The fourth step is to conduct an assessment of potential suppliers. With the assistance of local CCRW, potential suppliers can be identified and Request For Quotes can be obtained. A total landed cost is a good first pass to assess if the supplier has comparable quotes. However, in the case of the Main Control Panel, it is too early to recommend a definitive local over global strategy, as more analysis needs to occur before committing to a change. For the weld controller, Company E provides both the global and local solution and has the lowest landed cost. GM CCRW has a long

term relationship with Company E, and therefore it is recommended that they maintain this supplier, working with them to ensure that the local option can provide features such as water lockouts and a touch safe design for regional use. Company E will continue to maintain the designs and provide service and support.

Attention should also be taken to ensure that the appropriate Incoterms are used to avoid overpayment or delays at customs. The GM Customs office specifically recommends using DDU terms of sale as well as the Importer of Record status, which means that GM will have to pay the tariffs and taxes. GM should refrain from using the Incoterm DDP whenever possible, to ensure that the value added tax is recoverable. Also, if the equipment is being exported after initial import, the importer of record should also be the exporter of record. The majority of the time, GM should be able to receive a refund for these taxes. With a local solution, the Incoterms become a non-issue.

As previously discussed, commercially available software is available that enables GM buyers to create and submit online Supply Chain Requests for Quotation (RFQs) that are used to inform potential suppliers of opportunities to design or manufacture line items. This allows the suppliers to reduce the turnaround time of the responses and improve bid quality. This allows GM buyers to communicate more consistently and quicker with suppliers on a global basis. The benefits allow buyers and suppliers to work together on sourcing activities, providing real time transactions, reducing paper processing, reducing e-mail transmission, providing availability at every desktop, and standardizing the sourcing process. This allows a study of multiple scenarios, involving part(s), GM Plant(s), volume, delivery method, and supplier manufacturing location(s) to be analyzed prior to sourcing.

#### *Long Term Collaboration and Organizational Development*

As a fifth step, long term collaboration and organizational development should be assessed. For local sourcing to be developed, a local procurement organization needs to be on board with the policies for forwarding sourcing decisions, maintaining and monitoring supplier quality, for launch local support and continuing to make sourcing decisions. Regardless, the following must exist in order to ensure long-term collaboration:

- Clear goals must be defined for collaborative projects
- Compatible corporate cultures
- Clear division of responsibilities based on core competencies
- Opportunities and risk to be shared fairly
- Clear rules for conflict resolution

More generally, one option in supplier selection is to ask China CCRW representatives to leverage supplier knowledge and investments in capabilities that have already been established. This helps to offload the risk to the supplier, but there is still a longer-term investment in order for suppliers to be convinced to make the investment to develop the capabilities. There should be an expected sizable supplier development ramp up period for engineering support. Another option is to leverage suppliers that have already been developed by other MNCs, but there are limited opportunities that exist. There are also opportunities for redefining the sharing of capital expenditures. For example some suppliers may change to a product services contract and retain full cost ownership of the equipment.

It is recommended that a thorough financial assessment be conducted prior to selecting a supplier, taking into consideration that China does not follow the same GAAP requirements. Since reporting is not regulated, GM must be pragmatic in understanding that the true cost drivers are as compared to MNC counterparts. This can best be accomplished through site visits. It is also best practice to minimize cash/asset exposure with suppliers by keeping credit policies tight decision making essential investments with a pay as you go.

### *Summary*

In summary, there are significant savings from sourcing locally in China, however quoted prices do not always translate to cost savings. With issues such as global standards, ramp up, support, supplier development efforts can quickly erode purchase price savings. The recommendation is to limit the number of suppliers and develop long-term collaborative relationships. Moreover, executives should not be encouraged to rotate too quickly. Especially in Asian cultures, long-term relations are key to successfully negotiating contracts with business partners and even more important in

implementing them properly. Recruiting, personnel planning and personnel development teams should increasingly integrate staff and executives for the emerging markets.

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## APPENDIX

	tiy tiy ti P			xBtñ qs Bx bnt			
	/y ti	/y b	/y	/y ti	/y b	/y	
Conforms to CCC CE CSA and UL requirements	Yes	Yes	Yes	None	None	CCC only	
Operates on voltage range from 380 volts to 575 volts				Yes	Will Not Operate Above 480 VAC	Yes	
Remote Mounting Provisions				No	No	No	
All power components within same enclosure				Yes	Yes	No. Circuit breaker in another enclosure, but control cabinet has door interlock which trips breaker if door is opened	
International wire color standards				No	No	No	
Bus bar grounding				No	Yes	No	
Indirect water cooled SCR package				No	No	No	
Proportional air regulator				0-10 VDC operation	No.	Will not have capability of firing 2 schedules with different pressure or tip dressing	Yes
Weld Gun Valves					Single solenoid on retract cylinder	Yes. Retract valves directly wired to trigger switch	
Stepper software					No	Only two steppers. Will not work for equipment with tip dress function	Yes
Receptacles on Enclosure					No	Yes, for valve package and trigger switches	
Operator interface					Yes, custom	Yes, but built into cabinet door	
Lockouts on water and air valves					No	No	
Touchsafe design					No	Yes	No
Present Quote	<b>\$6,464</b>	<b>\$5,652</b>	<b>\$5,560</b>	<b>\$4,051</b>	<b>\$4,522</b>	<b>\$3,950</b>	

	Premise or named place	Customs Clearance (Export)	Loading	Inland Freight	Carrier Not Unloaded	Alongside ship Port of Loading	On-board vessel Port of Loading	On-board vessel Port of Destination	Unloaded Port of Destination	Customs Clearance (Import)	Named Destination	Inland Freight	Premise, Not Unloaded
EXW Ex works	●												
FCA Free Carrier Multimodal	●			●									
	Delivered at seller's premises												
FCA Free Carrier Multimodal				●		●							
	Delivered at carriers premises												
FAS Free Alongside Ship						●							
	Port of Shipment												
FOB Free On Board							●						
	Port of Shipment												
CFR Cost and Freight							●		●				
	Named Port of Destination												
CIF Cost, Insurance, and Freight							●		●				
	Named Port of Destination												
CPT Carriage Paid To						●						●	
	Named Port of Destination												
CIP Carriage and Insurance Paid to						●						●	
	Named Port of Destination												
DAF Delivered at Frontier									●			●	
	Named border												
DES Delivered Ex Ship									●				
	Named Port of Destination												
DEQ Delivered Ex Quay									●	●			
	Named Port of Destination												
DDU Delivered Duty Unpaid									●	●	●		
	Named Port of Destination												
DDP Delivered Duty Paid									●	●	●	●	

